CTDOT

Single-Level Passenger Rail Cars

Technical Specification

Rev. A

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Technical Specification

CTDOT Single-Level Passenger Rail Cars

Chapter 1

Specification Summary

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1.00 Specification Summary

1.01 Overview

The purpose of this specification is to define the performance and technical requirements for a fleet of new single-level passenger rail cars for use by the Connecticut Department of Transportation (CTDOT), hereinafter also referred to as "Engineer" or "Customer", for use on the New Haven Line, Hartford Line, and Shore Line East routes. All technical characteristics and performance parameters for these cars are contained herein, as well as the design review, inspection, testing and documentation requirements for producing and supporting these rail cars.

1.02 Regulations

The CTDOT cars shall be fully compliant with all applicable federal regulations for safety, operations, design, accessibility, testing and materials standards, as well as numerous industry standards as developed by the American Public Transportation Association (APTA), the American Welding Society (AWS), and others. A complete listing of all regulations, standards, recommended practices and specifications that are referenced in this document can be found in Chapter 2. This is not to be interpreted as a comprehensive and exhaustive list of all regulations and standards that the Contractor must adhere to in the design and manufacture of the rail cars. The Contractor shall retain sole responsibility for complying with all standards, recommended practices and regulations that apply to the design and production of these rail cars.

1.03 Concept

A. The Single-Level passenger rail cars are intended to be a single-level intercity car fleet for use on the New Haven Line, Hartford Line, and Shore Line East routes. The new cars will include the following features:

   1. One or two large entry vestibule(s) for high-volume passenger loading and unloading, depending upon car type
   2. Trainline-controlled side entry doors
   3. Full compliance with all applicable ADA requirements
   4. Seat spacing for comfort as well as capacity
   5. Workstation tables
   6. A cab control car and locomotive control trainlines for push-pull service
   7. Convenience outlets with USB capability at every row.
   8. Exterior crew door control switches
   9. Accessible toilet room adjacent to the ADA-accessible vestibule

B. This document was developed with the following ideologies:

   1. The Specification is heavily dependent on accepted industry standards, which have been referenced herein.

2. All cars and car types supplied under this technical specification must be capable of fully functional co-mingled operation, both among themselves and when in mixed CTDOT train consists of all types of CTDOT single-level passenger cars in any combination, including if individual cars are turned end-for-end. Complete functional electrical and pneumatic interoperability must be provided with all applicable diesel and electrical locomotives, and with all CTDOT single-level trailer and cab cars. All pneumatic trainline, Head End Power (HEP) trainline and communications/door control trainline functionality shall be maintained. Push-pull trainline functionality shall also be provided when coupled to other CTDOT cars and locomotives so equipped. All cars shall be fully compatible for unlimited duration movement when locomotive hauled, and locomotive pushed, or when coupled to conventional freight cars as in a freight train. Details shall be presented to the Engineer for approval as part of the design review Process. [CDRL 01-001]

3. The cars shall be designed and manufactured to perform satisfactorily for a minimum of 40 years. The carbody and all its structural elements, including trucks and running gear, shall have a minimum design life of 40 years of operation at full seated passenger load. The design and the selection of materials shall prevent corrosion damage, including the effects of extreme weather conditions, during the 40-year design life.

4. Safety, reliability and maintainability are primary objectives of this specification. Use of specialized tools or equipment shall be limited. Ease of access for inspection, maintenance and repairs is a major design consideration.

5. Various components have been specified by manufacturer and part number in this Specification. The Contractor may propose alternate manufacturer's components, but the use of alternate components or manufacturers must be approved by the Engineer. Proposed alternative components must be functionally interchangeable in form, fit and function with components called out herein.

6. For safety critical items, introduction of alternative components will only be considered if such components have an established record, in North America, and/or have undergone an appropriate qualification program that demonstrates an acceptable level of safety, service and reliability for intercity or commuter passenger cars. The data shall be submitted to the Engineer for approval.

7. Design reviews and mockups will be employed to assess all proposed designs for compliance with specification requirements including safety, maintainability, ergonomics, functionality and passenger comfort. The areas to be created in full-scale mockups for Engineer review include:

    a. Passenger seating area

    b. Accessible toilet room

    c. Cab control compartment

    d. Side doors

    e. Overhead luggage storage

    f. The mockups will allow the Engineer, and those invited by the Engineer, to review the configuration and layout of the proposed design, to get a feel for the workability, comfort, access and functionality and to fine-tune the design for maximum benefit.

1.04 Summary of CTDOT Car Specification

Where conflict exists between the descriptions below and the actual chapters, the verbiage in the chapters will be used.

1.04.01 Car Types and Arrangements

A. This technical specification provides for two types of cars – a trailer car and a cab car.

B. The two types of cars are summarized as follows:

1. The trailer car is a single-level car with revenue seating.
    a. Provisions for wheelchair access and wheelchair parking adjacent to accessible toilet room.
    b. An ADA accessible toilet room.
    c. Overhead luggage storage area above each seat.
    d. Revenue seating includes several facing pairs of seats with workstation tables.
    e. All seating rows include convenience outlets with 2 USB ports per row.
2. The cab car is similar to a trailer car with the following exceptions:
    a. A full-width cab control compartment is located at the F-end to provide locomotive control for push-pull operation.
    b. The forward end of the cab car conforms to all FRA structural and crashworthiness for cab car forward-facing ends.
    c. The forward end is fully equipped for push-pull operation, including a replaceable pilot (for protection from snow, ice, grade crossings and other debris). The forward end of the cab car shall have streamlined styling for reduced wind resistance to reduce fuel consumption and enhance train performance at high speeds when the trainset is operated from that end.
    d. Both ends of the cab car shall be capable of being connected to other equipment or trainsets for interoperability.

1.04.02 Capacity and Consist Performance

A. Capacity

1. As specified, the CTDOT cars are configured to have the following passenger capacities:

Trailer	80 revenue seats minimum
	1 wheelchair parking location
Cab	72 revenue seats minimum
	1 wheelchair parking location

2. These capacities may be defined differently in Chapter 23, in which case Chapter 23 takes precedence. This configuration may be changed at the discretion of the Engineer.

B. Consist Performance

1. Trains typically consist of 3 to 6 cars with all trainline functions operating normally.

2. Maximum consist of 10 cars for all trainline functions to operate at reduced battery voltage levels, as specified by the Engineer.

3. Maximum consist of 10 cars for brake system to operate properly.

4. Cars are designed for continuous operation for up to 24 hours and 1,200 miles (1,931 km) per day.

1.04.03 Dimensions, Clearances and Track Geometry

A. Overall Carbody Dimensions

1. The cars shall be designed to meet the following overall carbody dimensions:

Overall Length:	85 ft (25,908 mm) (over pulling faces)
Overall Height:	14 ft 8 in. (4,470 mm) maximum above top of rail
Overall Car Width:	10 ft 6 in. (3,200 mm) maximum (except at threshold)
Truck Centers:	59 ft 6 in (18,136mm)
Floor Height:	4 ft 3 in. (1,295 mm) above top of rail
Minimum Side Door Openings:	2 ft 10 in. (864mm) clear opening

2. The overall carbody dimensions must include any antennas and any other devices mounted upon the carbody.

3. The cars shall be designed and built to conform to the following overall dry weight limitations:

Trailer:	105,560 lbs (47,882 kg)
Cab:	109,960 lbs (49,877kg)

4. All cars shall be weighed at the Contractor's facility, and shall have weight distribution and balance as follows:

   a. End-to-end balance within 5% (both at full supplies and no supplies)

   b. Lateral balance (side to side) within 30,000 inch-pounds (3,390 Nm) (both at full supplies and no supplies)

B. Clearances

The cars, including the F-end snowplow pilot on the cab car, shall fully conform to:

1. Drawing No. MNR-NO. 8, Rev. B

2. Drawing No. MNR-NO. 9, Rev. C.

C. Track Geometry

1. The cars shall be designed and tested for revenue operation at all speeds up to 125 mph (201 kph), on all classes of track from FRA Class 1 to Class 7. Track quality shall be the minimally compliant for each class of track, per FRA regulations and AREMA standards. Ride quality standards and testing methods are specified.

2. The cars shall operate on standard gauge track. Standard gauge is 56.5 in. (1,435 mm).

3. The cars shall be capable of negotiating a 250 ft (76,200 mm) radius (18 degree) horizontal curve, coupled to other equipment, without damage to any portion of the car, including trucks and suspension, coupler, draft gear, air and electrical connections, carbody, diaphragm or track.

4. The cars shall be capable of negotiating a 1000 ft (304,800 mm) radius vertical curve (concave or convex), coupled to other equipment, without damage to any portion of the trucks and suspension, coupler, draft gear, air and electrical connections, carbody, diaphragm or track.

5. The cars shall be stable while stationary and at all design speeds including at 5 mph (8 kph) above maximum design speed.

6. The car shall have no more than 50% wheel unloading when stopped on 7 in. (178 mm) superelevation.

7. The cars shall be capable of operating up to 5 in. (127 mm) cant deficiency according to 49 CFR Part 213.329.

8. The cars shall be capable of safely passing other trains that are operating at maximum authorized track speed in either direction on adjacent tracks with 12 ft (3,658 mm) centers. The maximum authorized track speed for other vehicles is greater than 125 mph in some locations.

9. The cars shall be capable of negotiating a number 8 crossover between two tracks with centers 12 ft 2 in (3,709 mm) apart, coupled to other equipment, without damage.

D. Catenary Wire

The Amtrak Northeast Corridor is equipped with an overhead catenary power supply system, operating at 3 voltage potentials. The minimum wire height is 15 ft (4,572 mm) for 11,500V, 25 Hz catenary and 15 ft 6 in. (4,724 mm) for both 13,200V, 60 Hz catenary and 25,000V, 60 Hz catenary. All wire heights are measured from the top of the running rail to the bottom of the contact wire. The Contractor is responsible to ensure that the cars to be supplied are immune from the effects of any electrical interference from the catenary system, including induced electrical currents into the carbody and potential ground return currents through the trucks and wheelset journal bearings, and that the cars are in compliance with all aspects of Drawing No. MNR-NO. 8, Rev. B and Drawing No. MNR-NO. 9, Rev. C.

E. Third Rail

Portions of the Amtrak Northeast Corridor are equipped with segments of both overrunning and underrunning wayside third rail, operating at a potential of up to 750VDC. The Contractor is responsible to ensure that the cars to be supplied are immune from the effects of any electrical interference from the third rail system, and that the cars are in compliance with all aspects of the Drawing No. MNR-NO. 8, Rev. B and Drawing No. MNR-NO. 9, Rev. C.

F. Passenger Stations

1. The single-level passenger car operates at both high-level and low-level boarding passenger station platforms with the following characteristics:

   a. Design height of high-level platform above top of rail: 4 ft (1219 mm) to 4 ft 4 in. (1,321 mm), station dependent

   b. Minimum distance of high-level platform edge to centerline of track: 5 ft 7 in. (1,777 mm)

   c. Design height of low-level platform above top of rail: 16 in (408 mm)

   d. Minimum distance of low-level platform edge to centerline of track: 5 ft 1 in. (1,549 mm)

2. It is required that the cars have the capability for ground-level access for maintenance access, passenger emergency evacuation and fire/rescue access to the car interior.

G. Wayside Signal System

The Amtrak Northeast Corridor signal system consists of wayside signals and cab signals controlled by 100 Hz and 200 Hz double-rail track circuits. US&S Tru-II, GRS Phase Selective and US&S Phase Selective vital track relays are used. Pickup current values vary depending upon the manufacturer. The Contractor is required to verify these values with the manufacturer during emissions testing. Train detection at highway grade crossings is performed by audio frequency overlay track circuits. The minimum cab signal system in-rail current is 2.0 amp at the entering end of a track circuit.

1.04.04 Carbody (Chapter 4)

A. Stainless steel carshell with Low-Alloy, High-Tensile (LAHT) end underframe and other primary structural components.

B. Corrugated stainless steel roof for longitudinal structure and durability.

C. Carshell shall be fully compliant with FRA's requirements for structural strength, crashworthiness and testing per 49 CFR Part 238:

   1. Meets or exceeds 49 CFR Part 238, Subpart Dstructural requirements

   2. Meets or exceeds APTA-PR-CS-S–034-99 Rev. 2 for the Design and Construction of Passenger Rolling Stock

   3. Carshell tested to 800,000 lb. (3.56M N) buff load

   4. 300,000 lb. (1.33M N) collision post load test

   5. All components attached to withstand longitudinal/lateral/vertical accelerations of 8/4/4g

D. Each side of the car has at least two side entries.

E. All cars feature large windows with glass or polycarbonate panes. All cars will have emergency exit windows in full compliance with FRA regulations.

1.04.05 Trucks (Chapter 5)

A. The specification provides for either cast or fabricated (preferred) trucks.

B. All trucks will use standard Amtrak wheelsets, with 36 in. (914 mm) nominal new wheels, type F outside bearings, and tread and disc brakes.

C. Primary and secondary suspension is provided through the use of steel coil springs, or air springs or chevrons as approved by the Engineer.

1.04.06 Couplers (Chapter 6)

A. All cars use H-type couplers as specified in Chapter 6.

B. Couplers, coupler carriers and uncoupling mechanisms shall be compliant with FRA standards and requirements.

1.04.07 Brakes (Chapter 7)

A. Electronically controlled pneumatic air brake system compatible with conventional type 26C schedule.

B. Locomotive supplies air for brake pipe and main reservoir functions:

1. 110 psi (758 kPa) brake pipe operation (for train air brake control)

2. 140 psi (965 kPa) main reservoir operation (for auxiliary functions such as water pressure, toilet flushing, etc.)

C. Braking rates:

1. Full service: minimum of 1.35 miles per hour per second (mphps) (2.17 kph/s) deceleration from 125 mph (201 kph) down to 70 mph (113 kph), then increasing to not less than 2 mphps (3 kph/s) average below 70 mph (113 kph).

2. Emergency: minimum of 2.5 mphps (4.0 kph/s) below 70 mph (113 kph).

D. Tread and disc brakes on all axles. Track brakes are not used.

E. Wheelslide protection provided on all axles and controlled on a per-truck basis.

F. Electric and pneumatic brake applied/released indicators are provided on the side of each car.

G. All cars are equipped with a handbrake, located at the B-end. A spring applied parking brake is allowed as approved by the Engineer.

H. The cab car shall have the ability to apply full service brake on the cab car only through use of the brake control handles.

1.04.08 Door Systems (Chapter 8)

A. The trailer cars feature at least two side entry doors per side, body end doors, and sliding pocket vestibule doors. The cab cars feature at least two side entry doors per side, a body end door at the non-cab end, and a sliding pocket vestibule door at the non-cab end.

B. Side doors throughout the train can be controlled from any door control station located on the same side of the car as the door control station and can also be trainlined or opened individually.

C. The door system complies with all FRA safety provisions, including obstruction detection, traction interlock, zero-speed protection, status lights and signage, emergency release, and crew control.

D. Side doors feature enhanced access for maintenance of door operator hardware.

E. All cars have exterior side door crew key switches for employee access.

F. Vestibule doors are sliding pocket doors with upper and lower press plates, obstruction detection, manual isolation, Type 1 glazing in the window and a removable panel in the lower half of the door, as required by the FRA.

1.04.09 Interiors (Chapter 9)

A. All cars shall be equipped with energy-absorbing workstation tables, convenience outlets with USB at every seat, and overhead luggage storage.

B. Interior surfaces shall be made of fiberglass-reinforced plastic, decorative laminates and wainscot panels below the windows.

C. Each car shall have one ADA accessible toilet room.

D. All cars will be fully equipped with emergency signage and low-location exit path markings, in conformance with APTA standards and FRA requirements.

E. The interior and furnishing shall present a clean, pleasing appearance and require little maintenance and be easy to clean.

F. Interior décor shall be developed by the Contractor, to provide a comprehensive look to the interior of the car through coordination of seat fabrics and other color palettes. The Contractor shall provide several storyboard options for the interior décor for the Engineer to choose from.

G. Seats shall be selected at the discretion of the Engineer. All seats and workstation tables shall be mounted in seat tracks for easy installation, and to allow different seat pitches at the direction of the Engineer.

1.04.10 Heating, Ventilation and Air Conditioning (Chapter 10)

A. The Heating, Ventilation and Air Conditioning (HVAC) system will use efficient scroll compressors, environmentally friendly refrigerants, microprocessor controls and multiple temperature sensors for system operation.

B. The HVAC system shall be a hermetically sealed, packaged unit that is roof top mounted.

C. Two identical HVAC units will provide cooling and overhead heat for each car.

D. The HVAC system shall maintain the car interior, including the Engineer's cab, to the specified temperature of 68°F (20°C) to 76°F (24°C).

E. Maximum interior sound levels are specified to minimize blower and diffuser noise.

F. Filters are easy to access and replace.

G. Water system components are equipped with freeze protection.

H. Side door thresholds are heated.

I. Emergency exhaust fans shall be provided.

J. Return air drawn from the vestibules at each end of the car.

1.04.11 Lighting (Chapter 11)

A. Interior lighting relies on Light Emitting Diodes (LEDs) for energy efficiency and reliability. All LED passenger lighting shall be powered from the 74VDC battery system. Emergency lighting will have individual battery back-up. Halogen lights are not to be used. Incandescent lights are not used anywhere on the car except for cab car headlights.

B. The normal and emergency lighting system meets all new APTA standards and FRA requirements for charging and emergency light levels.

C. Emergency lighting relies on LED lamps and high-efficiency capacitors for power source.

1.04.12 Communications and Passenger Information (Chapter 12)

A. All cars will feature a Public Address (PA) system, intercom, a passenger information system, a data communication system, and a video surveillance system.

B. PA and intercoms are compliant with FRA requirements for emergency communication.

C. An On Board Train Information System (OTIS) accommodates wireless technology using satellite or mobile telecommunications ISP for internet connectivity, a separate Ethernet Train Backbone trainline network between cars dedicated to passenger internet access and provision of 802.11ax access point in each car to provide wireless internet services to passengers.

D. OTIS is compliant with ADA.

1.04.13 Electrical (Chapter 13)

A. Primary power source is locomotive-provided 480 Volt Alternating Current (VAC) Head End Power (HEP).

B. Power distribution system converts the HEP to 120VAC, 74VDC and 24VDC, (cab car only) for use throughout the car.

C. The batteries and battery charger system provide the low-voltage power supply for systems requiring power when HEP is lost (PA, door operators, lights, cab controls).

D. All cars will be equipped with standard trainlines:

1. 480VAC HEP trainline (in compliance with APTA-PR-E-RP-016-99)
2. 27-Point Multiple Unit (MU) Trainline (in compliance with APTA-PR-E-RP-017-99)
3. 27-Point Communication (COMM) Trainline (in compliance with APTA-PR-E-RP-017-99)
4. Receptacles will be located on both sides of each car for maximum flexibility in building train consists (either end of any car can be connected to either end of any other car).
5. 120 Vac utility outlets with USB will be located in all toilet rooms, equipment rooms, the electrical locker, operating cab and utility rooms, for ease of maintenance and cleaning.

1.04.14 Food Service (Chapter 14)

Not used.

1.04.15 Water and Waste (Chapter 15)

A. Fresh water [112-gal (424 L) storage capacity for cab and trailer] will be used for toilet room functions such as toilet flush and hand washing.

B. All waste water will be captured and stored in a 100-gal (379 L) waste retention tank at the B-end of each car.

1.04.16 Cab and Controls (Chapter 16)

A. Each cab car will be equipped with a locomotive control cab at the forward end.

B. The cab will be full width and will provide seating for an operator and an observer.

C. FRA Type 1 windshields will be provided on the end of the car for the Operator and the Observer. These windshields will be heated for defrosting and defogging. Opening windows will be provided on each side of the cab for sideways visibility.

D. The Operator will have access to all locomotive train controls and indicators to operate the train safely in push-pull service.

E. Federally mandated safety systems such as an event recorder, alerter and Positive Train Control (PTC) shall be incorporated into the design of the cab.

F. Secure cabinets will be located behind the cab for emergency equipment and storage of crew belongings. A secure locker will be provided for data storage from the event recorder and PTC systems.

G. The cab end of the cab car will include streamlined styling to the extent practical, considering the limitations of a pass-through door, for reduced wind resistance, which reduces fuel consumption and enhances locomotive performance at high speeds when in push mode.

1.04.17 Emergency Equipment (Chapter 17)

A. All cars will be equipped with emergency equipment as required by the FRA, including, but not limited to, fire extinguishers, pry bar, first aid kit, AED (on the cab car only) and light sticks.

B. Signage for the emergency equipment shall meet all applicable FRA requirements.

1.04.18 Materials and Workmanship (Chapter 18)

All materials, parts and workmanship that go into the design and manufacture of the rail cars are subject to rigorous standards for quality, performance, method of assembly and compliance with applicable regulations and industry standards.

1.04.19 Testing Requirements (Chapter 19)

A. The cars will undergo extensive testing as prescribed in the Specification, to ensure that the cars meet all requirements for design, performance and quality.

B. Four major categories of tests are specified:

1. Material certifications

   These tests are performed on the materials that are used to manufacture the cars, to ensure that they are manufactured in accordance with all specified requirements. These are usually performed at material testing laboratories or manufacturer facilities.

2. Proof of design tests

   Proof of design tests are performed to validate the concept of a component or system, to ensure that the design of the component or system performs as intended or specified, with no adverse or unexpected consequences. Proof of design tests are normally conducted on the first components or assembled systems, and the first completed cars, so that subsequent cars or components may be redesigned to resolve design problems.

3. Production tests

   Production tests are required for all cars and selected components (such as truck frames) where safety is critical. Production tests are conducted at the Contractor's facility, and at the facility of the major component suppliers.

4. Acceptance tests

Acceptance tests are conducted on each car at the Engineer's facility to verify all car functionality, including train consist compatibility, prior to placement of the car into revenue service.

1.04.20 Documentation and Training (Chapter 22)

A. Support documentation, such as maintenance and operating manuals, as-built drawings, parts lists and troubleshooting guides, are included in the technical specification.

B. A training program is established for familiarizing operating, mechanical and supervisory staff on the proper maintenance, repair, troubleshooting and operation of the equipment.

1.04.21 Customer Variables (Chapter 23)

A. This chapter describes features of the car such as exterior graphics, interior décor considerations, seats and interior layout, testing with existing fleets, and other aspects of the car design.

B. Specific components may be called out here by the Engineer.

1.04.22 Standard Keys

A. A total of two types of standard keys shall be used on the various car types, a coach (Conductor's) key and a cab master controller key.

B. The coach key is used by the train crew and shall be used as the general key for door control and to open all doors and car interior access covers that specify a key-locked door. All such coach key locks and key control switches shall accept the standard Amtrak coach key, J.L. Howard Part No. 2555, or approved equal, in accordance with the latest revision of Amtrak Drawing B-144. Where possible, all such coach key locks and key control switches shall accept the standard Amtrak and standard MTA key. The coach key shall operate the Conductor door control panels, side door mechanical locks, end doors, cab door, cab side window lock, communication system, equipment and storage lockers and crew lockers. Wherever an electrical switch is operated by the coach key, the tumbler shall be set back at least 0.5 in. (25.4 mm) from the face and protected by a fixed keyway spacer to prevent operation by a screwdriver or similar device.

C. The cab master controller key shall be used by the Operator to activate the cab electrical controls and propulsion system master controller.

D. The Contractor shall submit for approval, a matrix of the key type used in each lock or key switch. [CDRL 01-002]

E. The Contractor may also propose an alternative key design for the Engineer to review and approve.

1.05 Contract Deliverable Requirements List

CDRL #	Title	Car Type
01-001	Compatibility Plan	All
01-002	Key Matrix	All

* End of Chapter 1 *

Technical Specification

CTDOT Single-Level Passenger Rail Cars

Chapter 2

References and Glossary

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2.00 References and Glossary

2.01 Overview

A. Regulations, standards and specifications that are referenced in this document are listed below as a guide to the Contractor but shall not be construed as complete.

B. Unless specified otherwise, the Contractor shall comply with the revision of the reference documents in effect at time of Notice to Proceed (NTP).

C. The Contractor is responsible for ensuring that all applicable regulations, standards and specifications are followed when complying with the requirements of this specification, including those released after NTP.

D. Nothing in this specification shall relieve the Contractor from ensuring that all applicable regulations, standards and specifications are followed. The Contractor shall provide proof of compliance for those items so governed before the first train set is accepted. The Engineer shall determine if the proof of compliance provided is acceptable.

2.02 Supplemental Regulations, Standards, Specifications and Drawings

Regulations, standards, specifications, and drawings, which pertain to this specification, are listed below. The following list is furnished as a guide to the Contractor, but shall not be construed as complete. When any of the following are superseded by a later revision that is approved by the issuing entity, the later revision shall apply. Unless specified otherwise, the Contractor shall be responsible for acquiring and maintaining copies of all applicable references from the appropriate source. The Engineer shall not be obligated to provide these referenced documents unless specifically stated. The Contractor will be responsible for determining if there are newer versions of the referenced specifications/regulations/standards and obtaining them. In case of a conflict between requirements, applicable laws, rules, and regulations unless otherwise specified, the more stringent shall prevail. In case of other conflicts, the Contractor shall report the conflict and request clarification from the Engineer.

2.02.01 Regulations

A. ADA (Americans with Disabilities Act)

36 CFR Part 1192.99: *Floors, Steps and Thresholds*
36 CFR Part 1192.113: *Doorways*
36 CFR Part 1192 Appendix: *Advisory Guidelines*
49 CFR Subtitle A, Figure 4: *Intercity Rail Car (with accessible restroom)*
49 CFR Part 38.101: *Lighting*
Americans with Disabilities Act of 1990 and regulations promulgated thereafter, including 49 CFR Part 27, 37 & 38.

B. DOE (U.S. Department of Energy)

Energy Policy Act (EPAct) of 2005

C. EPA (Environmental Protection Agency)

Title 40, 40CFR *Protection of Environment*
82: *Protection of Stratospheric Ozone*
201: *Noise Emission Standards for Transportation Equipment; Interstate Rail Carriers*
1033: *Control of Emissions from Locomotives*

D. FAA (U.S. Federal Aviation Administration)

AC 43.13-1B: *Acceptable Methods, Techniques, and Practices – Aircraft Inspection and Repair*

E. FDA (U.S. Food and Drug Administration)

21 CFR Part 1250: *Interstate Conveyance Sanitation*
1250.41: *Submittal of Construction Plans*

F. FRA (Federal Railroad Administration)

Title 49, 49 CFR *Transportation*, Section II, Parts 200-299
210: R*ailroad Noise Emission Compliance Regulations*
213: *Track Safety Standards*
213.329: *Curves, Elevation, and Speed Limitations*
213.333: *Automated Vehicle Inspection Systems*
213.345: *Vehicle Qualification Testing*
213.57: *Curves, Elevation, and Speed Limitations*
221: *Rear End Marking Device-Passenger, Commuter and Freight Trains*
222: *Use of Locomotive Horns at Public Highway-Rail Grade Crossings*
222.21: *When Must a Locomotive Horn be Used?*
223: *Safety Glazing Standards--Locomotives, passenger Cars and Cabooses*
229: *Railroad Locomotive Safety Standards*
229.11: *Locomotive Identification*
229.23: *Periodic Inspection: General*
229.46 through 229.59: *Brake System*
229.115: *Slip/Slide Alarms*
229.117: *Speed Indicators*
229.119: *Cabs, Floors and Passageways*
229.121: *Cab Noise*
229.123: *Pilots, Snowplows, End Plates*
229.125: *Headlights and Auxiliary Lights*
229.127: *Cab Lights*
229.129: *Horn*
229.131: *Sanders*
229.133: *Interim Locomotive Conspicuity Measures-Auxiliary External Lights*
229.135: *Event Recorders*
229.137: *Sanitation, General Requirements*
229.141: *Body Structure, MU Locomotives*
231: *Railroad Safety Appliance Standards*
236: *Rules, Standards, and Instructions Governing the Installation, Inspection, Maintenance, and Repair of Signal and Train Control Systems, Devices, and Appliances*
236 Subpart I*: Positive Train Control Systems*
238: *Passenger Equipment Safety Standards*
238.103: *Fire Safety*
238.105: *Train Electronic Hardware and Software Safety*
238.111: *Pre-revenue Service Acceptance Testing Plan*
238.113: *Emergency Window Exits*
238.114: *Rescue Access Windows*

238.115: *Emergency Lighting*
238.121: *Emergency Communication*
238.123: *Emergency Roof Access*
238.205: *Anti-Climbing Mechanism*
238.207: *Link Between Coupling Mechanism and Car Body*
238.211: *Collision Posts*
238.213*: Corner Posts*
238.215*: Rollover Strength*
238.217: *Side Structure*
238.219: *Truck-to-Carbody Attachment*
238.227: *Suspension System*
238.231: *Brake System*
238.233: *Interior Fittings and Surfaces*
238.235: *Doors (Emergency Egress)*
238.237: *Automated Monitoring*
238.303: *Exterior Calendar Day Mechanical Inspection of Passenger Equipment*
238.307: *Periodic Mechanical Inspection of Passenger Cars and Unpowered Vehicles Used in Passenger Trains*
238.435: *Interior Fittings and Surfaces*
238.441: *Emergency Roof Access*
238.447: *Train Operator's Controls and Power Car Cab Layout*
238 Appendix B: *Test Methods and Performance Criteria for the Flammability and Smoke Emission Characteristics of Materials Used in Passenger Cars and Locomotive Cabs*
238 Subpart B: *Safety Planning and General Requirements*
238 Subpart C: *Specific Requirements for Tier 1 Passenger Equipment*
239: *Passenger Train Emergency Preparedness*
239.101: *Emergency Preparedness Plan*
239.107: *Emergency Exits*
571.208, Subpart 6*: Federal Motor Vehicle Safety Standards: Occupant Crash Protection*

G. FTA (Federal Transit Administration)

FTA-IT-90-5001-02.1 of February 2002: *Quality Assurance and Quality Control Guidelines*

2.02.02 Standards

A. AAR (Association of American Railroads)

C-II: *Design, Fabrication, and Construction of Freight Cars*
M-101: *Axles Carbon Steel, Heat-Treated*
M-107/M-208: *Wheels, Carbon Steel*
M-114: *Helical Springs, Heat-Treated Steel*
M-201: *Steel Castings*
M-601: *Hose, Wrapped, Air Brake, "End Hose"*
M-618: *Hose, Air, Wire-Reinforced*
M-1001: *Design, Fabrication, and Construction of Freight Cars*
RP-585: *Wiring and Cable Specification*
S-100, Section B: *Bushings, Stainless Steel Tube–Coupler Shanks and Yokes*
S-400: *Brake Equipment-Installation Specifications*

S-471: *Brake Pipe Restriction Test*
S-580: *Locomotive Crashworthiness Requirements*
S-4200: *ECP Cable-based Brake Systems – Performance Specifications*
S-4210: *ECP Cable-based Brake System Cables, Connectors and Junction Boxes – Performance Specifications*
S-5502: *Automatic Engine Start/Stop System*
S-5506: *Performance Requirements for Diesel Electric Locomotive Fuel Tanks*

B. AHRI (Air-Conditioning, Heating, and Refrigeration Institute)

700: *Specifications for Fluorocarbon Refrigerants*

C. Aluminum Association

AA-ADM-105: *Aluminum Design Manual: Specifications and Guidelines for Aluminum Structures*
Aluminum Company of America (ALCOA) Technical Report 524, *Specification Covering Use of Aluminum in Passenger Carrying Railway Vehicles*
Aluminum Standards and Data

D. ANSI (American National Standards Institute)

B16.18: *Cast Copper Alloy Solder Joint Pressure Fittings*
C82.2: *For Lamp Ballasts-- Method of Measurement of Fluorescent Lamp Ballasts*
S1.4 Part 3: *Specification for Sound Level Meters*
S3.2-2009: *Method for Measuring the Intelligibility of Speech over Communication Systems*
Z26.1: *Safety Code for Safety Glazing Materials for Glazing Motor Vehicles Operating on Land Highways*

E. ANSI (American National Standards Institute)/ASME (American Society of Mechanical Engineers)

B1.1: *Unified Inch Screw Threads (UN and UNR Thread Form)*
B16.22: *Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings*
B18.1.2: *Large Rivets (1/2 Inch Nominal Diameter and Larger)*
B31.1: *Power Piping*

F. ANSI (American National Standards Institute)/IEEE (Institute of Electrical and Electronics Engineers)

730: *Software Quality Assurance Plans*

G. APTA (American Public Transportation Association)

Manual for the Development of System Safety Program Plans for Commuter Railroads Manual of Standards and Recommended Practices for Rail Passenger Equipment
PR-CS-RP-001-98: *Recommended Practice for Passenger Equipment Roof Emergency Access*
PR-CS-S-006-98: *Standard for Attachment Strength of Interior Fittings for Passenger Railroad Equipment*
PR-E-RP-002-98: *Wiring of Passenger Equipment*
PR-E-RP-006-99: D*iesel Electric Passenger Locomotive Dynamic Brake Control*
PR-E-RP-007-98, Rev 1: *Storage Batteries and Battery Compartments*
PR-E-RP-009-98: *Recommended Practice for Wire Used on Passenger Equipment*
PR-E-RP-012-99, Edited 4-1-04: *Recommended Practice for Normal Lighting System Design for Passenger Rail Equipment*
PR-E-RP-014-99: *Recommended Practice for Diesel Electric Passenger Locomotive Blended Brake Control*

PR-E-RP-015-99: *Head End Power Source Characteristics*

PR-E-RP-016-99: *Recommended Practice for 480VAC Head End Power System*

PR-E-RP-017-99: *Recommended Practice for 27- point Control and Communication Trainlines for Locomotives and Locomotive-Hauled Equipment*

PR-E-RP-018-99: *480 VAC Head End Power Jumper and Receptacle Hardware*

PR-E-RP-019-99: *27-Point Jumper and Receptacle Hardware for Locomotives and Locomotive-Hauled Equipment*

PR-M-RP-001-97: *Recommended Practice for Air Connections, Location and Configuration of, for Passenger Cars Equipped with AAR Long Shank Tight Lock or Similar Long Shank Type Couplers*

PR-M-RP-008-98: *Recommended Practice for Passenger Car Axle Design*

PR-M-RP-003-98: *Recommended Practice for the Purchase and Acceptance of Type H-Tightlock Couplers*

PR-M-RP-009-98: *Recommended Practice for New Truck Design*

PR-PS-RP-005-00: *Fire Safety Analysis of Existing Passenger Rail Equipment*

PR-CS-S-004-98, Rev 1: *Austenitic Stainless Steel for Railroad Passenger Equipment*

PR-CS-S-006-98, Rev 1: *Attachment Strength of Interior Fittings for Passenger Railroad Equipment*

PR-CS-S-011-99: *Standard for Cab Crew Seating Design and Performance*

PR-CS-S-012-02: *Door Systems for New and Rebuilt Passenger Cars*

PR-CS-S-015-99: *Standard for Aluminum and Aluminum Alloys for Passenger Equipment Carbody Construction*

PR-CS-S-016-99 Rev. 2: *Row-to-Row Seating in Commuter Rail Cars*

PR-CS-S-034-99 Rev. 2: *Standard for the Design and Construction of Passenger Railroad Rolling Stock*

PR-E-S-001-98: *Standard for Insulation Integrity*

PR-E-S-005-98: *Standard for Grounding and Bonding*

PR-E-S-010-98: *Standard for the Development of an Electromagnetic Compatibility Plan*

PR-E-S-013-99 Rev. 1: *Standard for Emergency Lighting System Design for Passenger Cars*

PR-M-S-005-98 Rev. 4: *Code of Tests for Passenger Car Equipment Using Single Car Testing Device (revision in effect at time of test)*

PR-M-S-006-98 Rev 3: *Standard for Parking Brakes for New Passenger Locomotives and Cars*

PR-M-S-007-98 Rev. 2: *Passenger and Crew Emergency Brake Device in New Passenger Cars MU Locomotives*

PR-M-S-011-99 Rev. 2: *Compressed Air Quality for Passenger Locomotive and Car Equipment*

PR-M-S-012-99 Rev. 1: *Standard for the Manufacture of Wrought Steel Wheels for Passenger Cars and Locomotives*

PR-M-S-014-06 Rev. 1: *Standard for Wheel Load Equalization of Passenger Railroad Rolling Stock*

PR-M-S-015-06: *Standard for Wheel Flange Angle for Passenger Equipment*

PR-M-S-016-06: *Standard for Safety Appliances for Rail Passenger Cars*

PR-M-S-017-06: *Standard Definition and Measurement of Wheel Tread Taper*

PR-M-S-018-10: *Standard for Powered Exterior Side Door System Design for New Passenger Cars*

PR-PS-S-002-98 Rev. 3: *Standard for Emergency Signage for Egress/Access of Passenger*

PR-PS-S-003-98: *Standard for Emergency Evacuation Units for Rail Passenger Cars*

PR-PS-S-004-99 Rev. 2: *Standard for Low-Location Exit Path Marking*

H. ASHRAE (American Society of Heating, Refrigeration and Air Conditioning Engineers)

41.1-2013 (R2006): *Standard Method for Temperature Measurement*

37-2009: *Methods of Testing for Rating Electrically Driven Unitary Air-Conditioning and Heat Pump Equipment*

I. ASME (American Society of Mechanical Engineers)

Boiler and Pressure Vessel Code

B1.13M: *Metric Screw Threads: M Profile*

J. ASTM (American Society for Testing and Materials)

A6/A6M: *Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling*

A53/A53M-07: *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless*

ASTM A269/269M: *Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service*

ASTM A312/A312M: *Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipes*

A380/A380M: *Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems*

ASTM A388/A388M: *Standard Practice for Ultrasonic Examination of Steel Forgings*

A488/A488M-07: *Standard Practice for Steel Castings, Welding, Qualifications of Procedures and Personnel*

A502-03: *Standard Specification for Rivets, Steel Structural*

A572/A572M, A568/A568M, A568, A588/A588M, A606/A606M, A715

A710/A710M: *High Strength Low Alloy Structural Steel*

A666: *Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar*

B26/B26M-09: *Standard Specification for Aluminum-Alloy Sand Castings*

B32-08: *Standard Specification for Solder Metal*

B75/B75M: *Standard Specification for Seamless Copper Tube*

B85/B85M-09*: Standard Specification for Aluminum-Alloy Die Castings*

ASTM B88: *Standard Specification for Seamless Copper Water Tube*

B108/B108M: *Standard Specification for Aluminum-Alloy Permanent Mold Castings*

B247-09*: Standard Specification for Aluminum and Aluminum-Alloy Die Forgings, Hand Forgings, and Rolled Ring Forgings*

B633-07*: Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel*

ASTM C1036: *Standard Specification for Flat Glass*

C177-10: *Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus*

C542-05*: Standard Specification for Lock-Strip Gaskets*

C1166-06: *Standard Test Method for Flame Propagation of Dense and Cellular Elastomeric Gaskets and Accessories*

D395-03: *Standard Test Methods for Rubber Property-Compression Set*

D412-06ae2*: Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension*

D523-08: *Standard Test Method for Specular Gloss*

D573-04*: Standard Test Method for Rubber—Deterioration in an Air Oven*

D746-07: *Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact*

D1149-07: *Standard Test Methods for Rubber Deterioration-Cracking in an Ozone Controlled Environment*

D2240-05*: Standard Test Method for Rubber Property—Durometer Hardness*

D3574-95: *Seat Cushion Testing Requirements*

D3774-96(2008)e1: *Standard Test Methods for Width of Textile Fabric*

D3775-08: *Standard Test Method for Warp (End) and Filling (Pick) Count of Woven Fabrics*

D3776/D3776M - 09a: *Standard Test Methods for Mass Per Unit Area (Weight) of Fabric*

D4956-07: *Standard Specification for Retroreflective Sheeting for Traffic Control*

E94/E94M: *Standard Guide for Radiographic Examination*

E119-10b: *Standard Test Methods for Fire Tests of Building Construction and Materials*

E162-09: *Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source*

E165/E165M: *Standard Test Method for Liquid Penetrant Examination*

E168-06: *Standard Practices for General Techniques of Infrared Quantitative Analysis*

E446-98(2004)e1: *Standard Reference Radiographs for Steel Castings Up to 2 in. [51 mm] in Thickness*

E662-09: *Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials*

E709-01: *Standard Guide for Magnetic Particle Examination*

E709-08: *Standard Guide for Magnetic Particle Testing*

E802-95: *Standard Reference Radiographs for Gray Iron Castings Up to 4 1/2 in. (114 mm) in Thickness*

F1344-10: *Standard Specification for Rubber Floor Tile*

K. AWS (American Welding Society)

AWS Welding Handbook

B2.1/B2.1M: *Specification for Welding Procedure and Performance Qualification*

B2.2/B2.2M: *Specification for Brazing Procedure and Performance Qualification*

B2.3/B2.3M: *Specification for Soldering Procedure and Performance Qualification*

C1.1M/C1.1: 2000 (R2006): *Recommended Practices for Resistance Welding*

C7.2M: *Recommended Practices for Laser Beam Welding, Cutting and Drilling*

C7.4/7.4M: *Process Specification and Operator for Laser Beam Welding*

D1.1/D1.1M: *Structural Welding Code – Steel*

D1.2/D1.2M: *Structural Welding Code, Aluminum*

D1.3/D1.3M: *Structural Welding Code – Sheet Steel*

D1.6/D1.6M: *Structural Welding Code, Stainless Steel*

D1.9/D1.9M: *Structural Welding Code— Titanium*

D17.2/D17.2M: *Specification for Resistance Welding in Aerospace Applications*

D17.3/D17.3M: *Specification for Friction Stir Welding of Aluminum Alloys for Aerospace Applications*

L. Boeing

BSS-7239: *Test Method for Toxic Gas Generation by Materials on Combustion*

M. Bombardier

SMP 800-C: *Toxic Gas Generation of "Flex 35 Rev. D" Rubber Compound*

N. British Railways Board Group Standard

GM/TT0088, Issue 1, Rev A: *Geometric Interfaces Between Railway Wheelsets and Track*

O. CENELEC (European Committee for Electrotechnical Standardization)

DIN 25570-1: *Pipes for Rail Vehicles*
EN 50128: *Railway Applications - Communications, Signaling and Processing Systems - Software for Railway Control and Protection Systems*
EN 50155: *Railway Applications - Electronic Equipment Used On Rolling Stock*
EN 50343: *Railway Applications - Rolling Stock - Rules For Installation Of Cabling*

P. CSA (Canadian Standards Association)

C22.2, No. 197-M1983: *PVC Insulating Tape*

Q. EIA (Electronic Industries Alliance)

649-A 2004: *National Consensus Standard for Configuration Management*

R. European Norms

DIN EN 13452-1: *Railway Applications – Braking - Mass Transit Brake Systems – Part 1: Performance Requirements*
BS EN 50126: *Railway Applications. The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS)*

S. (General Services Administration)

Federal Standards
QQ-B-654A: *Brazing Alloys, Silver*
QQ-P-416F: *Plating, Cadmium (Electrodeposited) (S/S by SAE-AMS-QQ-P-416)*
TT-P-38E: *Paint, Aluminum, Ready-mixed*
TT-P-664D: *Primer Coating, Alkyd, Corrosion-inhibiting, Lead and Chromate Free, Con-compliant (S/S by SSPC-PAINT25)*
WW-C-563A: *Conduit, Metal, Rigid, Electrical, Thin Wall Steel Type (Electrical Metallic Tubing), Straight Lengths, Elbow, & Bends (S/S by UL797)*
WW-C-566C: *Conduit, Metal, Flexible (S/S by A-A-55810)*
WW-T-799F: *Tube, Copper, Seamless, Water (For use with Solder-flared- or Compression-type Fittings) (S/S by ASTM-B88)*

T. IEC (International Electrotechnical Commission)

60571: *Electronic Equipment used on Rail Vehicles*

U. IEEE (Institute of Electrical and Electronics Engineers)

16: *Standard for Electrical and Electronic Control Apparatus on Rail Vehicles*
730-2014: *Standard for Software Quality Assurance Processes*
1016: *Standard for Information Technology-System Design-Software Design Descriptions*
1100-2005: *Recommended Practice for Powering and Grounding Electronic Equipment*
1476-2000: *Standard for Passenger Train Auxiliary Power Systems Interfaces*
1568-2003: *Recommended Practice for Electrical Sizing of Nickel-Cadmium Batteries for Rail Passenger Vehicles*
1558-2004: *Standard for Software Documentation for Rail Equipment and Systems*
C37.13: *Standard for Low Voltage AC Power Circuit Breakers Used in Enclosures*

C37.14: *Standard for* Low Voltage DC Power Circuit Breakers Used in Enclosures

C37.16: *Standard for Preferred Ratings, Related Requirements, and Application Recommendations for Low-Voltage AC (635 V and below) and DC (3200 V and below) Power Circuit Breakers*

P1477: *Passenger Information System for Rail Transit Vehicles*

V. IFI (Industrial Fasteners Institute)

Inch Fastener Standards, 7th Edition

Metric Fastener Standards, 3rd Edition

W. IPC (Association Connecting Electronics Industries)

2221: *Generic Standard on Printed Board Design*

X. ISO (International Organization for Standardization)

2631: *Mechanical Vibration and Shock – Evaluation of Human Exposure to Whole Body Vibration*

8434-1: *Metallic tube connections for fluid power and general use - Part 1: 24 degree cone connectors*

8573: *Compressed air -- Part 1 and Part 2*

9001:2000: *Quality Management Systems-Requirements*

12500-1: *Filters for compressed air - Test methods - Part 1 and Part 3*

15609-4: *Specification and Qualification of Welding Procedures for Metallic Materials – Welding Procedure Specification – Part 4: Laser Beam Welding*

Y. MIL (Military Standards)

MIL-C-5015: *Connectors, Electrical, Circular Threaded, AN Type, General Specification for FSC 5935*

MIL-C-7438G: *Core Material, Aluminum, for Sandwich Construction*

MIL-DTL-3950G: *Detail Specification: General Specification for Switches, Toggle, Environmentally Sealed*

MIL-DTL-55302F: *Detail Specification, Connectors, Printed Circuit Subassembly and Accessories*

MIL-HDBK-132A: *Protective Finishes for Metal and Wood Surfaces*

MIL-HDBK-505: *Department of Defense Handbook: Definitions of Item Levels, Item Exchangeability, Models, and Related Terms*

MIL-I-46058C: *Insulating Compound, Electrical (for Coating Printed Circuit Assemblies)*

MIL-P-13949: *Sheet, Printed Wiring Board*

MIL-P-23469/2B: *Pin-Rivet, Grooved, Brazier Head; Straight Shank, Six Locking Grooves, Aluminum Alloy, Corrosion-Resistant and Carbon Steels*

MIL-P-8053C: *Plywood, Metal-Faced*

MIL-S-83502: *Socket, Plug-in, Electronic Components, Round to Style (T05)*

MIL-DTL-83731B: *Detail Specification: General Specification for Switches, Toggle, Unsealed and Sealed*

MIL-S-83734: *Sockets, Plug-in Electronic Components (Right Angle Leads, for 14 and 16 Pin Dual-in-Line Packages)*

MIL-PRF-8805D: *Performance Specification: General Specifications for Switches and Switch Assemblies, Sensitive, Snap Action (Basic, Limit, Push Button and Toggle Switches)*

MIL-STD-882E *Department of Defense Standard Practice System Safety*

MIL-STD-883H: *Department of Defense Test Method Standard: Microcircuits*

MIL-STD-1472 Revision F: *Human Engineering*
MIL-T-16366F: *Terminals. Electric Lug and Conductor Splices, Crimp-Style*
MIL-T-55164C: *General Specification for Terminal Boards, Molded Barrier, Screw and Stud Types, and Associated Accessories*

Z. NFPA (National Fire Protection Association)

10: *Standard for Portable Fire Extinguishers*
70: *National Electric Code*
130: *Standard for Fixed Guideway Transit and Passenger Rail Systems*

AA. SAE (Society of Automotive Engineers)

AS81914/1: *Tubing, Plastic, Flexible, Convoluted, Polytetrefluoroethylene, Standard Convolutions*
AS7928: *General Specification for Terminals, Lug: Splices, Conductor: Crimp Style, Copper*
J995_199907: *Mechanical and Material Requirements for Steel Nuts*

BB. UMTA (Urban Mass Transportation Administration)

UMTA-MA-06-0153-85-8 1987: *Inductive Interference in Rapid Transit Signaling Systems, Volume II: Suggested Test Procedures*
UMTA-MA-06-0153-85-11 1987: *Radiated Interference in Rapid Transit Signaling Systems, Volume II: Suggested Test Procedures*
UMTA-MA-06-0153-87-2 1987: *Conducted Interference in Rapid Transit Signaling Systems, Volume II: Suggested Test Procedure*

2.02.03 Specifications

A. PRIIA (Passenger Rail Investment and Improvement Act)

305-001: *Specification for PRIIA Bi-Level Passenger Rail Car*
305-900: *Specification for Composition Brake Shoes and Disc Brake Pads*
305-901: *Public Address/Intercom System*
305-902: *Specification for Water Systems for use on Amtrak Passenger Vehicles*
305-903: *Flammability, Smoke Emissions and Toxicity for use on Railway Passenger Cars and Locomotive Cabs*
305-904: *Vendor Maintenance Manuals*
305-905: Builder Operating & Maintenance Manual Family, except 305-905 Appendix A and Section 5.5 reference to LinkOne.
305-906: *480, 240, 208, and 120 VAC 72VDC Relay and Contactor Panel*
305-907: *Disposable Air Filter*
305-908: *Valve and Exterior Equipment Identification Tags & Labels and Operating Instructions*
305-909: *National On-Board Signage Manual*
305-910: *Schematic, Wiring and Piping Diagram Drawings*
305-911: *Replacement of Copper Waste Piping with Non-Metallic Pipe*
305-912: *Operational and Environmental Conditions for Rail Rolling Stock*
305-914: *Side Door Control Panel Design and Function*
305-915: *High Performance Wire and Cable*
305-916: *Environmental & Operating Conditions*
305-917: *480, 240, 208, and 120 VAC and 72 VDC Switchboard Panels*

2.02.04 Drawings

A. PRIIA

305-800: *Single-Level Clearance Drawing*
305-803: *Speed Sensor and Cable Assembly*
305-804: *Temperature Probe and Connectors*
305-805: *Axle Single Level Program*
305-806*: Power Transformers*
305-808: *Emergency Equipment Cabinet Arrangement*
305-809: *Seat Track Reference Dimensions*
305-810: *Reserved*
305-812: *Axle, Superliner, 6-1/2 x 12*

B. Amtrak

B-144: *Standard Amtrak Coach Key (J.L. Howard Part No. 2555)*
(Available to contracted builders only)

C. Metro North Railroad

MNR-NO. 8, Rev. B
MNR-NO. 9, Rev. C

2.03 Definitions

Capitalized terms used throughout this Technical Specification but not defined in this section have the meaning ascribed to the in Part 2 (Definitions) of the RFP.

A-End (of the car) — Defined as the end of the car opposite from the B-end of all cars except the cab car.

A/F-End (of the car) — Defined as the end of the car opposite from the B-end of all car types.

Accessible — To be compliant with the applicable standards for accessibility as defined by the Americans with Disabilities Act of 1990 (ADA) as amended.

Accessible Toilet Room (ATR) — The larger of the toilet rooms in the passenger rail cars, designed to be compliant with all applicable standards for accessibility as defined by the Americans with Disabilities Act of 1990 (ADA) as amended.

Adhesion, Coefficient of — During rolling contact, the ratio between longitudinal tangential force at the wheel-rail interface and normal force.

Alerter — A button/switch designed to reset the alert system countdown in case the Operater is awake and aware of the situation but wishes to not adjust the throttle lever, brake lever, or use the horn.

Analysis — Written report of the systematic examination of the design, performance and condition of parts, components and systems against Contract and Technical Specification requirements.

Approval — Review and acceptance, in writing, by the Engineer. Engineer approval in no way relieves the Contractor of meeting all requirements of the specification.

Approved Equivalent/Equal — The term "approved equivalent" or "approved equal" shall mean an item, which is fully equivalent or superior in terms of function, performance and properties, to the specified item. Provides equal or superior form, fit, function, appearance, performance, interchangeability, availability and compliance with specification requirements to that of the design, component or system as originally specified and has been successfully deployed in North American intercity/commuter passenger rail service for seven years.

Assembly — A collection of subassemblies and components typically performing a variety of functions within the context of a larger system.

Authorize — To give authority or power to proceed.

Availability — The percentage of the car fleet usable for revenue service at the beginning of each day's schedule. Also, on per car basis, the percentage of time a car or locomotive is usable for service (MTBF)/(MTBF+MTTR).

Baseline Design — The design of the car or any of its components, apparatus, systems, subsystems, or materials, which has received both drawing approval and first article approval by the Engineer.

Baseline Work — All activities, which shall be performed on the cars in order to comply with the requirements of this Specification.

B-End (of the car) — The end of the car where the hand brake is located on all car types.

Braking, Blended — 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.

Braking, Dynamic — An electric primary braking system on locomotives so equipped, whereby the traction motors act as generators and the current derived thereof is modulated. This includes both rheostatic and regenerative modes.

Buff — Compressive forces acting longitudinally through the carbody's primary structure.

Burn-In — Operating a component, system, or device in a test mode, often in an extreme or cycled temperature environment, for a specified period of time or distance, to confirm reliable operation.

Cab Signal System — Provides the Operator with a continuous reminder of the last wayside signal or a continuous indication of the state of the track ahead.

Calibration — Comparing the performance of a measuring device of unknown accuracy against one of known accuracy.

Cant Deficiency — The condition when a rail vehicle's actual speed through a curve is greater than the speed at which the components of wheel-to-rail force, normal to the plane of the track, would be equalized for the outside and the inside rails.

Car/Cars — The railroad passenger cars to be provided by the Contractor pursuant to this Contract.

Carbuilder —Has same meaning as Contractor.

Catenary — A system of overhead wires used to supply electricity to a locomotive, tram (streetcar), or light rail vehicle that is equipped with a pantograph.

Characteristics — Any distinct property, or attribute, of the material, or services, that can be described, and measured, to determine conformance, or non-conformance, to Contract requirements.

Commissioning — Activities involved in delivering, adjusting, and testing the cars to demonstrate compliance with Specification requirements and prepare the cars for revenue service.

Component — Usually self-contained, a component is comprised of parts, devices and structure and performs a distinctive function necessary to the operation of a system or subsystem.

Concept Drawings — An initial set of drawings showing the general car layout and arrangement.

Conformed Specification — These Specifications as revised to include and reflect all approved change orders, variances and waivers implemented throughout the duration of the Contract.

Contractor or Carbuilder — The Proposer that CTDOT selects, and enters into the Contract with, to perform the Work under the Contract.

Contractor's Drawings — Items such as general drawings, detail drawings, graphs, diagrams, sketches, calculations, and catalog cuts which are prepared by the Contractor to detail his/her work.

Crash Energy Management, CEM — Carbody design such that the structures crush in a controlled manner and absorbs energy with the goal to significantly improve crashworthiness.

Customer —Has same meaning as Engineer.

Delivery, Delivered — The arrival of the completed vehicle at the Engineer's designated facility, ready for commissioning and acceptance testing.

Defect — Any instance of non-conformance with a specification for material, appearance, finish, function, performance or manufacture.

Door Press Plate — A switch that initiates the door-opening operation and door-closing operation of the vestibule end doors.

Detrucking — The complete disconnection and removal as required of all structural, mechanical, pneumatic, and electrical connections between the truck assembly and carbody in order to facilitate the complete jacking of the car to remove the carbody weight from the truck assembly.

Engineer – Commissioner of The Department of Transportation, Bureau Chief of the Bureau of Public Transportation acting directly or through a representative duly authorized.

Equal or Equivalent – Whenever the words "equal" or "equivalent" are used in connection with a specified component, material, system characteristic or performance requirement, the Contractor shall prepare and submit for Engineer approval an analysis that demonstrates that a design, component or system characteristic as proposed by the Contractor has equal or superior appearance, performance, interchangeability, availability and compliance with specification requirements to that of the design, component or system as originally specified. This equivalency shall take the form of a specification variance, and shall only be permitted with the specific written approval of the Engineer. The reason for the variance request must be included in the analysis as submitted.

Event Recorder – A device that records data about the operation of train controls and performance in response to those controls and other train control systems.

F-End (of the cab car or the locomotive) — The end of the cab car that is equipped with the locomotive control cab, per the requirements of 49 CFR Section 229.11. Also the front or controlling end of the locomotive.

Fail-Safe — A characteristic of a system which ensures that no malfunction will create a condition that is not known to be safe.

Failure — A condition in which equipment, components or systems do not function as specified, designed or intended.

Failure Mode and Effects Analysis (FMEA) — A procedure for analysis of potential failure modes within a system for the classification by severity or determination of the failure's effect upon the system.

Failure Rate — The frequency of failure, expressed as failures per hour or failures per mile. Failure rate is the mathematical reciprocal of MTBF or MDBF.

Fault Tree Analysis — A failure analysis in which an undesired state of a system is analyzed using Boolean logic to combine a series of lower-level events. This analysis method is mainly used in the field of safety engineering to quantitatively determine the probability of a safety hazard.

First Article — The first one of any production component of the base vehicle that is manufactured.

First Article Inspection (FAI) — The examination and approval by the Engineer of an initial part, major assembly, subassembly, system, subsystem, apparatus, or material, manufactured or assembled by either the Contractor or Subcontractors. The first article approval establishes the baseline design and the minimum level of quality.

For Information Only — The supplied documentation does not require any specific action from either party.

Free Travel — Is defined as the vertical lineal distance between the top of rail and a car body reference point as measured under static conditions when comparing an empty car (AW0) and fully loaded car (AW3).

Head End Power (HEP) — Electrical Power (480 VAC, 3-phase, 60 Hz power) produced by a locomotive or power car, or supplied from stationary substation, which is used as the primary electrical power source by the cars.

Independent Failure — A failure which is not the result of another failure, either directly or indirectly.

Indicated — As used in this Specification, "indicated" shall be understood to mean, "as shown on the Contract Drawings, as described in the Specifications, or as required by other Contract."

Inspection — The careful examination, measurement, and testing of the characteristics and performance of materials, components and systems to ensure conformance with Contract requirements.

Inspection Equipment — Any tool, gauge, fixture, apparatus, or other device used for inspection purposes.

Inspector — The person or firm designated and authorized to perform quality control inspections.

Interface — The points where two or more physical subsystems or systems meet to transfer load, energy or information.

Left-Hand Side — The side of the car on the left, when standing inside the car at the B-end facing the A-end.

Maintainability — A measure of a car's ability to be properly maintained taking into account the ease and frequency of maintenance tasks, ability to efficiently use applied labor, and accessibility of equipment to be maintained by the Engineer's maintenance staff.

Material — An all-inclusive term used to denote raw materials, parts, components, assemblies, and equipment used in the finished product.

Mean Time Between Failures (MTBF) — The mean operating time between independent failures, measured in calendar days.

Mean Distance Between Failures (MDBF) — The mean operating mileage between independent failures.

Mean Time Between Component Failures (MTBCF) — The mean time between individual component failures.

Mean Distance Between Train Delays (MDBTD) — The mean operating mileage between train delays caused by equipment or system failures.

Mileage, Operating — The total distance traveled by the car during scheduled and unscheduled movements.

Modify — To change the design, placement, or other aspect(s) of an item to provide for a different form, fit or function or to resolve deficiencies or improve performance.

New — An item, OEM or approved equal, which has not previously seen service in whole or in part.

No-Motion — The vehicle speed at or below the lowest speed detectable by the vehicle control systems. Also known as "zero speed".

Normal — As in, example, "normal operating conditions" or "operating normally" -- A condition in which relevant vehicle equipment is not in a failure mode and the environment is as specified.

Notice — A written announcement from the Engineer.

Observer – An individual who rides in the control cab with the Operator, typically on the side opposite the Operator's seat.

Open Items — Items not resolved on the car and documented as incomplete. It is the contractor responsibility to resolve and close these issues. Open items may be documented at any time during the contract duration.

Operator – An individual who operates the train from the control cab.

Original Equipment Manufacturer (OEM) — The original manufacturer of a hardware subsystem, component or completed vehicle.

Pantograph — An apparatus mounted on the roof of an electric train, tram or electric bus to collect power through contact with an overhead line.

Positive Train Control (PTC) — A system of functional requirements for monitoring and controlling train movements (a type of train protection system).

PRIIA Specification — A standard specification developed by the Section 305 Next Generation Equipment Committee ("NGEC") established pursuant to Section 305 of the Passenger Rail Investment and Improvement Act of 2008 (PRIIA) to develop specifications for standardized next generation intercity passenger rail equipment.

Procurement (Work) — The furnishing of all equipment, items, materials, parts, systems, data, design, services, incidentals, labor and management and performance of the contractual requirements defined in the Contract, including changes thereto, in order to produce and deliver the specified cars, spare parts, hardware and software goods, and services.

Proof (used as a suffix) — Apparatus as designated as splash-proof, dust-proof, etc., when so constructed, protected, or treated that its successful operation is not interfered with when subjected to the specified material or condition.

Push-Pull Operations — A method of controlling the actions of the propulsion, braking and other systems of a train from a control cab, located in either the locomotive or the cab car, for bi-directional operation.

Railroad — Owner(s) of the operating railroad over which the Engineer's trains operate, and/or the property and/or improvements used in connection with such operating railroads, as defined by 49 CFR 238.

Redundancy — The existence of more than one means for accomplishing a given function. The ability to accomplish a given function by two or more independent means.

Reliability — A term used to identify the failure rate of an item expressed as a percentage or in time of operating hours. The desired result is to have high reliability (100%) with a low failure rate (0%).

Remanufacture — To rebuild and recertify to OEM standards for functionality and appearance. Parts that cannot be remanufactured shall be renewed.

Renew — To replace with a new equivalent component (regardless of condition of part being renewed).

Repair — Correct specific damage to return to original condition or functionality.

Right-Hand Side — The side of the car on the right, when standing inside the car at the B-end facing the A-end.

Rosette Strain Gauge – An arrangement of multiple strain gauge sensors bound together before installation in a geometric pattern that allows for simple calculation of the Von Mises stress.

Safe — Secure from potential harm, injury, danger or risk; free from danger or risk.

Safety — The condition in which persons and equipment are free from threat, danger, harm, or loss arising from improper design, manufacture, assembly or function, or a failure of the car or any of its components or systems.

Safety Critical — An action, device or system that is necessary to maintain a safe condition.

Service — (as in-service use, service braking.) The operation of the cars under normal conditions.

Services —Work and incidental material specified in a contract such as inspection, nondestructive examination, calibration, testing, welding, analysis, etc.

Shipment — The physical movement of the car from the Contractor's production facility to the Contractor's designated acceptance facility or other designated destination.

Shop Drawings — Drawings or sketches prepared by the Contractor for use in its manufacturing facility, assembly facility, or shop, to fabricate, assemble, and/or install parts of the vehicles, whether manufactured by it from raw materials or purchased from others in a ready-to-use condition.

Slide, Wheel — During braking, the condition when the rotational speed of the wheel is slower than that of the actual pure rolling contact between tread and rail.

Slip, Wheel — During acceleration, the condition existing when the rotational speed of the wheel is faster than that of pure rolling contact between tread and rail.

Special Tools — Tools which have been specifically designed or developed for the purpose of repairing, maintaining, diagnosing or installing a particular component or system in a manner which cannot be performed with commercially available, "off-the-shelf" tools.

Specified or As specified — As stated in this document or other referenced documents.

Speed, Design — The specified maximum possible operating speed of the car. The car and all components shall be suitable for safe operation at all speeds up to and including this speed.

Standards and Specifications — When industry, government, association, or society standards or specifications are referred to, the applicable issue at the time of Notice to Proceed (NTP) signing shall be used.

Step, Signal — A signal having a constant value prior to the step and a different constant value immediately thereafter.

Stop, Emergency — The stopping of a vehicle or train by an emergency brake application.

Strain Gauge – A single sensor used to measure the strain in structural members by measuring its internal change in electrical resistance when external influences act on the stationary sensor.

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.

Subsystem — A defined portion of a system.

Superelevation — The vertical difference between the top surface of the outside and inside rails of a curve.

System — A combination of hardware, people, and or software systems, in any combination which are integrated to perform a specific operational function.

Tamperproof — Fasteners are designated as tamperproof when they are selected so that they cannot be easily loosened with common tools such as screwdrivers or pliers.

Tare — A term in weights and measurements which refers to the weight of an empty container. The tare weight can be subtracted when a filled container is weighed to determine the weight of the contents alone.

Test, Proof of Design — Proof-of-Design tests are engineering tests which are used to ensure equipment, as designed, meets the functional and performance requirements of the vehicle specifications.

Test Plan — A document that defines the plan and schedule for conducting all the tests required on the vehicle.

Test Procedure — A step-by-step procedure that identifies the equipment, exact sequence of events and criteria used to ensure that components and systems function properly.

Test, Production — A series of tests applied to each vehicle to ensure all systems and components perform according to design and specification.

Third Rail — A metal rail through which electric current is led to the motors of an electric vehicle.

Tight (used as a suffix) — Apparatus is designed as watertight, dust-tight, etc., when so constructed that the design will exclude the specified material from affecting the functioning condition or performance of the component or system.

Time, Warm-up — The elapsed time from application of power to an operable device until it is capable of performing its intended function.

Traction Interlock (door) — A traction interlocking device will prevent the train from moving while side doors are open.

Train — Any number of cars coupled to a locomotive and moving as one.

Train Delay — A train delay is defined as a car-related failure that causes a train in service to be: more than 6 minutes late at its destination terminal; canceled either at its originating point or en-route; or reduced in size or revenue capacity due to requiring a failed car to be removed from the train.

Trainset — A collection of passenger cars which are semi-permanently coupled to create a fixed consist to be used for a particular train application; a trainset car is that portion of the trainset which is located between coupling arrangements.

Tram — A condition of ideal truck geometry in which the axles are perfectly parallel and the wheels longitudinally in perfect alignment. The centers of the journal bearings represent the corners of a perfect rectangle. Tram is checked by measuring the diagonal and longitudinal distances between reference points on the axle bearing housing.

Universal Serial Bus — Industry standard that establishes specifications for cables and connectors and protocols for connection, communication and power supply between computers, peripheral devices and other computers.

U.S. Department of Transportation (USDOT) — Means the Secretary of the USDOT and other persons who may at the time be acting in the capacity of the Secretary, or authorized representative or any person otherwise authorized to perform the functions to be performed hereunder, including representatives of the Federal Transit Administration (FTA) and Federal Railroad Administration (FRA).

Vehicle History Book — A document specific to an individual rail vehicle containing records of technical and parts data pertinent to that individual vehicle.

Verification — Examination and testing by the QA Representative to confirm decisions made by those performing the work concerning conformance of material to Contract requirements.

Vehicle — Same as car or locomotive.

Vestibule — An enclosed area on a railroad passenger car at the end of the carbody, usually separated from the main part of the interior by a door. Entrance to and exit from the car is through the side doors, which lead into the vestibule. When passenger cars are coupled, their vestibules are joined by mating faceplate and diaphragm assemblies to create a weather-tight seal for the safety and comfort of passengers who are stepping from car to car.

Warp, Track — The vertical distance between a plane defined by any three of four rail head contact points (two on each rail) forming a triangle and the remaining point.

Wayside Signaling — Any signal - electrical, mechanical or otherwise - in a fixed location outside a train along the track.

Weatherproof — Able to withstand exposure to all weather and environmental conditions without damage or loss of function.

Weights, Assigned — The loaded car categories assigned by the Engineer as the basis for structural repair design and for subsystem and vehicle testing as indicated. Four weight categories are assigned:

1. AWO: Actual weight of empty car, ready for revenue service, but with neither crew nor passengers aboard. Includes full fresh water supply, empty waste system and full complement of provisions in the café/lounge car.
2. AW1: Car at seated load and no standees.

   Seated Load is defined as all the passenger seats occupied plus one crew member per car.
3. AW2: Car at normal full load.

   Normal Full Load is defined as seated load plus one standee per 3.0 ft^2 (0.31 m^2) of clear floor space.
4. AW3: Car at crush load.

   Crush Load is defined as seated load plus one standee per 1.5 ft^2 (0.14 m^2) of clear floor space.

Each passenger or standee is assumed to weigh an average of 180 lbs (82 kg).

Weight, Dry — The measured axle weight of an empty passenger rail car (measured dry). Fully assembled but with no water or provisions.

Work (Procurement) — Where the context will allow, the term "work" shall mean the production of goods and services furnished in accordance with the Contract.

Zero Speed — Has same meaning as “No motion”.

Zero Speed Protection (door) — When the vehicle is in "zero-speed" or "no-motion" this will ensure the doors remains closed until the train is totally stopped.

Whenever in the specifications or on the plans the words "**required,**" "**determined,**" "**directed,**" "**specified,**" "**authorized,**" "**ordered,**" "**given,**" "**designated,**" "**indicated,**" "**considered necessary,**" "**deemed necessary,**" "**permitted,**" "**reserved,**" "**suspended,**" "**established,**" "**approval,**" "**approved,**" "**disapproved,**" "**acceptable,**" "**unacceptable,**" "**suitable,**" "**accepted,**" "**satisfactory,**" "**condemned,**" or words of like import are used, it shall be understood as if such words were followed by the words in writing, "**by Engineer,"** "**to Engineer,"** "**the Engineer**" unless otherwise specifically stated.

Wherever the words "**provided,**" "**supplied,**" or "**installed**" are used in the specifications in reference to work to be performed by the Contractor, it shall be understood to mean "**furnished and delivered completed and ready for revenue service**."

2.03.01 Abbreviations

The following is a list of abbreviations in this specification. The list is not intended to be all-inclusive.

AALA	American Association of Laboratory Accreditation
AAR	Association of American Railroads
AC	Alternating Current
ACSES	Advanced Civil Speed Enforcement System
ADA	Americans with Disabilities Act of 1990 as amended
AED	Automated External Defibrillator
AEI	Automatic Equipment Identification
AESS	Automatic Engine Stop Start
amp	Ampere hour
ANSI	American National Standard Institute
APC	Automatic Passenger Counting System
API	Application Programming Interface
APTA	American Public Transportation Association
AREMA	American Railway Engineering and Maintenance-of-Way Association
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers
ASIC	Application-Specific Integrated Circuits
ASME	American Society of Mechanical Engineers
ASSE	American Society of Sanitary Engineers
ASTM	American Society for Testing and Materials
ATC	Automatic Train Control
ATOR	Above Top of Rail
ATR	Accessible Toilet Room
AWO	Empty vehicle operating weight, Ready-to-Run (Assigned Weight "0" load)
AW1	Car at seated load and no standees
AW2	Car at normal full load
AW3	Car at crush load

AWS	American Welding Society
BC	Battery Charger
B.C.P.	Brake Cylinder Pressure
BP	Brake Pipe
BTE	Bench Test Equipment
Btu	British Thermal Unit
°C	Celsius (degrees)
CAD	Computer-Aided Design
CCJPA	Capitol Corridor Joint Powers Authority
CCTV	Close Circuit TV
CCU	Communication Control Unit
CD	Compact Disk
CDT	Central Diagnostics Terminal
CEM	Crash Energy Management
CFC	Chlorinated Fluorocarbons
cfm	Cubic Feet per Minute
CG	Center of Gravity
CO	Central Office
COMM	Communication
COTS	Commercially Off-The-Shelf
CPE	Customer Premise Equipment
CPM	Critical Path Method
CVMS	Central Vehicle Management System
DAVW	Digital Audio Video Workstation
DB	Dry Bulb
dB	Decibel
dB/sec	Decibels per second
dBA	Decibels (Acoustic)

DC	Direct Current
DCS	Data Communication System
DNTU	Data Network Transport Unit
DR	Design Review
DTE	Diagnostic Test Equipment
DTL	Digital Trainline
DTN	Data Trainline Network
DVD	Digital Versatile Disc
DVD RW	Digital Versatile Disc - Rewriteable
EAB	Electronic Air Brake
ECN	Ethernet Car Network
ECP	Electronically Controlled Pneumatic
ECR	Engineering Change Request
ECSB	Engineering Change Service Bulletin
EEPROM	Electrically Erasable Programmable Read Only Memory
e.g.	exempli gratia (for example)
ELIST	Equipment List
EMC	Electromagnetic Compatibility
EMD	Electro Motive Diesel (a locomotive and component manufacturer)
EMI	Electromagnetic Interference
EMIS	Equipment Maintenance Information
EPA	U.S. Environmental Protection Agency
EPROM	Erasable Programmable Read Only Memory
ER	Equalizing Reservoir
ETB	Ethernet Train Backbone
etc.	et cetera (and so forth)
ETMS	Electronic Train Management System
ETP	Electrolytic Tough Pitch

F	Front (end of locomotive or cab car designator as defined by 49 CFR Section 229.11)
°F	Fahrenheit (degrees)
FAI	First Article Inspection
fc	foot-candle
FCC	Federal Communication Commission
FDA	U.S. Food & Drug Administration
FDR	Final Design Review
FEA	Finite Element Analysis
FEM	Finite Element Model
FMEA	Failure Mode and Effects Analysis
FMECA	Failure Modes and Effects Criticality Analysis
FMI	Field Modification Instruction
FPGA	Field Programmable Gate Arrays
fpm	feet per minute
FRP	Fiberglass Reinforced Plastic
ft	foot
ft^2	square foot
ft^3	cubic foot
foot-candle	Foot candle
FTA	Federal Transit Administration (U.S. Department of Transportation)
g	Acceleration due to gravity (386.1 inches per second per second)
gal	gallon
GB	Gigabyte
GFCI	Ground Fault Circuit Interrupter
GHz	gigahertz
gpm	gallons per minute
GPS	Global Positioning System
HAZ	Heat-Affected Zones

HBPS	Holding Brake Pressure
HDMI	High Definition Multimedia Interface
HEP	Head End Power
Hg	Mercury (pressure or vacuum – measured in inches)
HPPL	High Performance Photoluminescent
hr	hour
HSR	High-Speed Rail
Hz	Hertz
i.e.	id est (that is)
IC	Intercommunication
IDR	Intermediate Design Review
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronic Engineers
IEM	Interactive Electronic Manual
IGBT	Insulated Gate Bipolar Transistor
in.	inch
in^2	square inch
IPC	Illustrated Parts Manual
IPS	Iron Pipe Size
ISO	International Organization for Standardization
ISP	Internet Service Provider
IVDN	Inter-Vehicle Data Network
IWS	Instrumented Wheelset
JEDEC	Joint Electronics Device Engineering Council
°K	Kelvin (degrees)
kg	kilogram
kHz	kilohertz
km	kilometer

kph	kilometers per hour
ksi	1000 pounds per square inch (psi)
kW	kilowatt
LAHT	Low Alloy High Tensile
lb	pound
LDTS	Local Diagnostic and Test System
lbf	pounds of force
lbs/ft^2	pounds per square foot
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LLEPM	Low Location Exit Pathway Markings
lm	lumen
Log	Inspection and Test Log
LSA	Lead Service Attendant
lx	lux
LVPS	Low Voltage Power Supply
m	meter
mA	milliampere
MAC	Maintenance Allocation Chart
MAP	Maintenance Analysis Program
MB	Megabyte
Mbps	Megabits Per Second
MCAT	Minimally Compliant Analytical Track
MCSCM	Mechanical Committee of Standard Coupler Manufacturers
MDBCF	Mean Distance Between Component Failures
MDBF	Mean Distance Between Failures
MDBTD	Mean Distance Between Train Delays
mg/sq. in.	milligrams per square inch

Mhz	Megahertz
MIG	Metal Inert Gas
MIL	Military Specification
min	Minute, minutes
mm	millimeter
M of E	Maintenance of Equipment
MP3	MPEG Audio Layer 3
MPa	Megapascal
mph	miles per hour
mphps	miles per hour per second
mphpsps	miles per hour per second per second
MR	Main Reservoir
MSDS	Material Safety Data Sheet
msec	milliseconds
MTBF	Mean Time Between Failures
MTTR	Mean Time To Repair
MU	Multiple Unit
mV	millivolt
N/A	Not Applicable
NAS	Network Attached Storage
NBS	National Bureau of Standards
NC	Normally Closed
NDE	Non-Destructive Examination
NEC	Northeast Corridor
NEMA	National Electrical Manufacturers Association
NFL	No Field Lubrication
NFPA	National Fire Protection Association
NIC	Network Interface Card

Ni-CAD	nickel-cadmium
NO	Normally Open
NPT	National Pipe Thread
NSF	National Sanitation Foundation
NTSB	National Transportation Safety Board
NVR	Network Video Recording System
OCU	Operator Control Unit
ODBC	Open Data Base Connectivity
ODK	Operator Display Keypad
OFE	Oxygen Free Electronic
OTIS	Onboard Train Information System
oz	ounce
p/n	part number
PA	Public Address
PA/IC	Public Address/Intercom
PC	Personal Computer
PCB	Printed Circuit Board
PCMCIA	Personal Computer Memory Card International Association
PCS	Pneumatic Control Switch
PDF	Portable Document Format
PDR	Preliminary Design Review
PEI	Passenger Emergency Intercom
PHS	Public Health Service
PIDS	Passenger Information Display System
PIS	Passenger Information System
PISCU	Passenger Information System Control Unit
PKO	Power Knock/Out
PLD	Programmable Logic Devices

PM	Preventative Maintenance
POS	Point-of-Sale
ppm	parts per million
pphm	parts per hundred million
PRIIA	Passenger Rail Investment and Improvement Act
PROM	Programmable Read-Only Memory
psi	pounds per square inch
psig	pounds per square inch (gauge)
PTC	Positive Train Control
PTE	Portable Test Equipment
PTT	Push to Talk
PVC	Polyvinyl Chloride
PWM	Pulse Width Modulation
QA	Quality Assurance
QAP	Quality Assurance Plan
QC	Quality Control
RAID	Redundant Array of Independent Disks
RAM	Random Access Memory
RDP	Remote Download Port
RFI	Radio Frequency Interference
RGB	red green blue
RH	Relative Humidity
rms	root mean square
S&I	Service and Inspection
SAE	Society of Automotive Engineers
SCCP	Software Configuration Control Plan
SCI	Software Configuration Item
SCFM	Standard Cubic Feet per Minute

SD	Software Documentation
SDP	Software Development Plans
sec	second
SID	Software Interface Document
SIP	Systems Indicator Panel
SIV	Secondary Impact Velocity
SIVI	Secondary Impact Velocity Injuries
SME	Subject Matter Expert
SNR	Signal-to-Noise Ratio
SPM	Safety Program Manager
SQL	Structured Query Language
SSP	System Safety Plan
SSS	Sign System Server
SVD	Software Version Description
t	Thickness
T	Temperature
T/L	Trainline
T/R	Transmitter/Receiver
TB	Terabyte
TBD	To Be Determined
TCD	Train Communications Data
T&E	Train and Engine
TFT	Thin Film Transistor
TIG	Tungsten Inert Gas
TLC	Trainline Complete
TMS	Train Monitoring System
TOR	Top of Rail
TSA	US Transportation Security

TWC	Train to Wayside Communication
U.S.	United States
UL	Underwriter's Laboratories, Inc.
ULSD	Ultra Low Sulfur Diesel
UMLER	Universal Machine Language Equipment Register
USB	Universal Serial Bus
USDOT	United States Department of Transportation
USPHS	U.S. Public Health Service of the U.S. Department of Health and Human Services
USSC	United States Steel Corporation
UTR	Unisex Toilet Room
UV	Ultraviolet
V	volt
VAC	Volt Alternating Current
VDC	Volts Direct Current
VDSL2	Very High Speed Digital Subscriber Line 2
VMS	Vehicle Monitoring System
VSS	Video Surveillance System
VVVF	Variable Voltage Variable Frequency
VTI	Vehicle Track Interaction
W	watt
W/ft2	watts per square foot
WB	Wet Bulb
WCRS	Waste Collection and Retention
WiFi	Wireless Fidelity (Wireless Local Area Network protocol, IEEE 802.11b, 802.11g and 802.11n)
WLAN	Wireless Local Area Network
WMS	Work Management System

WPS	Welding Procedure Specifications
WUI	Web-based User Interface
yr	year
Z	Impedance

* End of Chapter 2 *

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Technical Specification

CTDOT Single-Level Passenger Rail Cars

Chapter 3

Project Management

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3.00 Project Management

3.01 Overview

A. These Technical Specifications, including the conceptual drawings, describe and illustrate the criteria to be used for the Contractor's design and manufacture of the CTDOT railcars.

B. The cars shall comply in all respects with the requirements of the applicable laws and regulations of the United States of America, including but not limited to the regulations of the Federal Railroad Administration (FRA). Testing will be conducted in full compliance with all FRA requirements. It is noted that while specific agency regulations and recommendations are called for in this Technical Specification, they shall not be considered to be to the exclusion of all others. The cars shall also comply in all respects with applicable standards and recommendations of the American Public Transportation Association (APTA) and the Association of American Railroads (AAR), unless specified otherwise.

C. The design criteria and constraints that are known to the Engineer have been specified. Further definition and clarification are anticipated during the design review process. The Contractor shall not be relieved of the overall responsibility of providing an adequate design for the required service conditions.

D. Various industry standards such as those published by AAR, APTA, ASME, ASTM, ANSI, IEC and IEEE documents mentioned in this Technical Specification are examples acceptable to the Engineer. Material standards and specifications which are used by the Contractor, unless otherwise approved by the Engineer, shall be of those organizations which are based in the United States, or are generally used on a commercial basis in the United States. The applicable document revision shall be that in effect on the date of contract award. The specified standards of this Technical Specification may be replaced with Engineer approved equivalent standards proposed by the Contractor after Contract award. The Contractor shall be required to establish the equivalency and to obtain explicit approval from the Engineer for any substituted documents.

E. Various components have been specified by manufacturer and part number in this Specification. The Contractor may propose alternate manufacturer’s components, but the use of alternate components or manufacturers must be approved by the Engineer. Proposed alternative components must be functionally interchangeable in form, fit and function with components called out herein.

F. For safety critical items, introduction of alternative components will only be considered if such components have an established record, in North America, and/or have undergone an appropriate qualification program that demonstrates an acceptable level of safety, service and reliability for intercity or commuter passenger cars. The data submitted by the contractor will be approved by the Engineer.

G. Component assemblies and subsystems provided on the first build lot of cars under this Specification must be designed so as to facilitate the exchange and substitution of alternative components for form, fit and function. Subsystem, assembly or component level for interchange will be determined by the Engineer as part of the design review process.

3.02 Regulations, Standards, Specifications and Drawings

A. The Engineer takes no responsibility for the identification of applicable chapters and paragraphs of regulations and standards with which the Contractor must comply. Nothing in this specification shall

relieve the Contractor from ensuring that all applicable regulations, standards and specifications are followed. The Contractor shall provide proof of compliance for those items so governed before the first train set is accepted.

B. The Contractor is responsible for ensuring that all applicable regulations, standards and specifications are followed when complying with the requirements of this document.

C. A summary list of regulations, standards and specifications is listed in Chapter 2 as a guide to the Contractor but shall not be construed as complete.

D. The Contractor shall, and shall require any of its subcontractors to, abide by CTDOT's System Safety Program Plan and all operating rules and regulation for all work performed on CTDOT's property or any associated operating Railroad's property or right of way.

3.03 Project Management

A. The Contractor shall submit to the Engineer for approval no more than 45 days after Notice to Proceed (NTP) a Program Management Plan (PMP). [CDRL 03-001] It shall contain at a minimum an organizational chart providing a definition of personnel responsibilities, the methods and communications to be used to control the program (its schedule, technical performance, program changes, subcontracts, material procurement and field engineering support) and details concerning the Critical Path Method (CPM) scheduling plan for the contract work, as described below. The PMP shall have a live document status. All changes must be submitted to the Engineer during the next monthly progress report covering the time period the change took place. Changes will be subject to approval by the Engineer.

B. The Contractor shall use an approved industry standard computer driven CPM plan to schedule all activities related to this contract, including its work, and the work of its subcontractor's and major supplier's work. The CPM system shall be approved by the Engineer. The CPM Plan shall have a precedence-type network, with the start date being the NTP, with every milestone listed in the Terms and Conditions being identified, including the delivery of each car. All intermediate milestones shall be shown in proper logical sequence. The CPM plan shall include all of the Contractor's work activities with sufficient detail such that all interfaces with all direct and related parties of the project are highlighted. The work of subcontractors and suppliers shall be shown on the schedule, being supplied by them and updated whenever necessary. A high priority shall be given to keeping their plans accurate and up-to-date. Major procurement activities shall be indicated, including submittal and approval of shop drawings and delivery of all material. Interruption of service, delivery of equipment, project phasing and any other specification requirements must be included. The Contractor shall require that all subcontractors and suppliers provide the information needed to properly update the plan, at a maximum period between updates of 30 days, and then provide the updated plan to the Engineer. Particular attention shall be given toward the early detection of any supplier delay, to allow proper response to be made by the Contractor as early as possible. [CDRL 03-002]

C. In addition to the requirement for updated versions of the CPM plan to be submitted to the Engineer, the Contractor shall submit to the Engineer a monthly progress status report in the form of updated computer printouts and narrative reports. [CDRL 03-003] In the narrative report, the Contractor shall state the percentage of work physically completed and include a description of the physical progress during the report period; plans for the forthcoming report period; problem areas, current and anticipated; delaying factors and their impact; and an explanation of corrective actions taken or proposed. Specifically addressed in the report shall be the status of uncompleted activities

which have less than 30 calendar days float and which are either in progress or scheduled to be started within the next reporting period. At the request of the Engineer, the Contractor shall participate in pre-update conferences to verify progress and review modifications to the detailed network schedule prior to the formal monthly submittal. This report shall also include the work done by major suppliers and subcontractors.

3.03.01 Correspondence Tracking

A. Following NTP, the Contractor and the Engineer shall mutually agree on a common correspondence identification coding system. All correspondence shall be coded by the sender with a letter(s) from the English alphabet to designate the originator and with a unique sequence number to ensure unmistaken identity. All correspondence shall readily display the Engineer's contract number, denote if a reply is required, and the identity of coded correspondence being replied to, if any. Both parties shall maintain a log to list the date a correspondence is sent or received. The Engineer intends to use an electronic correspondence platform or database for document control.

B. All submittals shall be made solely by the Contractor through the use of written correspondence describing the purpose of the submittal, the anticipated work and response by the Engineer and the specific identification of the material submitted in terms of drawing/revision numbers, document numbers, etc.

C. A standard format shall be used for documentation that is carried throughout the duration of the Contract.

3.03.02 Contract Deliverables

A. The Contractor shall submit for review and approval a listing and submittal schedule of all required documents and deliverables described in this Technical Specification within thirty (30) calendar days from the Notice to Proceed. [CDRL 03-004]

B. The Contractor shall submit all contract deliverables in accordance with the requirements of this Technical Specification.

3.04 Quality Assurance (QA)

A. The Contractor shall develop and implement a Quality Assurance (QA) program that conforms to FTA-IT-90-5001-02.1 of February 2002: Quality Assurance and Quality Control Guidelines, to assure the delivery of a quality product. The elements of the program shall encompass and control the Contractor's entire organization and all other manufacturers, subcontractors and suppliers that perform work relating to this car contract.

B. The QA Program shall assure that all aspects of car design, component manufacture and testing, car assembly and testing, and car commissioning are in full conformance with the design, materials and workmanship requirements provided in these Technical Specifications, and are comprehensively documented.

3.04.01 Quality Assurance Plan

A. A Contract-specific QA Plan (QAP) shall be prepared that details when and where in the manufacturing process each element of the Contractor's and major supplier's organizations will perform specific actions required by the associated QA manual using the quality procedures found

therein. The plan shall also specifically identify an adequate number of qualified staff to carry out the required QA tasks and their roles and responsibilities. [CDRL 03-005]

B. The plan shall illustrate how the Contractor intends to meet the quality assurance requirements of this Technical Specification.

C. Required elements of the QA Plan:

1. Overview of Contractor's QA program.

2. Corporate organization chart showing how the unit responsible for QA fits into the overall corporate structure, including how it relates to other functional units such as engineering, purchasing, production and warranty, and how the QA communicates with those other functions to ensure quality objectives are met.

3. Organization chart for the QA unit, including names, duties and responsibilities, and contact information for QA unit personnel.

4. Specific QA policies, procedures and objectives that are implemented at all stages of the project to ensure that the highest quality is maintained through the life of the project.

5. Role of the Engineer in the QA process, including Engineer design reviews, inspections and hold points, and the Engineer's authority to require corrective action to resolve quality problems.

6. Process for implementing, monitoring and revising/improving QA policies and procedures, including the means by which QA has the ability to take corrective action to resolve quality problems within engineering, production or testing, and the authority that gives QA the ability to stop production if problems go uncorrected.

7. Process for engineering changes, configuration management, production control and other manufacturing tools to ensure that vendors and production are working to current revisions of all drawings, specifications, policies and parts lists.

8. Process for auditing production to determine if QA policies and procedures are being implemented and maintained, and how problems are corrected.

9. Process by which vendors and suppliers are verified to be in compliance with the contractor's QA program, and the process for ensuring that vendors adhere to the QA plan, including source inspections, inbound material inspections, resolving vendor quality problems, certification of parts authenticity and anti-counterfeiting efforts, and long-term parts availability in conformance with contractual provisions.

10. Inspection process for monitoring quality during production, including flow chart and process for resolving defects and closing out nonconformances.

11. Process and schedule to accommodate the Engineer's inspectors for in-process inspections and tests

12. Schedule for inspection and recalibration for all tools and devices used for measurement, testing or inspection.

13. Process and objectives for defect reduction over the term of production of the vehicles, including trend analysis, engineering changes if necessary and modifications to inspection and testing processes.

14. Monitoring of post-delivery performance of delivered vehicles, including evaluation and analysis of fleetwide failures, engineering changes to production, and field modifications to delivered vehicles if necessary. Without limitation of any other remedies, CTDOT may declare a fleet defect in the event that cumulative failures by either system orientation or of any kind identical components serving substantially similar functions exceed three total failures or exceed five percent (5%) of the total number of such components in the vehicles (example: air compressor) for any consecutive twelve month period prior to the expiration of the warranty period for the last vehicle. Subsystems, systems, or components which are out of warranty shall not be included in the calculations above. Upon fleet failure, the remaining items shall be thoroughly inspected, receive repair, replacement or adjustment under the warranty, even those items which have passed beyond the warranty period before failure was recognized. All such items shall be subject to warranty reinstatement provided for in the following:

    a. The Contractor shall correct a fleet defect under the warranty provisions as defined herein. After correcting the defect, the Contractor shall promptly undertake and complete a work program reasonably designed to prevent the occurrence of the same defect in all other similar type vehicles overhauled under this Contract. The work program shall include inspection and/or correction of the potentially defective parts in all of the vehicles.

    b. The warranty on items determined to be fleet defects shall extend no longer than one (1) year from the date of final acceptance of the last unit to be overhauled in this program. The extended warranty shall begin on the repair/replacement completion date for the corrected item.

    c. In the event that the calculations of failures, based on the above percentages, results in a fractional figure it shall be rounded off to the next highest whole number. The approved QA plan and supplemental manuals, procedures and instructions shall be subject to regular scheduled and unscheduled audits by the Engineer.

D. The QA plan shall clearly indicate that the Contractor’s QA representatives shall have sufficient authority and organizational freedom to ensure that a nonconforming or discrepant product or service will not be delivered. The organization of the Contractor's QA program shall report to a level of authority within the Contractor’s organization that is independent from the manufacturing or purchasing responsibilities such as the General Manager, the Contractor's Project Manager or executive level, such as Chief Operating Officer through President position. In any case it must be completely independent of the Contractor's manufacturing or purchasing divisions. The QA personnel shall have complete freedom to identify and evaluate problems; to recommend solutions; to verify implementation of solutions; and to control further processing, delivery, or installation of a nonconforming or deficient item until proper and documented disposition has been obtained.

E. The Contractor's QA personnel performing inspections and tests shall be certified for such work. Certification of personnel shall be by the virtue of those skills which are obtained by experience or training and verified by testing. All manufacturing personnel performing special processes, such as welding, brazing, etc. shall be trained and certified for such work, in accordance with applicable industry standards and practices. Records of personnel certifications shall be maintained and monitored by the Contractor's QA department. The official records may be maintained in the Human Resources department for each trained and certified employee. These records shall be made available to the Engineer for review through the QA department.

F. The Contractor shall, upon request, place measuring and control recordings at the disposal of the Engineer and provide copies of documentation. The Contractor shall ensure that inspection and tests are based on the latest approved revision or change to drawings and specifications. A procedure shall be maintained that embraces the adequacy, completeness and updating of drawings, and the

control of changes. This procedure shall be in coordination with the change control system as provided in this Specification and Contractor's configuration management system. The Contractor shall ensure that requirements for the affectivity point of changes are met and that obsolete drawings and change requirements are promptly removed from all points of issue and use. Means of recording the effective points shall be employed and made available to the Engineer.

G. The Contractor shall establish and maintain an effective and positive system for controlling nonconforming material and workmanship, including procedures for its identification, segregation and disposition. Dispositions allowing the use or repair of nonconforming material or workmanship shall require the Engineer's approval. All nonconforming material shall be positively identified to prevent unauthorized use, shipment or intermingling with conforming material. Holding areas and procedures mutually agreeable to the Contractor and the Engineer shall be established by the Contractor.

H. Corrective action and related information shall be documented and made available to the Engineer upon request. Corrective action shall extend to the performance of all sub-suppliers and include as a minimum:

1. Analysis of data and examination of discrepant products to determine extent and causes with corrective action implemented in an expeditious manner prior to the next shipment, order or inspection.

2. Introduction of required improvements and corrections, initial review of the adequacy of such measures, and monitoring of the effectiveness of corrective action taken.

3. Analysis of trends in processes or performance of work to prevent nonconforming products.

I. The Contractor shall, for the purposes of this Contract, designate a person who has sufficiently defined responsibility, authority, resources and organizational freedom of action to be in charge of, and implement on behalf of the Contractor, such QA as is required to ensure a proper control of the production process. The QA organization must report independently from production and have fully independent authority to reject unsatisfactory material and subassemblies regardless of any effect on the progress of the Work.

J. The QA plan shall also contain or refer to a comprehensive collection of standard forms to be utilized for documentation of quality control activities. These forms shall be designed to assure compliance of materials, processes, personnel and products to the approved design drawings and applicable specifications.

K. Subcontractor Quality Assurance Requirements

1. The Contractor shall require that each subcontractor establish and maintain a QA program acceptable to the Contractor and the Engineer for the services and items it supplies. The Contractor is responsible for all subcontractor and supplier quality and performance.

2. The Contractor shall survey, audit and periodically review each subcontractor and their facilities to assure adequate capabilities to perform subcontracted efforts in compliance with the Contractor's QA program.

3. Each subcontractor or supplier shall have a QA system that is approved by the Contractor and fully implements the QA plan of the Contractor as it applies to the subcontractor or supplier's scope of work.

L. Quality Assurance Assessments

1. The Engineer shall have the right to visit all facilities of the Contractor, subcontractors and suppliers associated with this Specification to conduct initial and on-going assessments of their QA programs to determine if the QA programs are capable of assuring product compliance with the requirements of this Specification. During these assessments, the Contractor shall provide Engineer personnel reasonable assistance as they inspect production facilities, examine operations in progress and review documentation. If any deficiencies are noted, the Contractor shall ensure that the deficiencies are properly documented, and the necessary corrective action is promptly implemented.

2. For on-going assessments, the Engineer shall have free access to the production facilities of the Contractor and its Subcontractors. The Contractor shall perform periodic quality assurance audits and inspections during the execution of the car contract to ensure that all QA program obligations are being fulfilled and that all deliverables meet the requirements of the Technical Provisions and all approved drawings and procedures. Engineer audits and monitoring will be performed independent of and in addition to the Contractor's quality assurance function, but will in no way replace, negate, override or lessen the Contractor's QA obligations.

M. Quality Assurance Audits

The Contractor shall maintain adequate records of compliance with the QA program plan for the life of the contract and subsequent warranties are in force. These records, except the internal audit records, shall be made available to the Engineer's representative on demand, and a complete set of records shall be submitted to the Engineer through the project. The Engineer shall require that confidential internal audit records are available for reviewing at the Contractor's facility. Evidence of such submittals are to be provided at the end of the warranty period.

N. Engineer Audits

1. The Engineer will perform scheduled and unscheduled audits of the Contractor's quality assurance activities to assure compliance with the approved QA plan. As a minimum, the following audits of the Contractor will be performed:

2. During production of the first carshell (will include an audit of both the Contractor and major subcontractors)

3. During manufacturing, installation of equipment, and testing

4. Before acceptance of the first car

5. The Contractor will be notified of other audits to be performed by the Engineer as deemed appropriate.

O. Contractor Audits

The Contractor shall perform periodic internal audits throughout the life of the project to verify that all aspects of the Engineer-approved QA plan have been effectively implemented. The Contractor shall provide the Engineer with an internal audit schedule at the onset of the project and whenever revisions to the schedule occur. Deficiencies discovered during the audit process shall be documented and corrected. Corrective actions shall include measures to preclude recurrence of the deficiency. Deficient areas shall be re-audited on an accelerated schedule.

P. Subcontractor Audits

1. The Contractor shall audit subcontractors to assure compliance with the approved QA plan.

2. As a minimum, the following audits of each subcontractor shall be performed:

3. Prior to a subcontracted or purchased item being delivered

4. Within 30 days of the scheduled First Article Inspection (FAI), qualification test or the Contractor's acceptance of any supplies, items or services

5. The Engineer shall be notified in advance of any scheduled audit and may witness any Contractor performed audit.

Q. Audit Reports and Corrective Action

The Contractor shall fully plan and document all quality audit activities performed internally and at subcontractor premises. Likewise, the Engineer will provide the Contractor with an audit report within two weeks of each audit detailing any non-compliances found during the audit, recommending corrective actions and establishing dates by which corrective action is required.

3.04.02 Initiatives that Promote Sustainability in the Manufacturing Process

A. The Contractor shall have a program to promote sustainability and reduce the amount of material and energy waste produced by the manufacturing process. These initiatives shall identify the means by which manufacturing waste and energy consumption will be reduced, including tangible and quantifiable goals and the method for monitoring and improving the success of the program.

B. The waste reduction strategies may include (but are not limited to):

1. Creation and utilization of reusable packaging for the transport of materials and components between the facilities of the parts supplier and the Contractor;

2. Use of recyclable materials for packaging;

3. Use of recycled or renewable materials in the production process;

4. Reuse or recycling of excess material created during the manufacturing process;

5. Use of energy-efficient or low-emission vehicles and equipment for transportation and production purposes;

6. Capture of reusable or recyclable materials such as office paper, cardboard, copier toner, beverage containers and other post-consumer recyclable material;

7. Use of facilities that meet the standards of the Leadership in Energy and Environmental Design (LEED) program;

8. Employee awareness campaigns that promote reduction of material and energy waste; and

9. Strategies that promote the reduction of unnecessary use of materials and energy.

C. Plastic car components shall be marked with the proper recycling symbol.

D. Natural leather materials shall not be used.

3.05 Design Objectives

3.05.01 Reliability

A. Every complete car, as well as each constituent component, assembly, subsystem and system element shall be designed in such a manner as to perform its function reliably in revenue service. Each car under all system operating conditions shall operate with a failure rate not exceeding that defined in these Technical Specifications.

B. The Contractor shall prepare and submit at the Preliminary Design Review (PDR) for approval by the Engineer a Reliability Program Plan [CDRL 03-006] which shall, as a minimum, contain the following:

1. Program objectives
2. Reliability program schedule
3. Methodology to be used in reliability analyses
4. Organization of personnel responsible for managing the reliability program
5. Controls for activities of subcontractors and equipment suppliers to assure compliance with reliability program methods and objectives
6. Preliminary reliability demonstration testing plans for verification of compliance when calculations and analyses are inconclusive, or when past performance records are incomplete or unavailable
7. Reliability demonstration program
8. Reliability demonstration procedures
9. Reliability database in a database agreed upon by the Contractor and Engineer.

C. Reliability Objectives

1. The Contractor shall provide reliability objectives that identify the Mean Distance Between Train Delays (MDBTD) and the Mean Distance Between Component Failure (MDBCF) performance levels to be met for its car design to the Engineer for approval. [CDRL 03-007] The reliability of the cars shall be consistent with the requirements of this specification and the Contractor's maintenance plan.
2. The reliability objectives shall be based on single car operation at an average speed of 80 mph (129 kph) and a utilization of 150,000 miles/yr (241,500 km/yr).
3. The reliability burn-in period shall be at least 750 miles for pilot cars. For production cars, the reliability burn-in period shall be one round trip on the Hartford and Shore Line East routes.

D. Car Reliability Requirements

1. The car shall achieve a car MDBTD of at least 150,000 miles (241,500 km).
2. A train delay shall be defined as a car-related failure causing a train in service to be:
3. More than 6 minutes late at its destination terminal; or

4. Canceled either at its originating point or en route.

E. Component Reliability Requirements

1. Providing that the Contractor's specified routine maintenance is performed on the various car sub-systems and components, the following reliability (MDBCF) requirements shall be met:

System	Mean Distance Between Component Failure
Friction Braking System	250,000 miles (402,340 km)
Side and End Doors	300,000 miles (483,000 km)
HVAC System	250,000 miles (402,340 km)
Couplers	3,500,000 miles (5,633,000 km)
Trucks and Suspension	750,000 miles (1,207,000 km)
PA Systems	600,000 miles (965,600 km)
Auxiliary Power Systems	250,000 miles (402,340 km)
Lighting (except bulbs)	1,000,000 miles (1,609,300 km)
Toilet	750,000 miles ([1,207,000 km)
Cab Control Systems	450,000 miles (724,500 km)
Destination Signs	600,000 miles (965,600 km)
Monitoring and Diagnostics	650,000 miles (1,046,100 km)
Event Recorder	1,000,000 miles (1,609,300 km)

2. The Contractor shall provide records illustrating the product history and experience of existing systems and system components to verify that the specified MDBCF requirements are achievable. [CDRL 03-008] Where historical records of equipment performance, detailing equipment operations, have not yet been established, analyses shall be performed to identify weaknesses within the system hardware and software design. The analyses shall provide detailed information for the system designs for theoretical circuit behavior, random component failures, electrical interference, systematic component failures and software errors in software-based logic. The reliability analysis shall be submitted for approval and updated periodically.

3. Reliability of microprocessor software shall be assessed from previous experience with similar software in railroad and rail transit revenue service, or by reliability evaluation methodology based upon the number of errors detected in each phase of the software development cycle. The improvement in operational reliability provided by fault tolerance features shall be quantified.

4. The MDBCF shall be defined by the following equation:

$$\mathbf{MDBCF = d/F}$$

where d equals the total car operating distance and F equals the number of relevant failures.

5. A failure shall not include the following, for the purposes of calculating reliability:

6. Failure due to documented instances of recommended preventative maintenance not being performed; or

7. Failure due to accidents, vandalism or other physical mistreatment.

F. Reliability Demonstration Program

1. The Contractor shall prepare a detailed reliability demonstration program identifying all quantitative requirements, to demonstrate that design reliability concepts and guideline objectives are in compliance with the analysis. The program shall contain failure accounting ground rules, accept-reject criteria, number of test cars, test locations, environmental conditions, planned starting dates and test duration. The reliability demonstration plan shall be submitted to the Engineer at the preliminary design review. [CDRL 03-009]

2. The program shall provide a constant review of failure rate sources, de-rating policies, items with critical shelf life and prediction methods and shall identify planned actions in instances where prediction methods indicate non-compliance with the specified requirement. The program shall provide for compliance with all guidelines and provide that prohibited parts/materials are not utilized.

3. The program objectives shall include (but are not limited to):

   a. Reliability program organization, showing personnel and their responsibilities over the entire program.

   b. Reliability demonstration schedule.

   c. Specific tasks shall be identified for schedule development with start and completion dates, illustrating integration with major program milestones for design, manufacturing and testing.

   d. Reliability requirements compliance methodology to be used in reliability analyses for success-failure criteria measuring MDBCF values for individual equipment items and subsystems under demonstration.

   e. Reliability program controls, methods and objectives to provide compliance and change control procedures for implementing design changes during the demonstration program, for failures, identifying the cause and need for corrective action.

   f. Establishment of a joint Contractor/Engineer failure review board to classify failures, identify cause and propose corrective action, if required.

   g. Reliability demonstration procedures and forms for recording and submitting data, showing format, test logs, data records and date and location of test records.

4. The reliability demonstration program shall commence upon the conditional acceptance of the first car of the base order and shall continue to the end of warranty period of the last accepted car. The reliability demonstration program plan shall be submitted for Engineer approval. During the demonstration, the cars shall be maintained by qualified maintenance personnel according to the maintenance plan and maintenance manuals provided by the Contractor.

5. Reliability calculations will be performed using a 12-month moving window. All equipment failures during car burn-in shall be reported and recorded, but not counted in establishing MDBCF and MDBTD values. Determination of pass or fail will be assessed only at the end of the reliability demonstration.

6. The Contractor shall make necessary modifications during the reliability demonstration program in order to achieve the MDBCF and MDBTD requirements. The Contractor shall submit all requests for such design changes within 60 days of the end of the reliability demonstration using the Engineering Change Request (ECR) system and shall gain Engineer approval prior to the implementation of any change. All reliability-related modifications defined during the reliability demonstration program shall be implemented on all cars and spare parts within 180 days of the date of approval of the modifications by the Engineer.

7. If at the end of the reliability demonstration it cannot be determined that all specified MDBTD reliability requirements have been met, the Contractor shall re-design and modify or replace all such systems, subsystems, components, parts or equipment as needed to achieve acceptable reliability, at the Contractor's expense, regardless of whether these items have exhibited the defect or failure and regardless of the warranty status. Should such modifications not be completed within this time, the Engineer shall have the right, at its sole discretion, to perform any necessary engineering or studies, and to correct the defect or failure. All costs incurred by the Engineer for such engineering and corrective work shall be at the Contractor's expense. Any items replaced by the Engineer during such corrective work will be disposed of by the Engineer in the manner requested by the Contractor and at the Contractor's expense. If the Contractor fails to furnish disposition instructions, the Engineer will dispose of such items, at the Contractor's expense, in such a manner, in the Engineer's sole judgment, is appropriate.

8. Cars so modified shall undertake a further reliability demonstration of at least six months duration to prove reliability. Modifications shall continue at the Contractor's expense until the specified MDBTD reliability levels are met.

G. Reliability Demonstration Procedures

1. The Contractor shall provide a set of procedures to be followed in the reliability demonstration.

2. These procedures shall, as a minimum, contain the following:

   a. Method for all equipment failures to be reported during reliability testing, including forms and reliability database.

   b. The reliability program shall utilize failure data collected through the warranty failure tracking process.

   c. Details of the burn-in period for each car. All equipment failures during the burn-in shall be reported and recorded, but not counted in establishing MDBCF values.

   d. Procedure for corrective action when necessary to meet reliability requirements. This shall include proposed reliability demonstration restart procedures, proposed changes, and appropriate supporting data. The proposed plan shall clearly identify a specific method for verifying the effectiveness of change(s). Credit may not be taken for time from previous failed tests, and the specified performance and other required characteristics of the equipment shall not be changed to achieve reliability requirements.

   e. Method for recording all relevant data necessary to calculate MDBCF values for the car and major systems and to verify successful demonstration of the MDBCF requirements.

3. All parts or material returned to the Contractor for repair or replacement shall be accompanied by a failure analysis report form. This form shall clearly identify the part by description and part number; identify the car and service mileage of that car, date of failure and the nature and probable cause of failure. The Contractor shall comment on the cause and proposed action (if any) sections of this report and return it to the Engineer within 60 days of the failed item or system.

H. Reliability Database

1. The Contractor shall establish a computer-based reliability database that shall be utilized for the following tasks:

   a. Monitoring of overall car reliability on both a car and a component level

b. Tracking of all component failures and identification of epidemic failures

c. Tracking of all warranty claims

d. Maintaining a configuration record for each car

2. Each record shall contain, as a minimum, the following information:

   a. Car number

   b. Car acceptance date

   c. Detailed listing of all car system equipment and major components including description, supplier's name, Engineer part number, supplier part number, serial number, revision level and date of installation on car

3. The computer-based reliability database shall be able to interface with the Engineer's existing reliability and maintenance tracking system. Data recorded in the Contractor's computer-based reliability database shall be transferable to the Engineer's own maintenance or reliability database. The fields to be transferred/downloaded and format (e.g., comma-separated variables) shall be the subject of a design review

4. The Contractor shall maintain and update the database as required to ensure it remains current throughout the entirety of the warranty period and, if option so exercised by CTDOT, through the post-warranty service and support period.

3.05.02 Maintainability

A. The car shall be designed and built so as to minimize maintenance and repair time and overall costs over the car life. The following shall be considered good practice in designing for maintainability and shall be utilized in the car design:

1. All systems and components serviced as part of periodic preventive maintenance shall be readily accessible for service and inspection.

2. Removal or physical movement of components unrelated to the specific maintenance and repair tasks involved shall not be required.

3. Relative accessibility of components, measured in time to gain access, shall be inversely proportional to frequency of maintenance and repair of the components. (Items requiring more frequent maintenance shall be easier to access).

4. Assemblies and components that are physically interchangeable shall be functionally interchangeable.

5. Modular or plug-in assemblies and components that are not functionally interchangeable shall not be physically interchangeable.

6. Systematic fault isolation procedures shall be developed for inclusion in the maintenance manuals.

7. Local built-in test points and fault/status indicators shall be provided and clearly marked for all major systems including friction braking, Heating, Ventilation and Air Conditioning (HVAC), passenger doors, auxiliary power, battery charger, Public Address (PA), and toilet system.

8. All test points, fault indicators, modules, wire terminations, piping, tubes, wires, etc., shall be identified by name plates, color coding, number coding or other means to assist the maintenance personnel.

9. Component placements in equipment cabinets, enclosures or confined places shall give the most accessible positions to those items requiring the most frequent maintenance or adjustment. Periodic adjustment of any component shall be only as essential, kept to a minimum, and only as accepted by the Engineer.

10. Door panels and openings shall be of sufficient quantity, size and placement to permit ready access from normal work areas.

11. Standard, commercially available components and hardware shall be used wherever possible.

12. Captive fasteners shall be used on covers and access panels where periodic maintenance and inspection are to be carried out. The use of special tools for removal shall be avoided.

    a. Access shall be provided, to the greatest extent possible, to structural components to allow inspection for cracks and corrosion.

    b. Major components shall be designed for ease of removal. Handles and lifting eyes shall be provided as applicable, on heavy equipment and components not readily accessible.

    c. Means shall be provided to verify the operability of redundant hardware components, and their switching devices, during maintenance, troubleshooting and testing.

    d. Requirements for special tools and fixtures shall be minimized.

B. Maintainability Numbers

1. The Contractor shall prepare and submit for review at the PDR, a maintainability program plan utilizing design standard that minimize Mean Time To Repair (MTTR), cleaning and maintenance costs throughout the car's intended useful life. [CDRL 03-010]

2. The plan shall include the system MTTRs and car goal for the proposed car. An overall quantitative maintainability requirement goal for the car's corrective maintenance shall be the weighted average of the MTTR (mean time to repair) of the key system elements. Diagnostic and set-up time shall be included in the MTTR.

3. Preventive maintenance is defined as the maintenance tasks performed to minimize the possibility of future equipment failure, reduce or minimize wear rates, replace consumable parts, and satisfy warranty requirements. The elapsed time required to perform preventive maintenance (exclusive of servicing) on the car shall be demonstrated.

4. The objectives of the maintainability program, including corrective and preventive maintenance, shall provide for:

    a. Maximization of car availability

    b. Minimization of maintenance costs, including cleaning

    c. Minimization of car down time

    d. Minimization of special and high skill levels for maintenance

    e. Minimization of special tools and fixtures

5. Components and sub-assemblies requiring occasional removal shall be plug-in units, adequately identified and secured and keyed to prevent misapplication.

6. The need for adjustments shall be avoided wherever possible. Adjustment points shall be readily accessible, adequately identified and self-locking to prevent inadvertent operation and drift.

C. Mean Time to Repair Requirements

1. The MTTR a car fault and restore the car to operational readiness shall not average more than 1.8 labor hours including diagnostic and set-up time.

2. This shall be the weighted average of the MTTR values for the following subsystem elements:

System	MTTR or Replace Major Module (labor hours)
Friction Braking System	2.0
Side and End Doors	0.8
HVAC System	2.1
Couplers	2.6
Trucks and Suspension	1.6
Auxiliary Electrical System	1.5
Lighting	0.5
Wheels and Axles	4.0
Cab Control	2.5
PA/IC	1.0
Water and Waste System	2.0

D. Maintainability Demonstration

1. The adequacy of the car design for maintainability shall be evaluated to the satisfaction of the Engineer using product components and equipment, mockups and actual cars during the design, production and acceptance phases.

2. This demonstration shall include a shop exercise including troubleshooting, change out of components, corrective maintenance, and the use of Contractor-supplied special tools and equipment.

3. The maintainability of the following systems shall, as a minimum, be demonstrated:

   a. Trucks

   b. HVAC

   c. Brakes

   d. Wheels and axles

   e. Auxiliary electric equipment (including battery charger and battery)

   f. Side and end doors

   g. Couplers

   h. PA and intercoms

   i. Water and waste system

   j. Emergency equipment and lighting

k. Cab control equipment

4. The Contractor shall prepare and submit a maintainability demonstration plan for Engineer approval at the PDR. [CDRL 03-011]

5. During the demonstration, the cars shall be maintained according to the maintenance plan and maintenance manuals provided by the Contractor.

6. If at the end of the demonstration it cannot be determined that all specified maintainability requirements have been met, the Contractor shall re-design and modify or replace elements as needed to achieve acceptable maintainability at the Contractor's expense. Cars so modified shall undertake a further maintainability demonstration to prove maintainability.

3.05.03 Metrication

A. The designs, components and fasteners used on the new cars shall be of inch-standard units of measure wherever possible. While use of metric system of measure will be permitted where necessary, requests for their usage, defined at the subcomponent level, must be submitted to the Engineer for review and approval. There shall be no mixing of metric and inch-standard fasteners within a component or subsystem. All metric fasteners used in the car shall be clearly and distinctly called out on all project documentation.

B. For all drawings, manuals, specifications and inspection documents, all dimensions shall be shown in inch-standard units of inches and decimals, with a metric equivalent shown in parentheses adjacent to the inch-standard dimension. If a component or subassembly uses metric units as the primary system of measurement, then SAE equivalents shall be provided in parentheses.

3.05.04 Safety

A. Safety shall be of primary importance in the design of the car. The Contractor shall comply with all applicable laws, rules, regulations, standards and recommended practices including, but not limited to, New York State, Connecticut, FRA, APTA, AAR, NFPA, ADA, USDOT, U.S. Department of Health and Human Services, U. S. Department of Homeland Security, and OSHA. Deviations from, and substitutions of, specified standards, or portions thereof, shall be made only as approved in writing by the Engineer. The Contractor shall conduct a safety program, which ensures to the greatest extent possible, that the cars delivered to CTDOT are operationally safe and secure for passengers, employees, emergency responders, and the general public. The Contractor shall designate a Safety Program Manager (SPM) for carrying out the Contractor's System Safety Program, and to serve as a point of contact to the Engineer.

B. The Contractor's SPM shall also serve on the committee established by CTDOT to carry out safety and security certification program activities. The Contractor's System Safety Program shall support CTDOT's Safety and Security Certification Program efforts and generate the following system safety documents and analyses:

1. System Safety Program Plan (SSPP) [CDRL 03-012].

2. Preliminary Hazard List [CDRL 03-013].

3. Preliminary Hazard Analysis [CDRL 03-014].

4. Hazard Tracking Log [CDRL 03-015].

5. Failure Modes, Effects, and Criticality Analyses (FMECA) [CDRL 03-016].

6. Fault Tree Analyses [CDRL 03-017].
7. Subsystem Hazard Analysis [CDRL 03-018].
8. Operating and Support Hazard Analyses [CDRL 03-019].
9. Conformance Checklist [CDRL 03-020].
10. Fire Safety Analysis [CDRL 03-021].
11. Flammability, Smoke Emission, and Toxicity Test Matrix [CDRL 03-022] – See section 18.19.
12. EMC Safety Analysis – See section 3.5.5.
13. Ergonomics Hazard Analysis [CDRL 03-023].
14. Cyber Security Analysis [CDRL 03-024].
15. Safety Certification [CDRL 03-025]

C. General Safety Design Requirements

The general safety design requirements and the guidelines listed below shall be incorporated into the design of all car systems affecting safety. Permissive conditions are those that permit an action or event to take place. Restrictive conditions are those that limit the actions or events that can take place.

1. Only components with high reliability and predictable failure modes, and which have been proven in conditions similar to the projected service shall be utilized.
2. All electronic circuits shall be assumed capable of failing in permissive modes.
3. Software shall be considered capable of failing in an unsafe mode unless it is safety verified while operating in the proposed hardware.
4. Systems shall be based on closed circuit principles in which energized circuits result in permissive conditions, while interrupted or de-energized circuits result in restrictive conditions.
5. Any component or wire becoming grounded shall not cause a permissive condition. Safety circuits shall be kept free of any combination of grounds that will permit a flow of current equal to, or in excess of 75% of the release value of any safety device in the circuit.
6. Circuit impedance, signal encoding, shielding, layout and isolation shall be selected to reduce the effects of interference to the extent that safety is maintained under all conditions.
7. Commands that result in permissive conditions shall be propagated by no less than two independent signals, both of which must be present before the permissive condition can occur. The lack of either signal shall be interpreted as a restrictive command.
8. Systems controlled by variable level signals shall be arranged such that zero signal level results in the most restrictive condition. At least one enabling signal, however, independent from the variable control signal, shall be present before the control signal can modulate the system to a more permissive level.

9. Circuit breakers and fuses shall be guaranteed by the manufacturer to successfully interrupt rated currents. Circuit breakers and fuses shall be applied such that the maximum circuit fault currents cannot exceed the manufacturer's guaranteed operating ranges.

10. Systems that rely on structural integrity for safety shall have sufficient safety factors such that failures are not possible within the life of the car under all possible normal conditions.

11. Systems and devices subject to wear shall not wear to unsafe or permissive states within a period that is no less than three times the specified periodic maintenance interval under the worst-case combination of duty cycle, environment and all other influences. Such systems and devices shall be clearly indicated in the maintenance manuals.

12. Mechanical systems which apply force to achieve safe states shall not depend upon the application of fluid pressure or electrical energy, unless specifically approved.

13. All systems shall function safely under all combinations of supply voltages, fluid pressures, shock, vibration, dirt accumulation and the railroad environment.

14. All safety related systems, and devices within those systems, shall be clearly identified in all operation and maintenance manuals, procedures, and training materials.

15. Exposure of maintenance personnel to lethal or injurious voltages shall be minimized through compartmentalization, interlocks and similar measures.

16. All equipment containing hazardous materials, lethal or injurious voltages, or other risks shall be clearly labeled on both the outside and inside of the equipment.

17. No sequence of operations, or the simultaneous activation of any controls, shall result in unsafe conditions.

18. All systems shall protect against unsafe conditions resulting from human error.

D. Probability, Severity, and Risk

1. For the purpose of this section, the Contractor shall utilize the definitions for probability, severity and risk as defined in MIL-STD-882E.

2. For individual component failures rates used in the safety analysis, the Contractor shall utilize published failure rates for ground mobile equipment such as MIL-HDBK-217F. Use of field data may be used if approved by the Engineer.

3. For software failure probability rates used in the safety analysis, it shall be assumed that all software has a Safety Integrity Level (SIL) of zero as defined by EN-50128. For common mode failure of comingled or redundant software, a BETA or common mode failure rate of one shall be assigned. Alternatively, if the Contractor can provide independent certification (e.g. TÜV certification) for a higher SIL level, this may be used if approved by the Engineer.

4. Unless it is shown otherwise though daily test or preventative maintenance inspection, the "Time at Risk" for all failure probabilities shall be the design life of the vehicle. All time at risks shall be approved by the Engineer.

E. System Safety Program

1. The Contractor shall develop, implement, and maintain a comprehensive System Safety Program Plan (SSPP) that defines activities, management controls, and monitoring processes to be used

by the Contractor to ensure that safety considerations and compatibility with other system requirements are incorporated into the design of the cars. [CDRL 03-012]

2. The SSPP must demonstrate that the Contractor has a clear understanding of the system safety requirements and has an organization in place that is capable of identifying safety hazards and performing analyses to verify that the hazards have been eliminated or adequately mitigated. The SSPP shall be structured conforming to the requirements of 49 CFR 238 Subpart B, 49 CFR 238.105, 49 CFR 229 Subpart E, and MIL-STD-882 E in accordance with APTA's, "Manual for the Development of Rail Transit System Safety Program Plans," and shall contain the following information as a minimum:

   a. Specific information showing how the Contractor shall verify attainment of system safety requirements during the design, installation, and test phases.

   b. A description of organizational relationships and personnel responsible for system safety. The Contractor's SPM shall not report to, but shall have direct access to, the Contractor's Program Manager.

   c. Detailed listing, description, and schedule of specific system safety tasks.

   d. A description of the procedures for the reporting, recording, and resolution of hazards identified during design, installation, and testing.

   e. A schedule indicating key milestones to ensure that system safety activities are performed in a timely manner.

   f. Procedures for the Contractor's SPM and other personnel as required to participate in all design reviews, review and approve design changes and top-level drawings, and approve all safety-related elements of the Contract.

   g. A description of the hazard identification and elimination/control process.

   h. A description of the process by which the Contractor will certify the safety of the vehicle and major systems.

F. Preliminary Hazard List

The Contractor shall develop within 60 days of NTP an integrated vehicle level Preliminary Hazard List (PHL) to identify and list hazards. [CDRL 03-013]. This hazard list shall identify all potential hazards associated with the vehicle including those caused by mechanical failures, electrical/electronic component failures, software errors or defects, environmental impacts, human error, maintenance, and operational conditions.

G. Preliminary Hazards Analysis

The Contractor shall provide a quantifiable Fault Tree Analysis for all Category/Severity one and two hazards (MIL-STD-882E) identified in the PHA. These fault trees analyses shall be fully integrated across subsystems such that if events span multiple subsystems, the top event vehicle level hazard reflects all subsystem events. [CDRL 03-014]

H. Subsystem Hazard Analysis

1. Conformance Checklist

The Contractor shall submit a conformance checklist to verify all safety and security critical aspects of the Specification and federal and local regulation have been satisfied. [CDRL 03-020]

2. Fire Safety Analysis

   In addition to the Flammability, Smoke Emission, and Toxicity Test Matrix (section 18.19), the Contractor shall validate protection from smoke and fire originating under the vehicle floor through successful completion of a 30-minute floor fire test in accordance with ASTM E-119, NFPA 130, and 49 CFR 238. [CDRL 03-021]

3. Ergonomics Hazard Analysis

   The Contractor shall perform an ergonomic analysis to show any effect of design that can result in injuries to the operating crew or maintenance personnel. This analysis shall include repetitive motions, exerting excess force, localized pressure into a body part, awkward posture, etc. [CDRL 03-023]

4. Cyber Security Analysis

   The Contractor shall prepare and submit a Cyber Security Analysis identifying all potential system vulnerabilities, associated risks (including exploit likelihood and consequences), countermeasures applied, and resulting mitigated risk. The report format shall be similar to that of a Hazard Analysis. Exploits to be considered shall include (but are not necessarily limited to) the following, as appropriate: vandalism; eavesdropping; device/user impersonation; dictionary attacks; message modification; session hijacking; buffer overflow; denial of service; jamming (physical layer denial of service); virus/worm infection; unauthorized software installation; and unauthorized root/administrator access. [CDRL 03-024]

5. Safety Certification

   The Contractor shall submit a safety certificate which shall include a safety case which summarizes all of the SSPP activities and include all SSPP documents and their supporting references. [CDRL 03-025]

3.05.05 Electrical Interference

Electromagnetic Compatibility Plan

A. Prior to the Intermediate Design Review (IDR), the Contractor shall submit for review and approval an Electromagnetic Compatibility Plan (EMC Plan), [CDRL 03-026].

B. The EMC Plan shall include the Contractor's analysis of interference sources and receivers as outlined in APTA-PR-E-S-010-98 Section 5.4

   1. The Contractor’s EMC Plan shall ensure that the vehicle and its subsystems shall not interfere with wayside systems or be susceptible to emissions from wayside systems or existing vehicles under all operating conditions.

   2. The emissions and susceptibility of onboard equipment shall meet the requirements of EN50155. The limits for RF emissions and susceptibility shall be extended to six gigahertz to be compatible with new technologies as approved by the Engineer. The Contractor shall provide a test report or certification for each electrical LRU that shows compliance to EN50155. [CDRL 03-027]

   3. It shall be the responsibility of the Contractor to prevent interference between any subsystem or signal and any other subsystem or signal on the vehicle or train.

C. No vehicle system or subsystem shall be susceptible to the transmissions of a CTDOT hand held radio or any cell phone held 18 inches from any enclosure or cable.

D. No vehicle system or subsystem shall interfere with the operation of any CTDOT radio or any cell phone held anywhere on the car or adjacent to the vehicle under any mode of operation.

E. No vehicle or subsystem may interfere with public safety frequency bands. Use of transmitters in those bands shall be approved by the Engineer.

F. It shall be the responsibility of the Contractor to ensure that neither the vehicle nor its communications systems interfere with systems of neighbors of CTDOT's right of way. It shall also be the responsibility of the Contractor to ensure that the vehicle and its communications systems shall be immune to emissions and transmissions from neighbors of CTDOT's right of way.

G. The EMC Plan shall also include the Contractor's plans to mitigate conductive, inductive and radiated interference by means of but not limited to:

1. Selection of signal levels to maintain signal to noise ratio at least 6 db above interference levels
2. Frequency selection for transmitters
3. Filtering
4. Location and orientation and design of potential emission sources so as to minimize interference
5. Proper shielding and termination
6. Cable routing and use of separate conduits and cables to reduce cross talk and interference from power cables as outlined in IEEE STD 16-2004. Section 4.8.2.1
7. Suppression of spikes caused by inductive loads

H. The Engineer's acceptance of the EMC Plan does not relieve the Contractor of the responsibility to meet the requirements paragraphs A through G above.

3.05.06 Whole Train to Wayside Emission Limits

A. The Contractor shall have responsibility to verify limits for inductive and radiated emissions such that wayside and carborne signal equipment, will not be affected by vehicle or train emissions. [CDRL 03-028]

B. Inductive Emissions Limits

1. For measurement of inductive emissions, "Inductive Interference in Rapid Transit Signaling Systems, Volume II: Suggested Test Procedures", UMTA-MA-06-0153-85-8 shall be used. Modifications to the test procedure may be made to account for improvements in measuring equipment since the publication of the standard.
2. Radiated Emissions Limits
   a. Broadband Radiated Emissions from the train to the wayside in the .15 MHz to 1 GHz range shall not exceed the limits described in EN 50121-3-2 for whole train emissions up to 1 GHz.
   b. Radiated emissions shall be measured in accordance with EN 50121-3-2 with recalculation of limits based upon the actual placement of the measuring antenna.

c. Radiated emissions testing shall also examine ambient emissions and train broadband and narrow band emissions in the 1 GHz to 6 GHz range. Train emissions exceeding ambient emissions in this range by more than 10db shall be investigated and the source documented.

d. Non-broadcast narrow band emissions must be below a level which will interfere with any legal radio band.

e. Additional narrow band radiated emission limits may be imposed by the necessity to avoid interference with systems of neighbors to CTDOT's right of way.

C. Human Exposure Field Limits

The vehicle shall not produce any health hazard to the public, passengers, train crew or maintenance personnel. The Contractor shall develop as part of the EMC Plan a process to control and mitigate any potential health hazards from electromagnetic fields or radiation. The limits expressed in the EMC Plan shall be based upon IEEE Std. C95.6 for frequencies below 3000 Hz and ANSI C95.1/IEEE C95.1 Standard -1999 for frequencies above 3000 Hz. The Contractor shall perform a test to verify compliance with the above. [CDRL 03-029]

3.06 Design Review

A. Within 30 days of NTP, the Contractor shall submit an engineering plan for accomplishing the engineering design functions and objectives. [CDRL 03-030] The engineering plan shall include at a minimum:

1. Defining the relationship of the engineering team in the overall organization of the Contractor.

2. Organization of the engineering department, with identification of the subgroups as organized by function or system.

3. Critical path/workflow plan for completion of all engineering functions.

4. The schedule for completion of major design activities including all stages of design reviews, mock-up review, finalization of engineering, test plan development, carshell stress and structural performance analysis, proof of design testing and delivery of all required engineering documentation.

5. Oversight of vendor engineering functions and integration of supplier engineering into the Contractor's design.

6. Manufacturing engineering plan, including assembly station work scope, parts flow and estimated labor hours/station staffing plan.

7. Carshell engineering plan, including design, finite elements analysis, quasi-static and dynamic testing, measurement of critical dimensions, acceptance and shipment, and inspection/repair procedures.

8. Completed car weight control plan.

B. The design review process shall begin no later than one month after NTP. As a minimum, each design review report shall be completed including resubmission of design documents with revisions in accordance with detailed review comments, before progressing to the next review process. All design review meetings shall be held at the Contractor offices in designated location, unless another

location is specified by the Engineer. No less than 15 working days prior to a design review session, the Contractor shall submit to the Engineer, for approval, the documents (drawings, calculations, reports, etc.) addressed at the meeting.

C. The Contractor shall be responsible for the car design including all sub-systems and materials, with appropriate review by the Engineer. A system concept shall be used in the design to ensure that components, parts, and other equipment furnished by different subcontractors shall function as intended when installed. Design review activities shall continue throughout the entire pre-production period, with each succeeding stage presenting greater amounts of detail and reflecting the progress of the designs. In addition to his own designs, the Contractor shall submit the design of all components being purchased for review and discussion at the design review sessions. In all submissions and at all sessions the Contractor and supplier presentations shall be organized so as to show exactly how the design meets each specific requirement of the Technical Specification.

D. The Contractor shall provide equipment meeting all specified performance levels and be compatible with all elements of the railway system on which the Engineer will operate the equipment, for the useful life of the equipment.

E. Safety, reliability, ease of maintenance and compatibility with other intercity rail equipment shall be primary design considerations.

F. The vehicle design and construction shall be subject to progress reviews/program meetings, held monthly or as deemed necessary, or as scheduled by the Engineer, at which time the Contractor and the Engineer shall be present to discuss any and all details as required relative to the execution of the work. The Engineer will record the minutes of the meetings. The Contactor shall provide, immediately following the meeting, a copy of all documents presented/discussed at the meeting. The Contractor will also provide matrices showing status of the following:

1. System design reviews
2. Schematics
3. FAI and follow-up
4. Master test plan, procedures and test schedule
5. Manual status
6. Training action plan
7. Manufacturing status

G. Additional meetings shall be held as required by the Engineer, or at the request of the Contractor, in order to discuss the particular aspects of the work.

H. Manufacturers, subcontractors, suppliers, and/or other representatives, as determined necessary by CTDOT, shall be present at any meetings.

I. Items shall be referred to as "open items" if action or a decision is pending at the time of the minutes are issued. A summary of all Specification changes and "open items" shall be included.

3.06.01 Engineer Involvement

A. The Engineer shall be an integral part of all aspects of the design, inspection, testing and approval program for the rail cars. This involvement shall include design review and evaluation, supplier

selection, QA program review and approval, first article inspection, inspection of all phases of car production, witnessing tests and vehicle acceptance, post-delivery training, and warranty administration.

B. The Engineer shall designate to the Contractor those individuals and organizations that are participating in the design review and inspection process on behalf of the Engineer. These individuals may include employees of the Engineer's organization, consultants, representatives of the Engineer's operating and maintenance providers, constituent groups or others as designated by the Engineer. Only those designated as representing the Engineer shall have the authority to take actions on behalf of the Engineer that govern the contract, including approvals and acceptances, design review comments, witnessing of tests, and other activities that the Engineer shall participate in. The Contractor shall not recognize the actions of those individuals with no designated Engineer authority in the contract.

C. Representatives of regulatory agencies shall be afforded all desired access to the project, including inspections, design reviews, witnessing of tests and audits, as requested by the regulatory agencies. The Contractor shall advise the Engineer of all comments and direction received from regulatory agencies regarding the project.

D. The Engineer shall have the right to invite or permit to participate in any inspection, design review, audit or test anyone the Engineer deems desirable or necessary. The Engineer will give the Contractor reasonable notice of participants but reserves the right to include participants with no notice.

3.06.02 Approval of Suppliers

A. The Contractor shall be responsible for pre-qualifying all proposed subcontractors to the Engineer's satisfaction and approval.

B. Major suppliers shall include the suppliers of the truck, coupler and draft gear, friction brake system, passenger door system, interior panels, flooring and floor covering, passenger seats, HVAC system and controls, lighting, communications system, LVPS, toilet room, cab and locomotive controls, operational safety system, monitoring and diagnostics system, and manuals and training.

C. Within 30 days of NTP and before entering into any subcontracts, the Contractor shall supply a complete list identifying each major supplier and their product proposed for use on the car. [CDRL 03-031] Along with this, a listing of names and addresses of other users of similar equipment from that supplier, including the two most recent customers, and any other information necessary to prove that the proposed supplier has the necessary facilities, skill, integrity, past experience, and financial resources to perform the work in accordance with the terms and conditions of this Contract shall be submitted to the Engineer. This list shall have been updated and approved prior to building of mockups.

D. If the Engineer determines that the proposed supplier is not qualified, the Engineer will, within 10 days, notify the Contractor who may thereupon submit the name of another proposed supplier unless the Contractor decides to do the work itself. The Engineer approval of a supplier shall not relieve the Contractor of any of its responsibilities, duties, and liabilities hereunder.

E. The Contractor shall submit a copy of the purchase order and associated vendor acknowledgement for each major supplier to the Engineer. Proprietary and confidential information may be redacted. [CDRL 03-032]

F. The Contractor shall promptly, upon request, file with the Engineer a confirmed copy of the subcontract. Proprietary and confidential information may be redacted.

G. CTDOT or its representatives will not undertake to settle any difference between the Contractor and its Subcontractors, or between Subcontractors.

3.06.03 Configuration Management

A. The Contractor shall develop and submit to the Engineer for approval a configuration management plan within 45 days after NTP. [CDRL 03-033] The plan shall illustrate how the Contractor intends to meet the configuration management requirements and shall include as a minimum:

1. Flow charts of paperwork for design changes prior to and following design reviews and drawing approvals.

2. Forms to be used to convey, track and account for the design changes whether approved or not.

3. A description of the methods and communications to be used to control hardware configuration identification for purposes of receiving inspection, installation, test, retrofit, reliability, safety and inventory control.

4. A description of the forms and methods to reflect the current modification status of every car.

5. The method to be used to make required revisions to publications, drawings, education programs, photographs and any other program software.

B. The configuration management plan shall have a live document status. Any and all changes must be submitted to the Engineer during the next monthly progress report covering the time period the change took place. Changes will be subject to approval by the Engineer.

C. The Contractor shall maintain accurate and current configuration records which shall be available to the Engineer throughout the period of the Contract and for a three-year period after final Contract payment. The Contractor shall ensure that his supplier's equipment incorporated in the car design complies with all the related provisions that follow. The guidelines provided by DOD-STD-480A and EIA-649-A 2004 shall be adapted to the program in a responsible and disciplined manner consistent with good maintenance practices. The Contractor's technical documentation shall be capable of defining the approved configuration of hardware and computer software under development, test, production, or in operational use. The technical documentation shall identify the configuration to the lowest level required to ensure repeatable performance, quality and reliability.

D. Engineering Changes

1. If required, the processing of Engineering Change Requests (ECRs) and Field Modification Instructions (FMIs) shall control changes to drawings and specifications resulting from the performance of the work contained in this Contract. An ECR to modify, delete, add or substitute any part, assembly, or equipment shall be designated as a Class I change when one of the following criteria shall be affected:

   a. Interchangeability and availability

   b. Changes that require modifications to operating or maintenance manuals

   c. Changes that require modifications to periodic maintenance schedules

d. Changes to parts manuals

e. Mechanical or electrical form, fit, or function

f. Reliability or maintainability

g. Electromagnetic interference characteristics

h. Safety

i. Spares provisioning

j. Sources of repairable items (source control drawing)

k. Vehicles delivered

l. Weight

m. Wiring and or electrical function

2. All other changes shall be designated as Class II changes.

3. All Class I ECRs, together with supporting documentation, that contain the full details, instructions, tool list for post-production changes, parts list, procedures and drawings necessary for the performance of the work, shall reference all software (publications, drawings, education program, etc.) which must be changed giving the revised information, and also describe any needed revisions or modifications for interim use shall be submitted to the Engineer for review prior to approval and implementation.

4. Class II ECRs are informational in nature; corrections to drawings and documentation that do not affect the functionality of the vehicle. All class II ECRs shall be submitted to the Engineer for information, provided that changes do not deviate from the Specification requirement. The Contractor shall maintain an engineering change status report, which shall list all ECR changes, their status and completion dates. Engineering change status reports shall be submitted monthly. Implementation of an ECR shall be incorporated in all cars. Any ECRs not performed on every car must include supporting rationale and shall be subject to the Engineer's approval.

5. Documentation will be generated showing the date when each car was modified, and the technician's signature identifying the work was performed. Design and/or specification changes made after the completion and acceptance of rebuilt cars will be retroactively applied to those completed cars through an FMI process that shall be included in the Contractor's QA program. Any action or cost necessary to correct problems in the product or documentation arising from the Contractor's misclassification shall be borne by the Contractor. The Contractor shall also be responsible for classifying and controlling changes originating from his subcontractors.

E. Documentation Requirements

1. All documents shall, as a minimum, contain the following:

a. A title page with a clear and concise title block, which includes all pertinent references to the Contract and an accurate description of enclosed information.

b. Display approval signatures of the original document on the title page to serve as an easy reminder of the approval signatures required for all future revisions.

c. Display the CTDOT's contract number on the title page.

d. Display the originating company's name and address on the title page.

e. Display the overall revision level on the title page and display the varying revision level on each consecutive page.

f. Display the unique document number on each page of the document.

g. Record the specific changes of a revision on a dedicated page that includes space for new approval signatures for that revision without requiring the removal of previous approval signatures.

h. Record the revision levels of individual pages on a dedicated page for verification of proper document composition.

i. Contain a table of contents and an itemized listing of tables and figures.

j. Submittals requiring the Engineer's approval prior to implementation shall be reviewed and classified by the Engineer as follows:

k. Approved — The Engineer concurs with the information in its submitted form. The material may be incorporated into the program.

l. Conditionally Approved — The Engineer conditionally agrees with the submitted information in principle, but insufficient information was provided to allow a complete review, or some details must be revised to make the information fully approved. The material must be resubmitted in revised form for Engineer approval.

m. Disapproved — Means the Engineer does not concur with vital details. The Contractor shall not incorporate the material into the program. The Engineer's objections must be reconciled, and the material must be resubmitted in revised form for Engineer approval as specified by the Engineer.

n. Information Only - Additional information that does not require approval as determined by the Engineer

o. An approval shall not be construed as:

   i. Permitting any departure from the Contract requirements; or

   ii. Relieving the Contractor of the responsibility for any error including details, dimensions, materials and calculations.

2. Classification by the Engineer will be assigned within 30 days from the day the submittal is received based on a rate of submittal that is reflective of the pace of an orderly, properly managed program. Priorities will be given to special cases when possible. However, the Contractor shall consider the 30-day requirement and the time requirements involved for mailing when scheduling submittals. The days used by the Engineer in design review meetings or in travel to or from such meetings shall not be included in the 30-day figure.

3. If necessary, subsequent meetings shall be scheduled and organized by the Contractor for the purpose of clarifying and discussing design issues. The Contractor and the Engineer will mutually develop and distribute an agenda of topics for such meetings in advance of the meeting date. If so requested, the Contractor shall present an overview of the design information at the meeting, using sample articles, standard engineering drawings, specifications, catalog cuts and other similar material, and respond to comments raised by the Engineer in its review. At the conclusion of the meeting, the Engineer will identify any remaining problems to be resolved. Prior to termination of the design review meeting, a list of action items and assigned responsibilities will be decided upon by the Engineer and the Contractor.

4. The Engineer reserves the right to request additional design review data as it, in its sole discretion, deems necessary where information is lacking or is needed to clarify design issues,

and the Contractor shall furnish material requested within the time agreed to during the design review.

5. Additional information requested in writing by the Engineer to clarify specific issues shall be provided by the Contractor within 10 working days of receipt of written request. In such cases, the time allowed the Engineer for completing the design review shall be extended accordingly.

3.06.04 Design Review Process

A. Four types of design reviews will be conducted depending on the status of the designs: Preliminary Design Review (PDR), Intermediate Design Review (IDR), Mockup Review and Final Design Review (FDR). All design reviews will be held at CTDOT unless otherwise specified. The requirements for these Design Reviews are as follows:

B. Preliminary Design Review (PDR)

1. Preliminary Design Review (PDR) of system components shall be made at the 30% level of designs. The PDR shall include a review of the design concept, written descriptions of the functionality, schematics of the system wiring, and drawings of each component showing dimensions and structural elements. The Engineer retains the right to redline, comment, and request changes to improve design and/or functionality.

2. PDR submittals and activities shall comprise but are not limited to the following:

   a. CPM — The Contractor shall submit a first version of the CPM schedule in accordance with specification requirements giving particular attention to the entire design review program portions of the procurement. The CPM is to be updated by the Contractor every 30 days.

   b. Compliance Matrix — The Contractor shall provide a matrix showing all technical requirements, the Contractor's proposed design and/or vendor and a determination as to whether the proposed design is compliant with the specification or not. [CDRL 03-034]

   c. Drawing Schedule — A drawing schedule for all distinct releases covering the design of all areas and subsystems of the cars in conformance with the Contractor's configuration management plan shall be prepared at the start of the PDR and submitted to the Engineer for approval. Each release shall be given a proper title for the top drawing and a drawing number. Arrangement drawings to be developed during the PDR shall also appear on this schedule with a title and number. The drawing schedule shall be immediately updated to reflect any revisions. [CDRL 03-035]

   d. Arrangement Drawings and Related Documents — During PDR arrangement drawings and related documents of the cars and all major subsystem hardware items as described above shall be submitted to the Engineer for review and approval. Drawings shall show at a minimum:

      i. Overall dimensions, orientation, center of gravity, weight, points of normal support, and method of support during mounting and removal.

      ii. Location of all doors, access panels and covers in relation to any enclosed equipment.

      iii. Required space for opening of all doors and access panels.

      iv. Location and space requirements for ventilation intake and exhaust openings and cable entrances.

      v. Location and space requirement for all major equipment.

e. Detailed Technical Specification — Within 60 days following the start of the design, the Contractor shall submit detailed technical specifications for all major systems and components. [CDRL 03-036]

f. Review Program — The Contractor shall submit to the Engineer an interim detailed technical specification covering the methods, materials and arrangements proposed for construction of the pilot cars. The document shall be similar in style and format to this Technical Specification, which shall take precedence in the event of any differences. An appendix shall give a complete tabulation of all suppliers and the products they are supplying, indicating any revisions to the manufacturer of goods, country of origin, and cost data. After approval by the Engineer, it shall be updated by the Contractor every 30 days to continuously represent the current configuration of the details of the car, including all specification changes and addendums. A monthly revision sheet shall contain a complete listing of the original and revised text, and details of the approval given by the Engineer. [CDRL 03-037]

g. Weight Analysis — After receipt of the approved minutes of the first design review meeting, and then monthly until the complete weighing of the pilot cars the Contractor shall submit to the Engineer a report on the estimated car weight. This shall include the most recent weights for the carbody without trucks, each truck and the complete car. It shall also include a list of weights for every subsystem on the car, indicating its percentage of the total car weight, and if these subsystem weights are based on actual scale weights of complete equipment. The Contractor shall make scale weighings of all components as early as possible. [CDRL 03-038]

C. Intermediate Design Review (IDR)

1. An Intermediate Design Review (IDR) shall be held when the design of the car is at approximately 60% complete. This shall represent an advancement of the design of the cars from the preliminary design stage to development of draft production drawings, arrangements, component and material specifications and schematics for all systems, subsystems and components on each car type, which will be used by the Engineer to evaluate the proposed design of the car to a level of detail sufficient that the Contractor shall be able to proceed with the development of the car design to the 95% draft final stage.

2. Storyboard palettes shall be provided proposing a variety of interior décor schemes for materials, patterns and colors to be used throughout the car.

3. Engineer comments from the PDR stage shall be reviewed, and the Contractor shall provide documentation that the Engineer's comments were incorporated into the car design. All drawings, specifications, schematics and other project documentation shall be updated for the IDR.

4. Once reviewed, the drawings and designs shall be updated to incorporate Engineer comments. The drawings as revised after the IDR shall be used as the basis for the development and assembly of all required mockups.

5. The Contractor shall present the initial manuals, outline of expected maintenance, and repairs and special tools at the IDR.

6. At the IDR, the Contractor shall provide the finalized mockup review plan for Engineer review and comment. The mockup review plan shall describe all mockups to be developed by the Contractor, including the locations where the mockups will be built and reviewed and the schedule for completion and review of the mockups. [CDRL 03-039]

D. Mockup Development and Review

1. Upon the completion of the intermediate design review stage of the design review process, the Contractor shall complete the assembly of full-size hard mockups of the following areas and systems of the cars [CDRL 03-040]; according to the drawings as reviewed and approved at the IDR, for Engineer review and comment:

2. A representative area of the passenger seating area shall be built, including:

   a. Two facing 2-person passenger seats

   b. Workstation table between the facing seats

   c. Overhead luggage rack

   d. Wall panels, window and window mask

   e. Convenience outlets

   f. Heater grilles and diffusers

   g. Bike rack

   h. A fully functional example of an overhead luggage rack shall be provided mounted at the design height and including the adjacent ceiling panel, built so that the loading and removal of baggage may be performed.

   i. Cab car:

      A full mockup of both sides of the cab control compartment shall be built, with all controls, gauges, indicators, windshields, and car structure simulated for evaluation of visibility to gauges and indicators as well as to the front and sides of the car. Controls shall have simulated operation to evaluate the range of motion and effort required to operate the control equipment. Seats shall be installed to evaluate circulation, ease of getting into and out of the cab, and knee/leg room under desktop.

   j. Accessible toilet room:

      A fully equipped Accessible Toilet Room (ATR) shall be assembled, for the purpose of evaluating and confirming that the design arrangement of the ATR meets all ADA requirements for layout, circulation and access to controls and appliances.

   k. Electrical locker:

      i. The electrical locker shall be mocked up with all switches, breakers, relay panels, access panels, doors, controls, indicators and components simulated to evaluate access, visibility, maintainability and removal. Each electrical locker arrangement shall be mocked up.

      ii. Vestibule wall and ceiling panel area for access to door equipment:

      iii. The vestibule ceiling and wall area shall be mocked up to simulate access to all side door equipment that requires inspection, adjustment, maintenance or lubrication. All wall and ceiling panels shall correctly simulate the means of attachment, removal and operation, to ensure that the ceiling panels are safe and easy to use by maintenance personnel.

3. All mockups shall be constructed of materials with sufficient strength so that they can be evaluated safely and thoroughly by the Engineer. This includes the ability to sit on seats, lean on countertops, open and close doors, simulate operation of controls, appliances and equipment;

and view the mockup from a variety of angles. These mockups will be presented to the public for viewing and should be sufficiently robust. The mockups shall include all finishings, colors, patterns, textures, fasteners and hardware as designed.

4. The mockups shall be built at the Contractor's facility, or the facility of subcontractors or other locations as determined by the Contractor. Comments from the mockup review shall be incorporated into the car design and presented to the Engineer at the final design review. Following any design changes from the design review, the mockups shall be delivered to CTDOT at a location to be determined by the Engineer.

5. The Contractor may build additional mockups for Engineer review at different points in the design review process, to assist in the development of the car design.

E. Scale Model

The Contractor shall provide a 1:20 scale model of each car type to the Engineer. The roof shall be hinged and removable, and the interior shall be fully detailed to the degree practical. Each model shall be finished in a manner that will make it representative of the actual car to be provided. Each model car shall be secured to a modeled section of ballasted track. Each car and track shall be furnished in a separate clear plastic enclosure with a wood base on a 34 in. (864 mm) high pedestal as approved by the Engineer. The enclosure shall be provided with a nameplate of raised or recessed lettering clearly identifying the vehicle type, manufacturer, date of manufacture, and customer name, as approved by the Engineer. [CDRL 03-041]

F. Final Design Review (FDR)

1. The Final Design Review (FDR) of the system components shall be held at the 95% or greater percent level of design. The FDR shall include a review of all documents and plans for the design as revised, including the written descriptions of the functionality, schematics of the system wiring, drawings of each component showing dimensions and structural elements. Redlines and comments from the IDR and mockup review shall be reviewed. The Engineer retains the right to provide additional comments during this process as production progresses and concerns are brought to the Engineer's attention.

2. FDR submittals and activities shall comprise but are not limited to the following:

   a. The continuation and updating of all activities specified as ongoing in the PDR, IDR and mockup review, i.e., CPM, weights analysis, detailed technical specification, car functional analysis, drawing schedule, arrangement drawings and supplier identification.

   b. Detailed Drawings and Related Documents — The Contractor shall submit as a minimum the following detailed drawings and related documents to the Engineer for review and approval:

      i. All top and associated sublevel release drawings, properly dimensioned, detailed, to scale and in accordance with the approved drawing schedule.

      ii. Single line control schematic and functional block diagrams for each subsystem, and electrical wiring diagrams and schematics for all electrical circuits. All test points shall be displayed. The functional block diagrams shall identify the "normal" functional paths as well as the functional paths made available through cutouts, bypasses and redundant circuits. The diagrams shall identify, as a minimum, the critical hardware that permits safe movement of the car, safe ingress/egress of passengers, and essential environmental needs of the passengers and Operator. The functional block

diagrams shall display the levels of hardware (as defined in Military Specification MIL-HDBK-505) that identify the Lowest Level Replacement Unit (LLRU).

iii. A complete set of drawings related to clearance. These shall include static and dynamic envelopes relative to the wayside allowances, including clearances for all parts of the truck, and general arrangement drawings with all static dimensions including camber, low level platforms, high level platforms, curves, etc.

iv. Single line piping and flow diagrams for all pneumatic circuits, displaying all valves and control components. All test points shall be displayed.

v. Graphs and curves giving response and functional characteristics of the car, subsystems and major items.

vi. Manufacturer's data and specification sheets on all control items.

vii. Maintenance requirements and necessary procedures for all equipment in each subsystem. These shall be listed from daily inspection and 92-day inspection to complete overhaul, with frequency and time needed to service being tabulated, and shall highlight all FRA-required inspections.

viii. Stress Analysis — A stress analysis of the carbody shall be submitted to the Engineer for approval.

3.06.05 Component Approvals

A. All vehicle components, except as listed in this document, shall be subject to approval by the Engineer. The goal is to use, as much as possible, components known by the Engineer to perform successfully in the North American intercity passenger railroad environment. This is not intended to prevent the use of innovative concepts, provided the advantages outweigh risks in the judgment of the Engineer.

B. The Contractor may proceed with design pending receipt of design review comments, but at its own risk. Regardless of whether a comment has or has not been provided, the Contractor shall meet all requirements of the Contract.

C. Component Substitution

1. The Contractor is responsible for the selection of all components, parts and materials that are to be used in the design and manufacture of the cars, except where a specific component, material or technology is designated. In the event that a component, material or type of technology is not available as specified, or cannot meet the requirements of this specification, the Contractor shall propose an alternative that meets all applicable specification requirements and is available for use on the rail cars. The proposal shall be submitted to the Engineer for approval in the form of a contract variance, and shall include, at a minimum:

2. Identification and description of the specified part or material that is not available or not specification compliant.

3. Reason the part is not available or not specification compliant. Part or material that is proposed for substitution.

4. Characteristics of the part proposed for substitution, including performance, history of use, supplier or manufacturer, equivalency to the part originally specified, compatibility with other

parts and systems in use on the car, and other relevant information necessary for the Engineer to determine the adequacy and equivalence of the proposed component.

3.06.06 First Article Inspection (FAI)

A. The Contractor shall perform First Article Inspection (FAI) of all major components, subassemblies and fully assembled cars. Any special tool(s) required to maintain the item under FAI must also be present for demonstration at the FAI. The Engineer or its representatives shall be present to witness all FAIs. The Contractor shall perform a satisfactory preliminary FAI on each article prior to notification of the Engineer of a FAI.

B. These inspections shall be conducted at the facilities of the Contractor or subcontractor.

C. FAI Process

1. Within 90 days of NTP the Contractor shall provide to the Engineer, a list of assemblies and subassemblies subject to FAI along with their projected schedule. [CDRL 03-042] The FAI inspection plan shall include the following requirements at a minimum:

   a. A tracking system shall be developed and maintained which will identify each FAI subject and accurately reflect the present status of each inspection.

   b. FAIs shall be performed on an actual sample considered to be complete by the manufacturer and reflecting the approved baseline drawings. Successful completion of engineering tests for the subsystem is a prerequisite for conducting the FAI.

   c. The FAI shall be performed using the approved baseline drawings in conjunction with the Technical Specification reflecting specific requirements of the subject along with any special tools and/or equipment needed to verify the design requirements, configuration and operation (if applicable) of the item being inspected.

   d. All technical data required for maintenance manual and or parts catalogs shall be submitted as initial drafts prior to the full acceptance of the FAI. The initial drafts shall contain enough information to adequately maintain the equipment during the pilot program and initial production car delivery.

   e. The Engineer shall be given notice of an upcoming FAI at least 45 days before its schedule date.

2. This document shall be updated monthly and presented as an attachment to the program meeting minutes.

3. For equipment that requires a FAI, the equipment shall not have passed the FAI unless the Engineer participates in the inspection to its satisfaction. Should the equipment fail inspection, the problem(s) shall be corrected and re-inspected to the Engineer's satisfaction before the FAI is considered passed and production released. An inspection that requires the Engineer participation but is conducted without a qualified Engineer representative shall not be considered as having passed.

4. None of the material and/or parts listed in this section of the Technical Specification shall be installed on the equipment unless the FAI has been performed and approved by the Engineer.

D. Systems Requiring FAI Approval

1. A listing of proposed FAI items shall be included in the QA plan submitted to the Engineer for approval. This shall include as a minimum the following:

a. Carshell (including all major subassemblies)
b. Floor panels
c. Door leaves
d. Door hardware, latches
e. Manual doors
f. Power doors, operators and controls
g. Windows
h. Trucks-frame
i. Trucks-fully assembled
j. Wheel and axle assemblies
k. Couplers and draft gear
l. Air brake system
m. Wheel slide control system
n. Major fiberglass interior components and hardware
o. Seats (including cab seat)
p. Tables (workstation and lounge)
q. HVAC system, controls and temperature controls
r. All external and internal lighting systems
s. Communication system
t. Electrical lockers
u. All electrical panels
v. Batteries and charging system
w. Toilet room
x. Waste collection and retention system
y. LDVR

2. FAI for Cab Car Only

a. Pilot
b. Cab seat
c. Observer seat
d. F-end frame door
e. Alerter/speedometer/overspeed
f. Event recorder system
g. Positive Train Control (PTC) system
h. Windshield wipers

3. The final approval of colors and finishes shall also be subject to FAI and acceptance by the Engineer.

4. Equipment shall be shipped from the point of manufacture only after the FAI has been approved. The Contractor shall provide notice of each FAI inspection to the Engineer at least 45 days prior to the inspection.

5. Audits will not be performed unless the design drawings, production processes, production tooling and any other relevant documentation required for the item to be inspected have been conditionally approved or approved.

6. Approved FAI items shall establish the quality of workmanship for the remainder of the same items being produced and for the car. That quality shall be well documented. Samples of welds fit-ups, finishes, and colors, photographs, FAI documentation, etc., shall be retained for the duration of the production phase in a secure area at the Contractor's facilities for reference by the Contractor's and Engineer's representatives. Changes, modifications or adjustments to this baseline must be approved by the Engineer and will be cause for initiating another FAI by the Engineer.

7. Availability of the information in a timely manner is essential to ensure that the appropriate level of the Engineer's technical expertise is available for the FAI and that the individuals have sufficient prior information to inspect the equipment. The Contractor shall provide the following information to the Engineer at least 15 working days before a scheduled FAI:

    a. A complete list of the equipment and its bill of materials to be inspected.

    b. Identify each completed assembly along with the configuration in which it is to be presented.

    c. A copy of the technical Specification for the equipment and the subcontractor's scope of supply.

    d. A complete drawing package with current drawing approvals. The drawing package should be in sufficient detail to inspect, at a minimum, the fit and finish of the assembly and subassemblies, wire and pipe routing, clearances between components, ergonomic considerations, and any other details that are required to ensure that the equipment is acceptable for the intended purpose.

    e. System schematics, electrical, fluid, pneumatic and piping, with current approvals. The schematics shall be sufficient to determine that the equipment will operate as intended

    f. All instruction manuals, operating manuals, maintenance procedures and heavy repair shall be presented at the FAI for review.

    g. A report by a recognized independent testing laboratory certifying that all materials used in the equipment comply with the 49 CFR Part 238 Appendix B requirements and NFPA 130, as applicable.

    h. An Engineer-approved inspection and acceptance test procedure and an Engineer approved qualification test procedure to which the equipment will be inspected. A functional test shall be required as part of the FAI.

    i. All pertinent calculations or analyses to show that the design is adequate for the purpose intended.

    j. The Contractor shall submit to the Engineer a complete stress analysis and summary, in sufficient detail for the Engineer to analyze, of stress analyses of the car structure, trucks

and major equipment supports, to show compliance with strength level requirements. This stress information shall be submitted at least 30 days prior to the beginning of the compression test, or vertical load tests. If a new truck design is proposed, a complete stress analysis and summary, in sufficient detail for the Engineer to analyze, of the trucks shall be submitted at least 30 days prior to the beginning of the truck fatigue test.

k. Should any of the above documents be incomplete or otherwise unacceptable to the Engineer, this shall be grounds to delay the FAI until they are made right. The burden of any delay shall be with the Contractor.

l. All manufacturing variations of specified materials that vary in color, texture, pattern, etc., shall be presented, for approval by the Engineer, at FAI. Samples of acceptable variation extremes will be retained for reference in future inspections.

m. The FAI sample shall be retained by the equipment manufacturer until the completion of production of all cars.

E. FAI Findings

1. The Contractor shall provide, within one week of the inspection, a package, which includes a copy of all the documents presented/ discussed at the meeting.

2. The Contractor shall provide an FAI report within 10 days of the inspection. It shall include the findings of the inspection, tests and deficiencies, and an action plan to correct all deficiencies discovered during the FAI. The FAI will remain open until all action items are completed to the Engineer's satisfaction. Depending on the severity of the deficiency, follow-up FAI may be required. [CDRL 03-043]

3. The Contractor shall provide color photographs on 8.5 in. (216 mm) by 11 in. (279 mm) size paper and in a digital format within 30 days of the FAI, of each item subject to FAI. [CDRL 03-044] A second set of these photos shall be compiled into an album for the Engineer’s reference for future car inspections and will be supplied to the Engineer with the delivery of the first car.

3.07 Inspection

A. The Engineer shall, at all times, have the right to inspect the work. The Contractor shall grant the Engineer access to the facilities of the Contractor, subcontractors and suppliers to conduct initial and on-going inspections and assessments of the work to determine if it is being performed in accordance with the Contract. During these assessments, the Contractor, subcontractors and suppliers shall make every reasonable effort to assist Engineer personnel.

B. Inspection or lack of inspection, approval or acceptance of any portion of the work by the Engineer shall not relieve or release the Contractor from its obligations to fully comply with all requirements of the Contract.

C. The Contractor shall correct any portion of the work not meeting the requirements of the Contract at the Contractor’s expense to the satisfaction of the Engineer.

D. The Engineer at any time before issuance of final acceptance for any car may order re-inspection of any portion of the work.

3.07.01 Inspections and Tests

A. Inspection of components to be used by the Contractor in performance of the work under this Contract shall be the responsibility of the Contractor, preferably performed at the plant of the subcontractor at which such component is manufactured. This is to give such subcontractor every opportunity to correct, under factory conditions, any inadequacies found. Inspection of components shall be performed again at the Contractor's plant to identify any damage in transit. The Engineer may also inspect selected items at any time, whether or not accompanied by the Contractor's representative, which shall in no way lessen or delete the Contractor's responsibility to make proper inspection.

B. The Engineer shall have the right to inspect any materials, processes, assembly and testing of equipment at subcontractor manufacturing facilities, deemed necessary to ensure compliance with the Contract and technical specifications.

C. The Engineer shall have access at all times to those parts of the plants of the Contractor and/or subcontractors in which any portion of the work is performed for the purposes of inspecting materials and workmanship, and of determining conformity to the Specification during the progress of construction and assembly of the equipment.

D. If any portion of the car shall become hidden by subsequent work contrary to the specific request of the Engineer, that portion of the car shall be made visible for Engineer inspection by the Contractor at the Contractor's expense.

E. The Engineer shall be allowed to participate in all Contractor and/or subcontractor tests and inspections of all components of the equipment, at the Contractor's and subcontractor's plants, for the purpose of QA. Such right to participate shall include the Engineer's right to supplement its on-site inspector with additional experts as necessary according to the particular nature of the test or inspection involved.

F. The presence of the Engineer in the plant of either the Contractor or subcontractor shall not, in any way, supplant or relieve the Contractor's responsibility for making proper inspections or meeting the requirements of the Specification. The Engineer shall have the right to reject all materials and workmanship that do not conform to the Specification. When repetitious rejections occur above 10%, the Contractor shall prepare a written report for the Engineer detailing the problem(s) discovered during inspection and the efforts to be taken to remedy the problem(s). No further acceptance or production shall take place until the Contractor notifies the Engineer in writing that the problems have completely resolved.

G. The Contractor shall document the results of both inbound material inspection and outbound car inspection and testing for each car. Likewise, a "traveler" shall be attached to each car to track QA functions as the work progresses through the shop. A copy of the report must be attached to each car through conditional acceptance.

H. An Inspection and Test Log (Log) shall be maintained by the Contractor during equipment assembly. The Log shall be submitted to the Engineer for review before each car will be released for shipment to the delivery site. All Contractor and Engineer in-process inspection sheets and test data records for that car shall be contained in this Log, which will be provided in the vehicle history book.

I. For those routine inspections and tests of components that are typically performed solely by the Engineer, the Contractor shall give at least 72 hours notice of such inspections or tests to the Engineer. The Engineer shall be allowed to participate in such Contractor or subcontractor inspections or tests at the Contractor's or subcontractor's plants for the purposes of QA.

J. The Contractor must maintain office copies of all records, and they must be accessible to the Engineer, not more than five days after such notice is given.

3.07.02 Contractor Provisions for Engineer's Inspectors

A. From NTP continuously through production, the Contractor shall provide office facilities for the Engineer's representatives at no additional cost to the Engineer. Office facilities will be required at the car construction plants, including the final assembly site and the carshell fabrication site (if a separate facility), as well as similar facilities at any car or equipment qualification testing sites for the duration of the tests. These office facilities shall enable convenient inspection of materials, work and equipment under this contract. The office facilities shall be secure, heated, cooled, and adequately lighted private office for a minimum of three people, with access to toilets and a private conference area, and shall be furnished with desks, chairs and lockable locker facilities. Desks and file cabinets shall be lockable and all keys submitted to the Engineer. Three dedicated telephones with an outside line, high speed Internet connection, access to a photocopy machine capable of high-quality copies shall be provided either within the Engineer's office or nearby (adjacent) area

B. Reserved parking places shall also be provided for all Engineer representatives assigned to the Contractor's facility.

C. Copies of all drawings, manufacturing procedures, test procedures, test reports, test equipment calibration certificates, welder certifications, diagrams, schedules, changes, deviations, revisions and data shall be furnished to the Engineer at the same time these are made available to the Contractor's QA department and in advance of any work being performed. Data shall be sufficient to verify design, construction, assembly, installation, workmanship, clearance, tolerance and functioning of the cars.

3.07.03 Scheduling of Inspections and Tests

A. Inspection and testing activities by Engineer staff will normally be conducted during normal daytime shifts and will not be conducted on Saturdays, Sundays or any holidays observed by the Contractor. Engineer staff may be made available in extenuating circumstances outside normal hours, provided a fully substantiated request is made at least 48 hours in advance in writing and is approved by the Engineer. This request will include compensation by the contractor to the Engineer for this additional expense.

B. In the event that there is no full time CTDOT representative present at the Contractor's facility, the Contractor shall give the Engineer at least 10 working days notice prior to any inspection and testing activities.

C. During the manufacturing sequence of the cars and if a CTDOT representative is already present at the Contractor's facility, the Contractor shall present a written schedule of inspection and testing activities to the Engineer's inspectors at least 72 hours before the activities are to take place.

D. For all inspections and testing activities at subcontractor's facilities, the Contractor shall present a written schedule of activities to the Engineer at least 10 working days prior to the activities. The Engineer will advise within five calendar days whether a representative will attend the inspection or test.

3.07.04 Receiving Inspection

The Contractor shall provide for the inspection of all incoming systems, subsystems, components, parts, equipment and materials to ensure their conformance with procurement documents and condition. All

material certifications and test reports used as the basis for acceptance shall be reviewed for compliance with specifications, retained by the Contractor and kept readily available for inspection by Engineer personnel.

3.07.05 Manufacturing/Assembly Inspection Hold Points

A. The Contractor shall establish inspection hold points in the car manufacturing process to provide for critical inspections by the Contractor's quality staff and the Engineer's representative of completed operations/installations or to inspect items that are about to be covered by succeeding assembly operations.

B. As part of the QA Plan, the Contractor shall submit a list of hold point inspections for review and approval, which shall include as a minimum the following:

1. Each carshell section before painting
2. Each carshell section after painting
3. Each truck frame
4. Each assembled truck, prior to installation under a car
5. Each car underfloor area prior to receiving trucks
6. Each carshell watertightness test prior to installation of insulation and interior finishings
7. Each car final watertightness test
8. Each car interior wiring and components before being covered by panels
9. Each car underfloor area and connections prior to concealment
10. Each finished car interior Each finished car exterior

C. The Contractor shall provide the Engineer 72 hours advance notice of each such inspection.

D. The Contractor and Engineer representatives shall use inspection forms to record any discrepancies noted during inspection. Nonconforming products shall not be released from a hold point area until all discrepancies have been corrected. The inspection forms shall be posted at or near the point of inspection for each car and included in the vehicle history book when all discrepancies have been eliminated.

3.07.06 Car Pre-Shipment Inspection

A. After all work, including factory testing as per Chapter 19, is completed, the Engineer shall perform the car pre-shipment inspection according to an Engineer approved procedure. All manufacturing or testing nonconformance reports shall be closed out and no configuration upgrades will be pending before pre-shipment inspection begins. The vehicle history book as specified in Chapter 22 shall be complete and ready for review and approval signature by the Engineer. The Contractor shall provide a qualified supervisor to accompany the Engineer during inspection to assure that proper corrective action is taken. The Contractor shall provide the Engineer labor and appropriate tools to remove or open and reapply covers and doors. During inspection, all systems shall be operational with use of approved types of special equipment or power supplies.

B. The Contractor shall provide the Engineer 72 hours advance notice of each such inspection.

3.07.07 Car Shipping Inspection

Following pre-shipment inspection, the Contractor shall ensure the car is properly prepared, protected and loaded for shipment in accordance with approved procedures. For shipments by sea, this shall include all necessary preparations for shipment below decks. The Engineer representative will then perform a cursory walk through inspection to confirm that the car has been adequately prepared for shipment before issuing a Release for Shipment document to the Contractor. The Contractor shall provide the Engineer 72 hours advance notice of each such inspection. See Chapter 21 for additional shipping requirements.

3.07.08 Car Modification Inspection

A. The Contractor shall provide written procedures for Engineer review and approval, for the inspection of any car changes or retrofits arising from engineering changes implemented either at the Contractor's facility or on Engineer property. Upon completion of the change, the Contractor shall verify satisfactory completion and modify any quality assurance documentation affected by the change, including the Vehicle history book.

B. The Contractor shall provide the Engineer 72 hours advance notice of each such inspection.

3.08 Contract Deliverable Requirements List

CDRL #	Title	Car Type
03-001	Program Management Plan (PMP)	All
03-002	CPM Plan	All
03-003	Monthly Progress Status Report	All
03-004	Contract Deliverable Requirement List	All
03-005	QA Plan (QAP)	All
03-006	Reliability Program Plan	All
03-007	Reliability Objectives	All
03-008	Product History and System Records verifying MDBCF Requirements.	All
03-009	Reliability Demonstration Program	All
03-010	Maintainability Program Plan	All
03-011	Maintainability Demonstration Plan	All
03-012	System Safety Program Plan	All
03-013	Preliminary Hazard List	All
03-014	Preliminary Hazard Analysis	All
03-015	Hazard Tracking Log	All
03-016	Failure Modes, Effects, and Criticality Analyses (FMECA)	All
03-017	Fault Tree Analyses	All
03-018	Subsystem Hazard Analysis	All
03-019	Operating and Support Hazard Analyses	All
03-020	Conformance Checklist	All
03-021	Fire Safety Analysis	All
03-022	Flammability, Smoke Emission, and Toxicity Test Matrix	All
03-023	Ergonomics Hazard Analysis	All
03-024	Cyber Security Analysis	All
03-025	Safety Certification	All
03-026	Electromagnetic Compatibility Plan (EMC Plan)	All
03-027	Test Report or Certification for Electrical LRUs	All
03-028	Wayside and Carbone Signal Equipment Inductive and Radiated Emissions Limits	All
03-029	Human Exposure Field Limits Test Report	All
03-030	Engineering Plan	All
03-031	List of Major Suppliers	All
03-032	Purchase Orders for Major Suppliers	All
03-033	Configuration Management Plan	All
03-034	Compliance Matrix	All
03-035	Drawing Schedule	All
03-036	Detailed Technical Specification	All
03-037	Pilot Car Interim Detailed Technical Specification	Pilot Cars
03-038	Weight Analysis	All
03-039	Finalized Mockup Review Plan	All
03-040	Mockups	All
03-041	Scale Model	All
03-042	FAI Inspection Plan	All
03-043	FAI Report	All
03-044	FAI Photographs	All

* End of Chapter 3 *

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Technical Specification

CTDOT Single-Level Passenger Rail Cars

Chapter 4

Carbody

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4.00 Carbody

4.01 Overview

A. This chapter describes the characteristics for the design and manufacture of the carshell, and the installation of major components associated with the carshell including glazing, safety appliances, diaphragms, equipment locker components and access doors, and exterior graphics. The major structural elements of the carshell are described, and the requirements for the performance of the carshell structure are defined.

B. The carshell shall be manufactured of stainless steel, American Iron and Steel Institute (AISI) type 301LN or approved equivalent, except for the end underframes which shall be constructed of Low Alloy High Tensile (LAHT) steel. Aluminum carshells will also be considered on a case-by-case basis. The design of the carshell shall comply with all strength and testing requirements as identified, and shall keep the carshell weight to a minimum subject to the car maximum weight limitations.

4.02 General Requirements

A. The carbody shall be designed to the normal and expected base set of requirements established by 49 CFR Part 238, APTA-PR-CS-S-034-99 and this specification.

B. The design shall meet the requirements of APTA-PR-CS-S-034-99 Revision 3.

C. The completed carbody structure shall be designed and constructed in full accordance with all applicable Federal and State rules, regulations and requirements for cars operating in trains, at speeds of up to 125 miles per hour (mph) (201 kph).

4.03 Arrangement

A. The carbody structure shall provide for the mounting of all ancillary equipment; the applicable mounts and the applicable equipment shall be designed and constructed in accordance with requirements of the FRA regulations, and the APTA Standards.

B. Apparatus requiring frequent inspection or attention shall be readily accessible and replaceable. The frequency of required service shall govern the degree of accessibility. Apparatus requiring attention more frequently than every ninety-two (92) days, or in emergencies, shall be accessible from the side of the car or from the inside of the car unless specifically approved by the Engineer. All other underfloor apparatus shall be arranged to provide ready access from maintenance pits and/or from the side of the car. Large apparatus shall be capable of ready replacement by forklift truck from the side of the car, or by overhead crane through appropriately sized roof access panels. Proposed arrangement, mounting details, and maintenance schedules for all equipment over 150 lbs shall be submitted to the Engineer for approval at the design review showing the requirements of the FRA regulations and APTA Standards are met. [CDRL 04-001].

C. The general arrangement of the ancillary equipment shall be approved by the Engineer during the mockup and design review process described in Chapter 3. [CDRL 04-002] Apparatus supports and housings shall be incorporated into the underframe structure, equipment compartments and equipment lockers so that the apparatus, as supplied by the manufacturers, may be mounted interchangeably.

D. All protective devices on the car that are not specifically required to be located inside the carbody, or to have provisions for resetting from within the carbody, shall be located undercar at the side or in

the overhead equipment compartments or other equipment compartments approved by the Engineer. Provisions shall be made for access to such devices without encroaching upon the clearance limit outline. For purposes of this paragraph, protective devices shall include air brake cut outs, circuit breakers, fuses, latching protective relays and other devices requiring replacement or resetting to move the car or cause auxiliaries to function. Locations for all protective devices shall be identified on arrangement and installation design drawings and approved by the Engineer. [CDRL 04-003]

E. All specified equipment on the car shall be arranged so that the maximum imbalance requirements in Chapter 1 are met.

F. A sufficient number of jigs, fixtures and templates shall be used to assure interchangeability of components and uniformity of structure throughout the fleet. Parts of the bodies, such as underframes, side frames, end frames and roofs shall be built on jigs. All weld and bolt patterns shall be identical on all cars. All equipment hangers shall be interchangeable on all cars without the use of shims or elongated holes.

G. The vehicle shall be designed for at least, but not necessarily limited to, the worst loading case arising out of the possible simultaneous combinations of the following loads acting on the vehicle:

1. Car tare weight (AW0)
2. Crush passenger load (AW3)
3. Vertical, lateral and torsional dynamic load due to wheel/rail interaction
4. Loads due to vehicle pitching caused by braking
5. Snow or ice loads
6. Aerodynamic load
7. Train passing wind loads: Compressive and lateral loads caused by another train passing in the opposite direction on an adjacent track with relative speeds of 250 mph (403 kph)
8. Buff load

H. A full width, dedicated operator's cab shall be provided on the cab car and shall maximize the operator's viewing area.

4.03.01 Dimensions, Weights and Under Car Clearance

A. The completed car shall have the following overall dimensions:

Length (over coupler pulling faces)	85 ft (25,908 mm)
Height (maximum) (ATOR)	14 ft 8 in. (4,470 mm)
Overall Car Width (maximum)	10 ft 6 in. (3,200 mm)
Truck Centers	59 ft 6 in. (18,136 mm)
Floor height (ATOR)	4 ft 3 in. (1,295 mm)

B. The completed car shall include all antennas and other devices mounted to the car, and shall fully conform to PRIIA Drawing 305-801.

C. The final car dry weight shall not exceed the following weight restrictions:

Trailer Car	105,560 lbs (47,882 kg)
Cab Car	109,960 lbs (19,877 kg)

D. Except for the pilot, the completed car shall comply with the minimum allowable clearance above top of rail for the carbody and all associated components under the worst combination of conditions, including fully worn wheels, solidly compressed or broken springs, AW3 passenger load, carbody deflection to zero camber and environmental conditions including wind, snow and ice.

4.03.02 Physical Requirements

A. The carbody structure shall be designed to prevent water, snow or dust ingress when operating at any permissible speed under all weather conditions consistent with the worst case climatic data as specified in PRIIA specification 305-912.

B. The carbody shall be designed to provide watertight performance without requiring topically applied sealant. Where sealant is used to enhance the watertight performance, it shall be applied in compression between assembled parts. Sealants shall have a service life of at least 40 years. Sealant type and location shall be detailed and submitted during the design review. [CDRL 04-004]

C. Housings for externally mounted equipment shall be completely watertight when covers are in place, excluding battery boxes, which are ventilated. Drain holes shall be provided to prevent the accumulation of water.

4.03.03 Carbody Materials

A. Materials used in carbody construction shall be in accordance with the provisions of APTA-PR-CS-S-034-99 and requirements of this Specification. The carbody shall be constructed of stainless steel, except the end underframe, which shall be constructed of LAHT. All welding shall conform to the requirements of Chapter 18.

B. LAHT shall be used for the end underframe assembly. The LAHT steel shall comply with all requirements of Chapter 18 and APTA-PR-CS-S-034-99. Dissimilar metals shall not be used at connections requiring disassembly for removal and replacement of equipment.

C. Cross sectional views shall be provided on carshell drawings and must be submitted for approval at the design review. [CDRL 04-005]

D. Carshell drawings shall show the location of all principal framing members, their cross-sectional area, material and metal thickness. Thickness of all sheathing materials shall be provided. The information shall be sufficient to manufacture structural parts for the repair of any damage to a car.

E. The Contractor shall submit for Engineer approval the types of materials and their respective locations to be used in the components of the carbody. [CDRL 04-006]

F. A corrosion-resistant coating shall be applied to the entire underframe and to the inside of the side and end sheets. A corrosion resistant coating is not required on stainless steel members. The method used by the Contractor to prevent corrosion from the inside surfaces of closed structural sections (i.e. inside of tubular sections) shall be reviewed at the design review. [CDRL 04-007] Any exterior location which may collect or direct water must be highlighted and proven against water entrapment during the design review.

G. If an aluminum structure is proposed, the benefits to CTDOT shall be thoroughly proposed. Each different alloy intended for the carbody structure shall be included in the proposal. APTA-PR-CS-S-015-99 shall be met for all aluminum structures. 2000 series and 7000 series aluminum alloys shall not be used. Proposed exterior surface treatment and painting processes shall be detailed in the

proposal. Methods and processes shall be detailed showing how dissimilar material isolation is ensured. Intended suppliers and welding processes for aluminum shall be detailed in the proposal. Any aluminum exteriors shall not be etched during the intended life of the vehicle.

4.03.04 Carbody Exterior Finish

A. Specifications and samples for all external surfaces shall be submitted for review and approval. [CDRL 04-008]

B. Stainless steel carshells shall be unpainted, except as specified for exterior graphics. The Contractor shall submit six 8 in. x 10 in. (305 mm x 305 mm) samples of several standard finishes between 80 - 180 grit for selection by the Engineer. Alternative finishes may be proposed for Engineer approval. Side sheets shall have a horizontal grit finish while end sheets shall have a vertical grit finish. All sanded surfaces shall have the same finish whether applied by hand or machine. All stainless steel parts shall undergo a process of passivation in order to maximize the inherent corrosion resistance of stainless steel as per ASTM Standard A380-06. A passivation plan for exterior welds must be supplied for review at the design review.

C. All sheet metal, exposed to view, shall be as smooth as possible on the outside with a maximum variation from a straight line on flat surfaces, measured in any direction, of 0.125 in. (3.18 mm) and 0.0625 in. (1.59 mm) over a distance of 36 in. (914 mm) and 12 in. (305 mm), respectively, on the sides of the car and 0.1875 in. and 0.125 in. (3.18 mm) over a distance of 36 in. (914 mm) and 12 in. (305 mm), respectively, on the roof. The slope of any such deviation shall not exceed 0.1875 in. (4.76 mm) in 12 in. (305 mm) Dents, gashes or other surface imperfections shall not be permitted.

D. For carshell exteriors, all exterior surfaces shall be free of ripples and buckling. Maximum allowable variation from a straight line or the designed curved line shall be as follows:

   1. All exterior side and roof surfaces not hidden by covers or shrouds shall have a maximum 0.09375 in. (2.38 mm) variation (peak to valley) in 36 in. (914 mm) measured in any direction.

   2. Areas within 8 in. (203 mm) of the side doors and vehicle ends may have a gradual slope towards the doors and ends with a maximum deviation of 0.1875 in. (4.76 mm) from the side sheet contour.

   3. Exterior surfaces hidden by covers and shrouds shall have a maximum 0.125 in. (3.18 over a distance of 36 in. (914 mm).

E. Structural members of the underframe visible from the perpendicular side view of the carbody shall be minimized and views shall be submitted during the design review for approval.

F. The carbody shall incorporate front masks on the cab end which shall provide an aesthetically attractive and modern appearance using aerodynamic streamlined, lightweight, high-strength, fiberglass reinforced plastics, or approved equivalent.

   1. The masks shall be attached using fasteners at points with integral stainless-steel reinforcement plates.

   2. The masks shall be designed to direct water from the roof to the outer corners of the car and minimize the flow of water over the ends.

   3. The masks shall be designed for ease of replacement installation.

4.03.05 Fabrication

A. The carbody structure shall be assembled by welding. Connections of LAHT 0.125 in. (3.18 mm) or greater shall be designed in accordance with AWS Standard D1.1, while connections in thinner material shall be designed in accordance with AWS Standard D1.3. Connections of stainless steel shall be designed in accordance with AWS Standard D1.9. Resistance welding shall be in accordance with AWS Standard D17.2/17.2M. Refer to Chapter 18 for structural welding practices.

B. Where the carbody structure must be assembled with mechanical fasteners, the fasteners shall be high-strength lock-bolts and all locations shall be approved by the Engineer. [CDRL 04-009]

C. All welds, bolt patterns, and bonds shall be regularly spaced and identical on all cars, to the maximum extent practical. All weld and bolt patterns visible from the perpendicular side and end views of the carbody shall maximize symmetry and aesthetics.

D. Bolts, rivets or welding may be used to join secondary structure or for attaching brackets and equipment to primary structure in subassembly. Otherwise, attachments that are not part of the carbody structure shall be attached to the structure with mechanical fasteners.

E. Sheet metal screws and self-tapping screws shall not be used to attach access panels or other frequently removed items.

F. Rivets, blind rivets and lock-bolts shall be set with power tools.

G. All holes for mechanical fasteners shall be clean and free of burrs.

H. Adequate drainage shall be provided in all body structure members. Any enclosed structural cavities of steel members shall be treated with a rust-inhibiting coating as specified in Chapter 18. Any exterior location which may collect or direct water must be highlighted and proven against water entrapment during the design review.

I. The proposed construction tolerances of the finished vehicle shall be submitted for review and approval. [CDRL 04-010]

J. Where used in the carbody, shims shall be permanently attached to the carbody structure and submitted for review and approval. [CDRL 04-011]

K. All mechanically fastened connections shall be designed using a factor of safety of 1.5 based on the proof load of the fastener. Clamping force friction shall be ignored in the design and analysis of mechanically-fastened connections.

L. All bolts supplied shall be a minimum SAE J429, Grade 5, or approved equivalent, including markings.

M. All nuts shall be per SAE J995 and shall match the strength of the bolts.

N. Tapping plates shall be presented for approval during the design review, and if used, shall be attached to the car structure by welding or with mechanical fasteners unless considerations of reduced material properties and stress concentrations have been considered in the original design and analysis. The tapping plate shall be equal to or greater in thickness than the diameter of the bolt for which the tapping plate is intended, and clearance hole shall be drilled in the structure for the bolt. Tapping plates shall be designed to the same strength standards as the equivalent nut. [CDRL 04-012]

O. Intermittent fillet welds on tension members, or in the areas that experience fatigue are prohibited. All plug welds, as well as slot welds on tension members or in areas that experience fatigue are not allowed except when specifically approved by the Engineer based on justification provided by the Contractor, and appropriately enhanced inspection protocols. Intermittent groove welds are

prohibited. Stud welding to carbody structure is prohibited; however, stud welding to non-load carrying members and secondary structure shall be permitted.

4.04 Structural Design Details

4.04.01 Level

The difference in height Above Top of Rail (ATOR) of the four corners of the finished car shall not exceed 0.375 in. (9.52 mm) measured at the end sills. The measurement shall be made on the completely assembled and equipped car mounted on its completed trucks. The measurement may be made from any suitable structural member of the underframe, and shall be documented in each vehicle history book.

4.04.02 Camber

A. Carbody camber shall be defined as its vertical curved shape as viewed in side elevation, and shall have smooth curvature from end-to-end of the carbody. Maximum camber shall be measured from a datum line drawn between the intersections of the primary arc with the centerline of the body bolsters to a line tangent to the arc midway between bolsters.

B. The car shall have a positive camber not to exceed 0.5 in. (12.7 mm) under AW1 conditions and must be designed so that under full load, AW3, (and for the life of the car) a negative camber shall never occur. The difference between the maximum cambers of each side sill, shall not exceed 0.125 in. (3.18 mm). The Contractor shall evaluate and submit predicted camber values at five locations along the side sills, not including bolster locations, at AW0, AW1 and AW3 load for approval at the design review. Predicted camber values shall be verified during structural testing.

4.04.03 Carbody Strength

A. The strength of the carbody shall equal or exceed the requirements of 49 CFR Part 238, Subpart C and APTA-PR-CS-S-034-99.

B. Fatigue

1. The carbody strength shall be sufficient to permit operation with up to AW3 loading for the design life of the car (40 years) without structural damage, including fatigue cracks. The carbody shell shall meet the static and dynamic strength requirements stated in this section.

2. Allowable fatigue stress of welded elements shall be determined from AWS Standard D1.1, for steel. Where insufficient information is available due to the lack of published data on this subject, the allowable fatigue stress shall be determined experimentally through testing by the Contractor.

3. The completely equipped carbody shall be designed to carry its AW0 carbody weight (not including truck weight) plus a uniformly distributed passenger load equal to the passenger portion of AW3. The stresses in the carbody, under an applied AW3 load less the truck weight load, shall not exceed the lesser of 50% of the guaranteed minimum material yield strength, or the buckling strength. The inelastic buckling strength of structural members subjected to any combination of compression and shear shall be calculated. The variation in the stainless steel compression modulus with stress shall be addressed in calculating compressive stability of stainless steel members. The buckling values shall be used as the basis for the allowable stress values for the specified load cases. Any structural member in any of the elastic static analyses with a calculated compressive stress equal to, or greater than, 35% of its material's yield strength shall be included.

4. Notwithstanding the previous paragraph, for each joint design, the static stress at the AW3 carbody load shall be less than the stress that determines the allowable fatigue stress range. The allowable fatigue stress range shall be computed by multiplying the static stress at the AW3 load by the dynamic factor (fatigue load range). This stress range shall be within the design fatigue stress range (fatigue limit) obtained from AAR Standard C-II, Section 7.2, or AWS Standard D1.1, and as approved by the Engineer.

5. The Contractor shall conduct fatigue tests to determine allowable fatigue stresses for joint designs not covered by AAR Standard C-II, Section 7.2 or AWS Standard D1.1.

6. The dynamic factor shall be determined by the Contractor and shall not be less than ±20% of the vehicle's AW3 mass vertically and laterally, and ±10% longitudinally. The fatigue design shall be based on applied and allowable fatigue stress ranges at 10 million cycles.

4.04.04 Underframe Structure

A. The underframe shall be composed of the center sill, if used, end underframes, floor stringers, subfloor, cross bearers and side sills. All parts of the underframe shall be constructed of stainless steel, except the end underframe which shall be constructed of LAHT steel.

B. Side and center sills shall connect the end underframe assemblies and support the transverse floor members. Side sill materials shall be compatible with the side sheet materials.

C. Cutouts, holes, and passthroughs in the structure of the end sill, body bolster, draft sill, and side sill shall be minimized. When it is necessary to pass through closed structural sections of these subassemblies with wiring, drains, piping, etc., the structure shall first be closed with separate structural elements, such as a pass-through pipe, before installing the components which pass through.

D. End underframe

1. The end underframe assembly, at each end of the car, shall be a weldment comprising the body bolster, draft sill, end sill, coupler support structure, buffers and other adjacent structure.

2. The coupler and draft gear carriers shall be included in the assembly. The end underframe shall be constructed of LAHT steel.

3. Fusion welding of one-sided joints in the fabrication of the end underframe shall incorporate the use of back-up strips where 100% penetration of a single beveled weld is desired. The single bevel weld shall be reinforced by the application of an additional fillet weld where joint strength requires it.

4. The end underframe weldment shall provide for continuity of flanges and webs at any place where load-bearing members intersect. The end underframes shall be designed so that, in case of excessive impact, failure shall be by buckling or crushing of structural elements rather than by shearing of structural elements or by failure of connections between elements.

5. The end underframe shall be constructed of LAHT, assembled by arc welding, in accordance with Chapter 18 and AWS Standard D1.1, using AWS pre -qualified complete-joint penetration groove welded joints as defined by AWS Standard D1.1, wherever primary loads are carried across the joint in tension or compression. AWS pre-qualified partial joint penetration groove welded joints may be used, when approved by the Engineer, where primary loads are carried in shear along the length of the weld. Fillet welds may be used in joints which do not carry primary loads.

6. If heat treatment is required for stress relief, the assemblies shall be heat treated after welding in accordance with AWS Standard D1.1 and identified during the design review.

7. In order to avoid difficulties in attaching the light-gauge floor pans to heavy underframe members, brackets or clips may be provided on the underframe for subsequent attachment of floor pans.

E. End sill

The end sill shall include the buffer beams, the anti-climbing arrangement and the collision post stubs and shall be securely attached to the collision posts, side sills and the draft sill. The collision post stubs shall extend down to the bottom plate of the end sill and shall be securely welded to both the top and the bottom plates.

F. Anti-climbing mechanism

The carbody design shall provide an anti-climbing system at each end of each car. The anti-climbing system shall be designed in accordance with 49 CFR Part 238.205 and of APTA-PR-CS-S-034-99. Anti-climbers shall be compatible with all vehicles in the Engineer's fleet. An anti-climbing system for each car type shall be proposed to the Engineer within 90 days of NTP. [CDRL 04-013]

G. Coupler carrier

A coupler carrier shall be provided as part of each end underframe assembly and provide a low friction sliding surface for the coupler. The coupler carrier, and those portions of the carbody to which it is attached, shall be designed in accordance with the requirements of APTA-PR-CS-S-034-99, 49 CFR Part 238.207, and Chapter 6. The coupler carrier, and those portions of the carbody to which it is attached, shall also be designed to withstand the loads caused by supporting one end of the car on the coupler carrier, with the truck attached, such might occur during emergency jacking or lifting with a crane in the event of a derailment. Under this coupler carrier load, the allowable design stress of the coupler carrier, or any part of the carbody structure to which it is attached, shall be the yield strength, the critical buckling stress or 80% of ultimate tensile strength, whichever is lower.

H. Body bolster

1. The body bolster shall be designed to transmit loads between the truck and the carbody, and between the draft sill and the body and side sills. The design shall provide clearance for the truck in all positions and accessibility for truck maintenance and de-trucking. Positive stops shall be provided on the carbody and truck bolsters to limit the vertical and transverse movement of suspended trucks when the carbody is lifted. The stops shall comply with APTA-PR-CS-S-034-99.

2. The design and construction of the bolster shall consider the high fatigue environment in which it will be operating. Welding shall be as per AWS Standard D1.1.

I. Draft sill

The draft sill shall extend longitudinally from the end sill to the body bolster and shall include the coupler support structure. It shall be designed to transmit the specified loadings from the anti-climber and coupler into the body bolster.

J. Side sill

Side sills shall be provided on both sides of the car and form a structurally continuous bottom chord for the side frame.

K. Cross bearers, floor beams and floor pans

1. Cross bearers shall be provided to transfer the applied vertical loading from the center sill (if used) to the side framing, or between side sills. Floor beams shall be provided to transfer the vertical floor loads to the side sill and side framing. The cross bearers and floor beams shall be

fastened to the center sill, if used, so that they stabilize the center sill against column failure, both vertically and laterally.

2. A stainless steel floor pan shall be provided underneath the floor throughout the length and width of the car. The floor pan shall be securely fastened to the bottom flanges of the floor beams and to the draft sills and side sills, and shall be sealed in a manner approved by the Engineer. The floor plan shall be designed to facilitate replacement or repair of damaged portions and yet provide the attachment and sealing required to meet the structural, car pressurization and fire safety requirements. If the floor pans are separate sheets, they shall be securely fastened to the car structure. A weatherproofing sealant shall be applied to the edges of the sheets immediately before installation. The fastening and sealing system shall prevent air, moisture, dirt, dust and debris entry into the sub-floor for the life of the vehicle.

3. The floor pan shall contain the underfloor thermal and acoustic insulation. The pans shall be suitably reinforced for structural rigidity and to prevent resonant noise and vibration and "oil canning" under any operating condition.

4. Cross-sectional drawings, interface illustrations, and installation processes fully detailing flooring components, carbody structure and flooring supports, structural joints, subfloor pan components and joints, floor panel supports and joints, sealants, adhesives, acoustic layers, thermal insulation, and floor covering and seat attachments shall be approved by the Engineer. [CDRL 04-014]

L. Subfloor and floor system

1. The floor panel material shall be composite construction. Plywood based flooring is not acceptable. Floor panel material shall be a service proven product with at least 7 years successful revenue service on a minimum of 100 cars. Material type, melding and curing fabrication processes, and service history of the floor panels shall be submitted for Engineer review and approval. [CDRL 04-015]

2. Floors shall be designed and manufactured so that no permanent deformation or soft spots shall occur during the required service life of the vehicle. Floors shall be resistant to spills, washing solutions and moisture; the floor panel system shall be waterproof and resistant to degradation. Floor system panels shall be as large as possible extending the width of the interior, shall not form part of the vehicle shell structural strength and shall have no joints in the doorways and minimize joints in walkways. To the extent possible, floor panels shall be interchangeable throughout the vehicle and between vehicles.

3. Under a dead load and a maximum passenger loading of AW3, the floor panels shall deflect by no more than 1/250 of the short span between members, up to a maximum of 0.0625 in. (1.59 mm), without permanent deformation. Floor panels shall be attached to the carbody structure using an approved fastener system.

4. Elastomeric anti-squeak tape shall be applied between floor panels and supporting structure. The floor material shall have shear strength not less than 400 lbs/in.^{2} (3 MPa) and shall be capable of passing ASTM E119 fire test.

5. A single floor covering for the full length of the vehicle is preferred. Edges of the covering shall be bent upward to pool water away from vertical surfaces. The design shall not allow liquids to accumulate in voids around walls, door pockets, thresholds, seat mounts, and heaters. Dry and wet friction coefficients of the covering shall be provided to the Engineer for approval. After the floor covering installation has been inspected, a temporary protective floor covering shall be installed to protect the entire floor and remain in place until the acceptance of the vehicle. [CDRL 04-016]

4.04.05 End Frames

A. The car end frames shall consist of two corner posts, one each at the juncture of the front end and side frames, two collision posts located at the approximate third points of the end frame width, but in any case not more than 40 in. (1,016 mm) apart, an end door, a structural shelf, framing posts and sheet metal sheathing connected to the structural framing members as necessary. It shall be designed to resist the specified vertical, transverse and torsional loads as required by APTA-PR-CS-S-034-99.

B. The door posts and header shall be designed to carry the end door while maintaining weather tightness. Corner posts shall be continuous from the end underframe to the side rail at the side frame/roof connection.

C. If exposed, the end sheets shall be of the same material as the side sheets and securely framed to the car structure.

D. Composite masks on the end walls are preferred but the sum of endbody elements shall still be equivalent to a 0.5 inch (12.7 mm), 25 ksi steel sheet strength.

E. Proposals utilizing Appendix F of 49 CFR Part 238 to meet regulatory requirements, and in place of applicable collision post and corner post requirements below, will be considered by the Engineer. A summary of design concepts, strength evaluation methods, and testing plan shall be included in the proposal. Validation of Appendix F designs shall be through analysis and testing.

F. Alternative, history proven designs, which include CEM, will be considered by the Engineer.

   1. Vehicles with CEM shall meet APTA-PR-CS-S-034-99 Rev. 2 or the most CEM applicable, APTA standard at the time of proposal.

   2. Full size representations of the CEM and its surrounding carbody structure, explicitly designed to assist the CEM functionality, shall be tested dynamically.

   3. If a design which includes CEM is proposed, the following shall be provided in a dedicated carbody section of the proposal:

      a. A list of any item in this specification which may require modification or exemption to allow for the CEM alternative.

      b. A list of all documents, previously developed, which validated CEM component and/or subassembly design development, analysis, and testing. These documents shall be provided within 30 days of NTP.

      c. A detailed summary of the findings and results of the documents above, including intricate illustrations of the CEM's integration into the vehicle.

      d. Any additional design or testing activities needed to meet the requirements above.

G. Collision posts

   1. The car end structures shall be provided with vertical collision posts of stainless steel at both sides of the end openings, fastened securely into the roof structure at the top and welded to the top and bottom plates of the end underframe. The collision posts shall be constructed of stainless steel or LAHT.

   2. The collision posts shall be continuous closed sections from the bottom of the end sill to the top of the roof.

3. If reinforcement is used to provide the specified collision post shear strength at the floor, it shall be designed to transmit the specified shear and other loads into the end underframe.

4. At a minimum, the cab end reinforcement shall be continuous from the bottom of the end sill up to at least 30 in. (762 mm) above the top of the underframe, then gradually taper to a point not less than 42 in. (1,067 mm) above the top of the end sill. The non-cab end reinforcement shall, at a minimum, be continuous from the bottom of the end sill up to at least 18 in. (457 mm) and then taper to a point at 30 in. (762 mm). If shear reinforcement is not used, the post shall be arranged to penetrate the end underframe unit and weld to the top and bottom plates of the end underframe unit.

5. The connections and supporting structure at the tops of the collision posts shall be designed to develop sufficient horizontal, vertical and bending strength, so that if one or both posts, whichever is more critical, is overloaded in bending to ultimate strength, the post top connections and supporting structure, if stressed beyond their yield strengths by the resulting horizontal, vertical and bending loadings, shall deform plastically by buckling and bending of the members to accommodate the post plastic bending failure. The ultimate strength of the connections and welds shall be sufficient to prevent their failure, even with severe plastic deformation of the collision posts and of the top connecting and supporting structural elements.

6. Structural energy absorption capacity of the collision post and connecting structure as per the requirements of APTA-PR-CS-S-034-99, shall be designed into the structure and shall be demonstrated to the satisfaction of the Engineer.

7. Overload of collision post bottom connections shall result in buckling and crushing of the underframe structural members to which the collision posts and any collision post reinforcements are attached, rather than by shearing or fracturing of the posts.

8. For the stress analysis for bending in the plastic range of the material, the reduction in modulus of elasticity and its effect on the stability of the post compression flange shall be considered and included in the strength calculations. The calculation method outlined in the AAR *Manual of Standards and Recommended Practices*, Section C, Part II, Paragraph 4.2.2.16, or another method approved by the Engineer shall be used. The calculations shall be based on extended stress strain curves determined experimentally by the Contractor if these data are not otherwise available.

9. Lifting eyes shall be installed at the extreme top edge of each collision post.

10. Preliminary layout drawings and supporting calculations of the cab end frame members shall be submitted for approval before the end frame design is finalized. The drawings shall be clearly marked to indicate conformity to the requirements of this section.

11. The stress analysis as required shall include an analysis of the collision posts and corner posts together with their connections and supporting structure.

H. Corner post

1. A structural post shall be installed at each corner of the car. The posts shall be continuous closed sections from the bottom plate of the end sill to the roof. The posts shall be connected to the top and bottom plate of the end sill, side frame, roof structure and intervening structural shelves. The attachment of each corner post at the bottom shall be sufficient to develop its full shear value.

2. Overloading of the corner posts at the level of the top of the end sill shall result in the buckling and crushing of underframe members to which the posts are connected rather than the shearing-off of the posts themselves.

3. Structural energy absorption capacity of the corner post and connecting structure as per the requirements of APTA-PR-CS-S-034-99 shall be designed into the structure and shall be demonstrated to the satisfaction of the Engineer.

4. The corner post shall be connected to the side frame, end frame, and roof structures such that the yield strength of the connections and the supporting structure will not be exceeded when the corner posts are loaded to their yield strengths, as described above. In addition, the roof and roof connections shall resist, without failure, the top load of the corner post, when the corner post load is increased to the ultimate bending strength of the post.

5. The corner posts shall be continuous closed sections from the bottom of the end sill to the roof unless shear reinforcement is used. If shear reinforcements are used, the corner posts shall be welded to the shear reinforcement at the floor, to the intermediate side frame rails and sheathing, and to the roof rails to develop the full strength of the posts.

I. Structural shelf

A structural shelf shall be provided just below the cab end windows, connected securely to the corner post and the collision post. The shelf may be integrated with the control console in the cab control compartment.

4.04.06 Side Structure

A. Side frames shall consist of vertical members such as window posts and door posts, and longitudinal members such as roof rails, side sills, window top rails and belt rails. It shall include sheathing and internal skin stiffening members. Structural posts shall be located at the sides of door and window openings and elsewhere as required, to limit deflection and fatigue stresses. Structural posts shall be continuous between side sill and roof rail. All posts shall be formed sections. Where longitudinal rails are interrupted by posts, gussets shall be used to reinforce connections to effectively make the rails continuous. All gussets shall be full height. The side frame posts or stub posts (between side sills and belt rails) shall transmit applied vertical loadings from the body bolster ends, cross bearer ends and jack pads into the side frame sheathing.

B. The belt rail (the horizontal rail member at the bottom of the window openings in the side frame) and its supports shall be designed to resist the specified side load in accordance with APTA-PR-CS-S-034-99 and shall comply with the requirements of 49 CFR Part 238.217.

C. Intermediate structural elements between the side frames shall transfer all seat and floor loads to the side frame posts. Passenger seats shall be supported on the wall side by continuous structural members fastened to the side frame posts.

D. The carbody side and side frame posts shall be capable of supporting AW3 loads with a minimum safety factor of 2.0, based on yield strength, without permanent deformation, at a deflection not to exceed 0.125 in. (3.18 mm).

E. Side sheets

1. All the exterior sidewall and endwall surfaces of the carbody shall be stainless steel or composite if used as an end wall mask. The required appearance of exposed welds shall be as described in Chapter 18. Three samples of all exterior finishes shall be submitted to the Engineer for approval. [CDRL 09-017] These samples shall be used throughout the program to maintain quality. Dents, gashes or other surface imperfections shall not be permitted. Samples of the exterior finish specifying the direction of the grain and the flatness shall be submitted for approval at the design review.

2. Side sheathing shall be resistance spot welded to the outside of the side frame posts between the side sill and the roof. Exterior sidewall and endwall sheets shall be smooth and free of corrugations and shall be stiffened by corrugations or similar sections resistance welded to the inside face of the exterior sheet. Weld spacing shall be in accordance to Chapter 18. Flat side sheathing shall be a minimum of 0.059 in. (1.50 mm) thick.

3. The side sheet shall be attached to the side sill by a continuous fillet weld or by a series of resistance welds. If resistance welds are used, they shall develop the same strength as a continuous fillet weld. Strength in tension and shear shall be reviewed in the stress analysis.

4. As much as practicable, underframe structure shall be hidden by the side sheet. Side sheeting which extends beyond the side sill should be supported and protected from debris with structural members and mounts to the extent practical.

4.04.07 Roof

A. The roof shall be constructed with corrugated sheets. The car roof framing shall consist of carlines (transverse) and purlins (longitudinal), all suitably fastened to the side and end framing to provide a strong, rigid, integrated structure. The roof shall be properly reinforced and braced with the structural members to carry the weight, stress and vibration due to roof mounted apparatus.

B. All members of the roof framing shall be designed and arranged to permit the installation and fastening of roof wiring, lighting fixtures, equipment, ventilation ducts and other required apparatus in a secure manner. The roof framing shall be arranged to allow the replacement and maintenance of overhead mounted equipment through removable interior ceiling panels without disturbing the carbody structural members. Ducting for the circulation of conditioned air shall be coordinated with the roof framing arrangement and configured to be consistent with the air distribution requirements of the heating and air conditioning system.

C. The roof shall be framed and reinforced around openings. All reinforcement shall be welded stainless steel. Reinforcements and joints on the roof shall be made watertight by welding or solderingNo through-roof mechanical fastening is permitted. The roof sheathing and structure shall be designed to support the specified roof loads. Both ends of the roof shall be designed to support the tops of collision posts and distribute the specified collision and corner post loads.

D. Flat surfaces or plates shall be provided on the roof for all roof-mounted appliances such as antennae. Roof penetrations for wiring or piping to roof-mounted equipment shall be suitably sealed, and all wiring and piping shall be routed to roof-mounted equipment through conduit. All roof-mounted equipment shall be mounted on the longitudinal centerline of the car unless otherwise specified.

E. All parts of the roof structure, sheets, equipment covers, roof walkway, screens and other guards shall have sufficient strength to withstand, without exceeding the yield strength, 80% of ultimate strength and critical buckling stress under the following conditions:

1. Meet the rollover strength requirement defined in 49 CFR Part 238.215.

2. 60 lbs/ft^2 applied over a 12 in. vehicle wide longitudinal section representing a mechanical car washer

3. Three concentrated loads of 250 lbs at 30 in. intervals applied over a 3 in. square to represent workers on the roof

4. Maximum ice and snow accumulations up to 12,000 lbs spread evenly across the top of the vehicle.

F. The design loads for equipment and apparatus attached or mounted to the roof, including gutters, air scoops, antennae, lights, equipment supports and supporting roof framing shall meet the carbody fatigue requirements in this Specification.

G. Equipment mounted under the roof suspended from the roof structure shall be bolted to the framing members. The framing members shall be reinforced in subassembly to accept the equipment load.

H. Emergency access "cut zone"

Roof emergency access shall be in accordance with FRA 49 CFR Part 238.123 and APTA—PR-CS-RP-001-98 and APTA-PR-CS-S-034. Perimeter of the cut-zone shall have a retro-reflective sign demarcating the opening, and clearly indicating the purpose, instructions and other emergency signage per APTA-PR-PS-S-002-98.

I. Gutters and deflecting plates

1. Water deflecting gutters shall be installed on the entire length of the roof on both sides of the car. They shall prevent water from dripping into or in front of the side door opening, any indicator lights, sign fixtures, or key switches when the car is stopped. Gutters shall also deflect water off the entire end of the car.

2. Deflecting plates shall be installed at the ends of the roof to direct water between cars. The design arrangement and installation of roof equipment shall not permit accumulation of water. Drainage provisions must be submitted for approval at the design review. [CDRL 09-018]

3. Gutters and deflecting plates shall withstand regular passage through a car wash. Gutters shall be made from the same material as the shell, roof and side sheets and if welded shall use welding methods to maximize aesthetics.

4. Alternative gutter designs that meet the Specification requirements shall require approval of the Engineer.

4.04.08 Jacking Pads

A. Eight jacking pads, with anti-skid plates, shall be provided in approved locations to lift the car, with trucks attached, at or inboard of the bolster for maintenance and at the extreme ends of the car in the event of a derailment. The car shall be designed to permit jacking for truck removal or re-railing with one end of the car resting on its truck, without damage to the truck attachments, underframes or any of the underfloor equipment.

B. It shall be possible to jack up a complete car, or either end of a car, utilizing portable jacking devices and to subsequently support the car with portable stands with trucks remaining on the rails and remove the portable jacks. It shall be possible to manually roll the trucks from under the end of the car when supported on jack pads.

C. The jack pads shall be a minimum of 32 in. (813 mm) ATOR. The jack pads shall be 8 in. wide and 5 in. deep (203 mm wide and 127 mm deep) (width is parallel to car's side sheet) with a suitable surface to avoid slippage. The pads shall extend 0.5 in. (12.70 mm) to 1 in. (25.40 mm) below the bottom of the side sill.

D. The design vertical load for each jacking pad shall not be less than one half the empty weight of a ready to run (AW0) car. The design horizontal load shall be 10% of the design vertical load. The horizontal load shall be applied simultaneously with the vertical load in any direction to produce the worst stress condition. The allowable design stress shall be yield or 80% of ultimate, whichever is lower or the critical buckling stress of any part of the jack pad or the structure to which it is attached. Jacking pads shall extend a minimum of 0.5 in. (12.70 mm) below the bottom of the side sill.

E. There shall be no permanent deformation when the car is symmetrically jacked from any combination of pads with the car at AW0 with the trucks attached.

F. The empty carbody, with trucks attached (AW0), shall be capable of being lifted on the outboard most diagonally opposite jack pads without resultant permanent deformation on any element of the carbody structure.

G. An analysis of the carbody structure under torsional loading of the diagonal jacking, all symmetric jacking, and all lifting conditions shall be included in the stress analysis.

4.04.09 Lifting Eyes

A. Lifting eyes shall be installed at the extreme top edge of each collision post of both ends of all cars to allow lifting the car with overhead cranes or a boom. Procedures, special tools, and designs shall be submitted to the Engineer for approval during the design review of the car. [CDRL 04-019] The lifting eyes shall be arranged such that they are readily accessible. The top of the collision posts, including lifting eyes, shall not extend above the surface of the roof.

B. The collision post lifting area shall have a suitable removable cover sealed to prevent ingress of water. It shall not require special tools to remove the cover. The lifting eye location shall not entrap water and any drain shall ensure water does not run down any exterior walls.

C. It shall be possible to lift the car at AW0 load with an overhead crane or boom at only one end with trucks attached and supported by the opposite end truck, without exceeding 50% of the yield strength of the material.

D. There shall be no permanent deformation when the car is symmetrically lifted from an upright position with both ends of lifting eyes with the car at AW0 with the trucks attached.

E. The stress analysis shall include an analysis of the collision post lifting eyes under all torsional loading showing all stresses on the carbody and all attachments during lifting of the car in, AW0 condition, from either end or both ends when ready-to-run in the following conditions:

   1. Car upright

   2. Car lying on left hand side

   3. Car lying on right hand side

F. For lifting from either the left hand side or the right hand side, the car shall be analyzed with equal lifting load applied to one collision post lifting eye on each end of the car. Stresses shall not exceed yield with a load factor of 1.1.

4.05 Truck–to-Carbody Attachment

A. An approved truck safety mechanism and truck to carbody rotation stops shall be provided in accordance with 49 CFR Section 238.219 and APTA-PR-CS-S-034-99.

B. The construction shall also provide a connection between the carbody and trucks so that the trucks are raised with the carbody, unless intentionally detached. The truck safety mechanism shall not interfere with normal suspension elements for any possible condition of shimming to accommodate for wheel wear variances.

C. All truck connections shall be strong enough to resist the max load possible from in service loads.

D. Distance between truck centers shall be 59 ft 6 in. (18,136 mm).

4.06 Bolster Anchor Rods and Brackets

A. Bolster anchor rods and brackets shall be provided to transmit the longitudinal loads between the carbody and the truck. The anchor rods shall be positioned to minimize longitudinal vibration to the carbody. Two bolster anchor rods and brackets shall be provided on each truck, one on each side of the truck, connecting the carbody to the bolster.

B. The rods shall extend horizontally from brackets attached to the side sills to brackets attached to the ends of the truck bolster. Elastomeric pads shall be installed between the radius rod assembly and anchor brackets to permit relative movement.

C. The attachment of the anchor bracket to the carbody shall be by mechanical fasteners, designed and constructed to permit interchangeability among cars, and arranged to permit removal of the bracket from outside of the carbody without interference from the car structure.

D. Each of the rods shall, as a minimum, withstand a longitudinal load equal to two times the weight of the complete truck, including brakes, and other apparatus mounted thereon, without exceeding the yield strength of the materials used.

E. Both radius rods together must also support the load that can occur if the maximum main reservoir pressure is applied to the brake cylinders assuming perfect wheel/rail adhesion. Perfect wheel/rail adhesion is defined as that condition where the wheels continue to roll (sufficient adhesion to prevent the wheels from sliding) with the brakes applied at maximum main reservoir pressure. This may be more or less than coefficient of friction of 1.0.

F. The anchor rod bracket or bracket mounting bolts shall be frangible. Any horizontal load which develops the ultimate load carrying capacity of the anchor rod bracket shall not develop a stress greater than yield, 80% of ultimate strength or the critical buckling stress in the side sill or other car structure. The longitudinal load shall be applied in either direction in the horizontal plane of any part of the anchor rod bracket below the side sill. A specially designed anchor rod bracket bolt, which breaks at a predetermined load, shall be permitted subject to the approval of the Engineer.

G. Each of the brackets, by which the bolster anchor rods are attached to the truck, the truck bolster and/or the carbody, and the members to which these brackets are attached, shall, as a minimum, withstand a longitudinal load equal to three times the weight of the complete truck assembly without exceeding the yield strength of the material used.

4.07 Doorways and Passageways

4.07.01 Side Doorway Framing – Trailer Cars

A. All doorways shall be in accordance with 49 CFR Part 38.93. All trailer cars shall be structurally framed to allow four sets of side passenger entry doorways (two per side) at the far ends of the cars, outboard of the trucks. This framing shall permit high-level boarding at these four side door locations.

B. Location and dimensions of these doorway frames shall be in accordance with Chapter 1. The actual number of doors desired at the above four framed locations will be an Engineer preference that is defined during the procurement process. All door frame locations that are not required to have doors shall be covered with side skin and windows (if appropriate) that are consistent with this Specification.

4.07.02 Side Doorway Framing – Cab Cars

A. All doorways shall be in accordance with 49 CFR Part 38.93. All cab cars shall be structurally framed to allow:

   1. Two sets of side passenger entry doorways (one per side) at the non-cab end of the cars. This framing shall permit high-level boarding at these two side door locations.

   2. Two sets of side passenger entry doorways (one per side) at the cab end of the cars, directly behind the cab. This framing shall accommodate high-level boarding at these two side door locations, with ladder access from the ground.

B. Location and dimensions of these doorways shall be in accordance with Chapter 8. The actual number of doors desired at the above four framed locations will be an Engineer preference that is defined during the procurement process. All door frame locations that are not required to have doors shall be covered with side skin and windows (if appropriate) that are consistent with this Specification.

4.07.03 Carbody End Doorways

Each trailer car shall include carbody end doorways at both ends. Each cab car shall include a carbody end doorway at the non-cab-end. These doorways shall provide access between two coupled cars through the diaphragm passageway. The carbody end doorways shall be at the same height above top of rail as the floor of the car, 51 in. (1,295 mm) at AW0. Diaphragms and associated components shall be installed to be compatible with the existing fleet of single-level cars identified in Chapter 1 under all operational conditions.

4.07.04 Passageways

All passageways shall be in accordance with 49 CFR Part 38.93. The passageways shall have a minimum width of 32 in. (813 mm) and shall allow for the passage of wheelchairs between cars under nominal operating conditions.

4.08 Diaphragm

A. A non-metallic modular, maintainable diaphragm shall be provided at each end of each trailer car and at the non-cab end of the cab car. Diaphragms shall provide a safe, stable, weatherproof passageway between two coupled cars, and shall exclude water ingress and drafts under all normal operating conditions. Diaphragm size, arrangement and installation shall be compatible with existing equipment as specified and shall be subject to approval by the Engineer during design review.

B. Easily replaceable wear plates to eliminate metal-to-metal contact shall be provided on diaphragm faceplates. A minimum clear horizontal opening of 32 in. (813 mm) through the diaphragm parallel to the end door panel shall be provided when the car is at rest on level tangent track.

C. Hinged stainless steel walkway plates, equipped with a safety tread surface, shall be provided at each end of the car to provide a continuous flat and level walkway between coupled cars.

D. The construction of the walkway plates, buffer and side stems shall be such that there shall be no metal to metal contact between moving parts, in order to prevent noise, minimize wear between all parts, and require no lubrication.

E. The walkway plates, buffer and side stems shall be so designed to permit coupled cars to negotiate minimum radius curves and crossovers, without any binding of the mechanism.

F. Diaphragm size, arrangement and installation shall be compatible with other single-level equipment as required.

G. A safety gate/bar(s) shall be provided to prevent passage through the body end door opening when the door is open and the car is at the end of the train. It shall be used to form a transverse barrier between collision posts. It shall be secured to one post on a pivot pin and shall latch securely in both the horizontal and stored (vertical down) positions.

4.09 F-End Snowplow Pilot

4.09.01 General

A snowplow pilot which meets the requirements of 49 CFR Part 229.123 shall be provided at the F-end of the cab car. See Chapter 16 for details.

4.09.02 Pilot Clearances

A. The design shall ensure that there is adequate clearance between the snowplow and any parts of other equipment that can be coupled to the F-end of the cab car. This shall include coupling of two cab cars with their cabs facing each other. The pilot shall be included in all clearance analyses and/or drawings. The clearance shall include all possible operating conditions, including wear or failures.

B. The pilot's vertical positioning adjustment procedure shall be approved by the Engineer during the design review process.

C. The design of the pilot should attempt to remove snow in a fashion that does not hinder the operator's view during operation.

4.09.03 Pilot Strength

A. The entire pilot assembly and its attachments to the carbody structure shall be consistent with its intended function. As a minimum, they shall be capable of resisting the following loads with stresses in the pilot or supporting structure not exceeding yield strength or 80% of the ultimate strength:

   1. 2 loads of 50,000 lbs. each longitudinally aligned with the centerline of the 2 rails, applied simultaneously at the level of at the bottom of the pilot.

   2. 20,000 lbs longitudinally applied as a single load at the bottom of the pilot at the centerline.

   3. 30,000 lbs transversely applied at the bottom of the pilot at the centerline.

4.09.04 Pilot Sheet

The F-end of the cab car shall have a closure plate below the end sill and mounted as close behind the pilot as possible. This pilot sheet shall be a minimum of 0.5 in. (12.7 mm) thick, 25 ksi steel or equivalent. The pilot sheet size shall be maximized to the largest extent possible while meeting the same clearance requirements of the pilot. The pilot sheets shall be a secondary measure to displace snow, ice, and right of way obstructions not successfully displaced by the pilot (snowplow).

4.10 Safety Appliances

4.10.01 Exterior

A. Railroad safety appliances shall be in accordance with 49 CFR Part 238 and/or 49 CFR Part 231.

B. The Contractor shall be responsible for obtaining from the FRA and submitting to the Engineer a determination of compliance with all applicable FRA safety appliance regulations. All car types should have the same safety appliances. [CDRL 04-020]

   1. Handrails shall be provided on the exterior of the carbody on each side of each entrance door to assist passengers when boarding or alighting from the car.

   2. Sill steps shall be provided near each end on each side of the car.

   3. Two handholds mounted either vertically or horizontally shall be provided above each sill step. The handholds shall be located at an optimum location to assist the crew during car moving operations. Location of the handholds shall be subject to Engineer approval.

   4. Design, location, and assembly of all safety appliances shall be submitted to the Engineer for review and approval at the design review. Safety appliances intended for train crew or maintenance personnel shall be separately documented for review.

   5. End handholds shall be provided near each side on each end of the car.

   6. Suitable warning signs shall be provided where appropriate.

   7. All safety appliances shall be within the specified clearance envelope.

C. The Contractor shall arrange for an FRA sample car inspection of the safety appliance applications and shall provide the Engineer with a copy of the FRA "no exceptions taken" letter prior to release of the first car of each type. [CDRL 04-021]

4.10.02 Interior Passenger Grab Handles

Passenger grab handles shall be ADA compliant and provided as follows:

A. At the side of the entrance area to allow crew to stand safely in the open doorway; and

B. In the end passageway adjacent to the end door, on both sides of the passageway and between the end door and the diaphragm.

4.11 Not Used

4.12 Underfloor Equipment, Equipment Rooms and Access Doors

4.12.01 General

A. The high-speed intercity nature of service for cars will require a high degree of protection from foreign object damage, and from the effects of winter weather conditions. All undercar equipment, other than the trucks, shall be housed in an undercar equipment enclosure meeting the materials and workmanship requirements of Chapter 18. The enclosure shall be aerodynamically designed for low drag, and to inhibit the collection of water, debris and snow. The ends of the enclosure facing the

trucks and/or the ends of the car shall be reinforced and protected to the greatest extent possible from foreign objects ran over by the car.

B. Equipment box structures, mounting brackets, hinges, lids, covers, access doors, vents and interior panels shall be designed to withstand the loadings received in the intended railroad service. All covers shall be made of a standardized, interchangeable size to the greatest extent possible. All equipment boxes and mounting supports shall meet the requirements of APTA-PR-CS-S-034-99.

C. Brackets and other means of support for the equipment shall be designed and installed to facilitate access for maintenance and servicing and for removal and re-application. Fasteners shall be conveniently accessible. Equipment boxes shall be of polyurethane painted LAHT steel, fiberglass-reinforced polyester plastic, stainless steel or polyurethane painted aluminum alloy.

D. In no case shall the strength of a fastener or the shearing of the fastener through the base material be the limit of the carrying capacity of a member. Fasteners are not always torqued correctly and sometimes the nut shakes loose. Analysis of all the attachments considering loose bolts should be considered. The analysis of the connection shall include considerations for fastener shear, pull out, and fastener tension.

E. All equipment boxes, which are required to be watertight, shall be given a water test. Junction boxes are required to be watertight. For the purposes of this test, adjustable cover latches shall be adjusted to compress the cover seals no more than 50% of the compressible height of the seal for covers so equipped.

F. Undercar equipment with a direct line of sight to a wheel for any possible truck orientation shall be protected from water splash and flying rock ballast or other missiles thrown by the wheel. If separately mounted solid metal shields are used to provide such protection, they shall not hinder the flow of air to a degree that might cause heat damage to wiring or apparatus. Alternatively, undercar equipment with a direct line of sight to a wheel shall have easily replicable enclosures or enclosure sections if damaged.

G. No apparatus over 25 lbs (11 kg) shall be supported by bolts in tension. The Contractor may submit to the Engineer, for specific approval, an alternative apparatus support design utilizing bolts in tension provided that such design includes an adequate stand-by support arrangement. The design of the standby support arrangements shall include the effect of the equipment dropping from its mount. Apparatus requiring removal and replacement for other than accident damage shall be supported so that both the bolts and nuts are accessible. Bolts used to mount or support underfloor equipment shall not be less than 0.625 in. (15.875 mm) diameter and shall meet the requirements of Chapter 18. Dissimilar metals shall not be used at connections requiring disassembly for removal and replacement of equipment except for the case that anti-corrosion methods are properly carried out. Equipment supported on resilient mounts shall have safety straps or other devices that will support it in case of a failure of the resilient mounts. The design of the safety straps shall include the effect of the equipment dropping from its mounts. Under no circumstances shall equipment be supported by bolts, in holes, that are tapped into the primary structure of the end underframe.

H. Bolted connections shall be designed with a factor of safety of 1.5 using bolts of not less than 0.375 in. (9.52 mm) diameter. All bolted connections in equipment supports shall be supplied with minimum SAE Grade 5 bolts or equivalent, plated for corrosion resistance in accordance with Chapter 18.

I. Final dimensions and arrangement of all equipment compartment accesses shall be subject to approval by the Engineer.

4.12.02 Floor and Roof Penetrations

The Contractor shall ensure that all floor and roof penetrations shall be sealed to inhibit pressure differential, and provide for a watertight and dust tight carbody. Floor penetrations shall be sealed with an

appropriate material to prevent flame propagation from underfloor flame sources; and shall last the life of the rail car.

4.12.03 Equipment Boxes

A. The interior of all electrical equipment boxes and terminal boxes shall be primed and shall be given one coat of white insulating coating. A single coat of insulating varnish, enamel, white (or approved color) or epoxy powder coating may also be used. Insulating coatings are not required on fiberglass surfaces.

B. Boxes required to be accessible from the side of the car shall be as flush as possible with the side of the car consistent with the car clearance diagram and shall be provided with top hinged access covers on the outboard side and, if required, the inboard side. Outboard covers shall raise a minimum of 90 degrees for quick examination of the interior without removing the covers. Inboard covers shall open to the maximum extent possible, but in no case less than 60 degrees. All hinged covers shall also be readily removable without more than 12 in. (305 mm) swing out and without the use of tools. Openings provided upon removal of covers shall be of sufficient size to permit removal and replacement of any component in the box and easy access to equipment in the box for inspection and maintenance. All covers shall have a permanently attached "hold open" feature. The "hold open" feature shall in no way interfere with or impede the easy removal or replacement of the cover.

C. The battery box shall be located under the car. It shall be constructed of stainless steel and shall be properly vented to prevent accumulation of gasses. The vents shall be covered with screens and deflectors to preclude entry of dirt and water. Large drain holes with deflectors shall be installed in the bottom. See Chapter 13.

D. The outer vertical faces of all enclosures and apparatus mounted along the side sill shall be located equidistant from the longitudinal centerline of the car and lie in the same vertical plane. Any devices enclosed in underfloor enclosures shall not be fastened directly to the walls, roof or floor of the enclosure, except for any heat sink assemblies projecting outside the enclosure, which shall have gaskets suitable for the temperatures involved. Internal equipment shall have at least a 0.5 in. (12.7 mm) clearance from interior surfaces of enclosures or covers.

E. Heat sensitive equipment and materials shall be located or shielded so that their life expectancy is not degraded. All external hardware used on enclosures or covers, such as hinges or latches, shall be stainless steel, or other highly corrosion-resistant material, and shall be attached using similar screws and locknuts. Where unavailable, exceptions will be made on a case-by-case basis.

F. Enclosures which, because of internal layout and/or limited external access, require removal from the car for mid-life overhaul shall have low voltage connections made by the use of connectors meeting the requirements outlined in this Specification. The connectors shall lie within the enclosure, and the cables shall enter the enclosure through watertight fittings mounted on an externally-removable gasketed plate. High voltage cables shall pass through similar fittings on a similar plate to enter. Fully enclosed cable ducts or conduits shall not connect directly to such enclosures but shall incorporate a flexible or rigid, detachable transition piece that will facilitate breaking the connection. Other enclosures shall have cables and wires entering the box through watertight fittings and shall terminate on devices, bus bars, terminal blocks, etc. All cables shall have sufficient slack for ease of installation. It is preferred that cables enter enclosures rising up from the horizontal, so as to direct water, melting snow and ice away from the cable entry seal.

G. All latches that must be manipulated to gain entrance to the enclosures shall be quick-release, spring loaded latches which operate with a toggling-type action. The latches and latch catches shall be arranged so that they do not protrude beyond the bottom or sides of the box or cover in the latched position. The latch and all its components shall be fabricated from stainless steel. Latches must be recessed or have protective side barriers to deflect debris traveling in the longitudinal direction or

have a safety lock which will prevent accidental activation. All latches shall be of the highest quality, designed for heavy-duty railroad service and applied in sufficient number to ensure adequate gasket compression needed for long term watertight quality sealing. All aspects of the packaging shall have the approval of the Engineer. The latches shall be adjustable to compensate for gasket relaxation and shall be adjusted as delivered to compress the cover gasket no more than 50% of the compressible height of the gasket, for covers so equipped.

H. A spring-loaded safety catch shall be provided at the center of each enclosure cover. The safety catch shall be designed to retain the cover at all operating speeds without the cover latches engaged. The safety catch design shall preclude damage from cover misalignment, slamming covers and attempts to open covers with the catch engaged. An approved cover nameplate, of sand etched stainless steel filled with black paint, shall identify the location of the safety catch.

I. All covers more than 3 ft (0.91 m) in width shall have two or more handholds arranged about the center of gravity of the cover, and recessed flush into the cover surface. The handholds shall not accumulate debris or moisture. The covers shall be arranged so that only one person is required to easily open, remove, reapply, close and lock any cover, regardless of size. Adequate clearances for all handholds, latches, etc., shall be provided so that a person wearing gloves in a winter environment is not hindered. All covers shall fit well and be adequately gasketed where necessary to prevent the entrance of water (including both a driving rain and a high-pressure car wash spray), dust and snow.

J. All gaskets shall be of a closed cell elastomer material that will ensure water tightness, keep resilient and remain intact for a period of at least 10 years. Only one common type of gasket shall be used on all covers, of a hollow closed tube or similar design, using a positive mechanical means of attachment. Flat foam strips or glue-on attachments shall not be permitted. The design shall allow for ease of gasket replacement, without use of adhesives. All removable doors on underfloor enclosures shall be interchangeable between similar enclosures on different cars without need for adjustments to ensure proper seal operation.

K. All enclosures shall be designed so that any condensation or water that should enter will gravitationally drain out. Enclosure floors shall be sloped toward the drain holes. All channels, reinforcements, etc., shall have provision for flow of liquid to the drain. The drain hole shall have a minimum 0.125 in. (3.18 mm) diameter and shall have baffling such that rain, snow and dirt will not be blown in by car motion. Drain holes shall be fitted with stainless steel cotter keys or other Engineer approved, simple drain clearing mechanisms.

L. Each cover shall have the car number stenciled in black paint in 2 in. (51 mm) high numerals at the top left inside corner of the cover.

M. Conduit shall be connected to equipment groups, using watertight connectors as manufactured by Universal, Erickson, or approved equivalent. Entrance of conduit into the top or bottom of equipment boxes shall not be permitted.

4.13 Windows

4.13.01 General

A. Frame and glazing rubber of side passenger windows and side door windows shall be designed to securely retain the glazing material under all operating conditions on specified track configurations and under applicable requirements of 49 CFR Part 223.

B. Glazing assemblies (frame, rubber and glazing material) shall be watertight over the entire operating environment. The sash itself shall be free of condensation, watertight and dust tight. The glazing

material shall show no physical damage or degradation of optical qualities when exposed to the environment encountered in rail passenger service.

C. Construction shall be a double-glazed side window with the exterior light to be tinted polycarbonate, and the inner light to be non-tinted polycarbonate. Laminated safety glass may be specified by the Engineer as a Chapter 23 option, for the interior, exterior, or both panes.

D. All glazing assemblies shall meet all applicable requirements of 49 CFR Part 223. They shall meet any applicable APTA requirements.

E. Material selection for glazing rubber and all other materials in all locations must take into account the possible interaction between the material as well as the environment. Glazing rubber material type shall be neoprene, EPDM or as approved by the Engineer.

4.13.02 Glazing Materials

A. Glazing material shall conform to the requirements specified in Chapter 18.

B. Material shall be integrally tinted with no appreciable variation in color over the entire area of each glazing and between panel of like color designation and thickness. Color measurements shall be taken with a spectrometer.

C. A permanent protective veneer shall be applied to the exterior surface of all glazing material. This protective covering shall significantly improve the abrasive resistant qualities of the glazing to abrasive materials, natural atmospheric acids, strong cleaning chemicals and cleaning brushes encountered during normal operating and cleaning conditions

D. Markings are to be in accordance with current ANSI Standard Z26.1 and 49 CFR Part 223.

E. Location of these markings must be visible for identification after installation.

4.13.03 Side Windows

A. Side windows shall conform to the requirements specified in Chapter 18.

B. An approved sealant shall be used as the primary vapor sealant on both sides of the desiccant spacer. The edges of the unit shall be sealed with a polyurethane sealant along the entire perimeter, filling all voids.

C. The window frames shall be extruded aluminum 6063-T5 alloy. Retention of glazing material in the frame shall be by means of a rubber extrusion. A "pound-in" strip shall secure the glazing from the inside of the car. A "zip strip" on the outside section of the rubber shall allow installation and/or removal of the main rubber extrusion from the carbody frame. A seal which remains leak proof during train passing wind loads shall be provided.

D. Emergency side windows

A two part "Emergency" handle shall be provided at a minimum of four designated "Emergency" windows for removal of the window from inside of the car per 49 CFR Part 238. The design of the glazing rubber shall also allow removal of the glazing from the outside of the car by emergency responders as described below.

E. Rescue access windows

1. All side windows shall be rescue access windows, and shall be capable of being removed from the outside of the car by prying and pulling a "zip-strip". Rescue access windows shall provide a means of rescue access by emergency personnel such as, police, fire department, etc. Emergency

side windows on each side of the car on each level shall be designated as an emergency and rescue access – dual-function window.

2. Identification and removal instructions shall be provided in accordance with 49 CFR Part 223, 49 CFR Part 238.114, APTA-PR-PS-S-002-98 and ASTM Standard D 4956-07 for Type I material sheeting.

4.13.04 Cab Car Windshield

The front windscreen shall be directly supported by the structure of the Operator's cab or the structure shall resist the windscreen as a whole moving into the Operator's survival space or off the vehicle entirely.

4.14 Insulation

4.14.01 Acoustical Insulation

A. To reduce movement, structurally-borne sound and noise generated by the vibration of the roof, floor and side sheets, panels, air conditioning ducts and other metal surfaces, in particular the doors, an asbestos-free damping material shall be applied to the inner side of these surfaces (exterior of the HVAC ducts). The thickness of the damping material shall be such that it shall provide ten percent of critical damping for the treated surface. The damping material shall have a vibration decay rate of not less than 35 decibels per second (dB/sec) as measured by the Geiger-Hamme Thick Plate Test Method. The damping material shall have a hydrodynamically smooth finish, and shall be receptive to painting. It shall be resistant to dilute acids, alkalis, greases, gasoline, aliphatic oils and vermin. It shall be unaffected by sunlight or ozone, and shall not become brittle with age.

B. This material shall be applied to the interior of the complete structural carshell including the roof, sides, underfloor, ends and webs of all posts, carlines, floor beams and other structural elements. The sound dampener shall be compatible with the material used at the affected locations in the car structure.

C. Application of this damping compound and the surfaces to which it shall be applied shall be in accordance with recommendations of the manufacturer of the compound, and as follows:

1. Prior to application, the Contractor shall ensure that surface temperature of the base material meets the supplier's recommended temperature settings. Ambient temperature shall not be used to qualify a base material for application of damping material.

2. The inner surface of the carbody structural shell, except for the end underframe welds, shall be coated with sound deadening compound. The inside surfaces or structural members shall be sprayed to the extent possible and required.

3. Structural members under the floor of the carbody shall not be coated.

4. The outside surfaces of the main air duct, the vertical underfloor equipment ventilation duct, and all ventilation cross ducts shall be coated with sound deadening compound.

5. Duct splitters (if used) shall not be coated.

6. The underside of the main air duct, top/bottom of floor beams and inside door pockets shall not be coated.

D. Acoustical insulation shall not be applied to exterior surfaces unless protected by stainless steel sheeting and approved by the Engineer.

4.14.02 Thermal Insulation

A. The floor, roof, sides and ends of the cars shall be insulated. The heat transfer through the carbody, using only the carbody's own floor heaters, shall not exceed 1,200 Btu/Hr/°F (2,279 kJ/hr/°C) under the environmental conditions specified in PRIIA specification 305-912 while carbody is stationary. Contractor to supply thermal analysis of completed car for approval at the design review. [CDRL 04-022] Glass wool or fiberglass insulation shall be used, which shall be manufactured from long, textile-type or rotary-type glass fibers which are drawn from a calcium borosilicate mixture. The use of urethane foam insulation is prohibited. All insulation used shall not mold, rot, have any odor nor corrode any metals, and be capable of performing to an upper temperature limit of 450°F (232.22°C).

B. As much as practicable insulation shall have an acoustic barrier and shall not settle or reduce in effectiveness from vibration conditions which may occur throughout the vehicle's service life.

   1. The roof insulation shall be retained and held in place to prevent the insulation from sagging or settling over time. Insulation retention method by insulation pins of the same metal as the car structure or alternative solution as approved by the Engineer. Side and end wall insulation shall be retained and held in place to prevent the insulation from sagging or settling. Retention method by insulation pins or alternate solution considered and approved by the Engineer. On the inside of the end and side powered door pockets the insulation shall be retained such that the insulation will not impede the door movement during the life of the car. Retention shall be by stainless steel sheets or alternative solution as approved by the Engineer.

   2. Side wall insulation located near heater assemblies shall be metal-backed with metal side facing the heater.

   3. A vapor barrier shall be provided between all interior linings and the carbody insulation.

   4. Thermal breaks shall be provided between the main conditioned air supply duct and roof structural members, between interior finish panels and any metal primary or secondary structural members which are thermally grounded to the outside surface of the carbody skin and at any other location where it is necessary to interrupt an all-metal path between interior of the carbody and outside of the carbody skin.

   5. Thermal insulation shall not be applied to exterior surfaces unless protected by stainless steel sheeting and approved by the Engineer.

4.15 Exterior Finish

4.15.01 General

A. Generally the stainless steel car exterior will not be painted, however some painting may be required for aesthetic as well as branding purposes. Refer to the Engineer exterior graphics requirements, as specified in Chapter 23 for details.

B. The surface preparation and graphics applications shall ensure that the car can operate at least fifteen years between major exterior finish repairs or replacement.

C. All exterior surface treatment plans and specifications shall be submitted to the Engineer for review and approval. [CDRL 04-023]

4.15.02 Painting-Exterior

A. The exterior of the carbody shall not be painted.

B. When painting is used as approved by the Engineer, care in painting application shall ensure freedom from drips, runs, sags, orange peel and other unsightly paint deficiencies, utilizing the paint supplier's written procedures with trained technicians.

4.15.03 Post Painting

Allow the car to remain inside for a minimum of 8 hours unless outside temperatures are above 60°F (16°C), utilizing the paint supplier's written procedures with trained technicians.

4.16 Graphics and Labels

4.16.01 Exterior Graphics

A. All exterior graphics, lettering and signage, including vehicle numbers and reporting marks, shall be applied to the vehicle in accordance with Engineer specifications as identified in Chapter 23.

B. Full size samples of the exterior graphics shall be available during the design review.

4.16.02 Labels

Exterior equipment shall be labeled in accordance with PRIIA Specification 305-908.

4.17 Not Used

Not used.

4.18 Summary of Load Cases for Structural Design Requirements

A. The following load conditions must meet the requirements as stated in this Specification, as well as those identified in CFR and APTA:

1. Fatigue
2. Side structure load Floor load
3. Roof load
4. Jack pad loads
5. Jacking loads
6. Lifting loads
7. Anchor rod loads
8. Anchor rod bracket loads

B. Where there is a conflict between this Specification, Federal requirements and APTA standards the more stringent requirement shall apply.

4.19 Stress Analyses

4.19.01 General

A. No later than 270 days after NTP and prior to carbody and truck testing, the Contractor shall prepare and submit, for review and approval during design review, stress analyses of the carbody and truck structure and equipment supports for any element of equipment weighing over 150 lbs (68 kg) in accordance with APTAPR-CS-S-034-99. Stress analyses for supports for safety related items weighing less than 150 lbs (68 kg) shall be included in the analysis. For non-safety related items, stress analysis may be requested for review at the discretion of the Engineer. [CDRL 04-024]

B. Structural strength requirements in other subsystem sections of this specification (such as trucks, couplers, interiors) may require a stress analysis report of the subsystem's connection to the carbody. These analyses shall include all structural components of the carbody in its verification analysis up to a reasonable amount of distance from the connections to verify the carbody is able to provide the necessary support for the requirement, i.e. luggage racks, bicycle racks, seats, truck attachments. Such subsystem stress analysis reports shall follow the stress analysis and reporting requirements of this section, as well as be readily organized and available upon request during carbody discussions and design reviews.

C. The Contractor shall use the stress analysis as an engineering tool to aid in the design of the lightest weight car and truck in compliance with the requirements of the Specification. Structural tests shall be conducted in accordance with the requirements of Chapter 19 to confirm the accuracy of the analyses as required.

D. Periodic Finite Element Model Update Reports, together with the FEA model with load distributions for each load case and underlying 3D solid models, shall be provided before simulations are started and continue until the approval of the Final Stress Analysis Report. [CDRL 04-025] The models shall be of an agreed upon format by the Contractor and Engineer, such as FEMAP, ANSYS, NASTRAN or approved equal. The purpose of the Periodic Finite Element Model Update Reports is to ensure the Engineer is provided regular progress updates if the design or model requires excessive revision and analysis iterations extending multiple months.

E. The Preliminary Stress Analysis Report shall be used as an example for the Engineer to review the Contractor's approach to the modeling, assumptions, analysis, and reporting which will be used in the Final Stress Analysis Report. The load cases to be included in the preliminary stress analysis shall be proposed in the Stress Analysis and Test Plan for review by the Engineer. The load cases included in the Preliminary Stress Analysis Report shall be fully analyzed and reported per the requirements herein.

F. The approved Final Stress Analyses Report shall be a prerequisite for fabrication of the test carbody shell, as well as submittal of the structural test procedures and structural drawings required by this Specification. The report shall be used as an aid in determining strain gauge locations during the tests.

G. All stress analysis reports shall conform to the requirements specified herein and include reference numbers of any outside standards used for ease of reference during the life of the vehicle.

H. The meanings described in the following section shall apply in performing the analyses.

I. Permanent Deformation — A member shall be considered as having developed permanent deformation if any one of the following conditions is met:

1. The minimum yield strength as published by ASTM for the specified material and grade is exceeded. For materials or grades not covered by an ASTM standard, the minimum yield strength as guaranteed by the Manufacturer is exceeded. For materials without a specific yield point, the 0.2 percent offset method shall be used to determine yield strength.

2. The material has buckled or deformed and does not return to its original shape or position after the load is released.

J. Ultimate Load Carrying Capacity — The ultimate load carrying capacity of a member is the maximum load that the member can support before it separates at its ultimate strength or completely fails as a column.

K. Margin of Safety (MS):

MS = (Allowable Stress/Calculated Stress) - 1

L. The calculated stress shall include the applicable load factors. MS shall be a minimum value but a positive number.

M. Load Factor — Load factor is a number by which the actual or specified load is multiplied in computing the calculated stress. The load factor shall include all applicable safety factors.

4.19.02 Stress Analyses and Test Plan

A. A Carbody and Truck Stress Analysis and Test Plan shall be submitted for approval no later than 120 days after NTP and before any other submittal required in Section 4.19. [CDRL 04-026] The Plan shall be discussed during the first design review meeting. The Plan shall be a working document and updated as the design develops. When the plan for the analyses and testing is revised, it shall be updated and resubmitted on intervals at the discretion of the Engineer but no more frequently than monthly. Each revision shall include revision level indications.

B. The Stress Analyses and Test Plan shall include an outline of the procedure the car builder shall use to analyze and test the design of the carbody and truck. It shall also include the following, with references to standards and publications as appropriate:

1. A listing of all load conditions to be used during analysis and test, including load magnitudes and points of application, with CFR, APTA, and Specification references.

2. A description of the analysis to be used for each load condition.

3. A description of the software settings, model setup, and meshing quality assurance.

4. Acceptance criteria for each load condition.

5. Diagrams displaying loads applied externally to the carbody and truck and points of support for each load case for each analysis.

6. Diagrams displaying loads applied externally to the carbody and truck and points of support for each load case for each test.

7. A table of material properties showing the engineering properties of each grade and temper of each material used in the car and truck structures. This table shall include the material designation, yield strength, ultimate strength and elongation, Young's modulus for tension, compression, shear elastic moduli and CEM material as required. For all material properties, an acceptable source for those properties shall be cited. In each case, minimum-guaranteed values from the specifications for the corresponding grade and heat treatment of the material shall be used. Materials, grades and tempers not used in the carbody construction shall not be included in

the tables. The table shall list the properties of the fasteners and the welds. For implicit and explicit (Large Deflection) non-linear load cases, input shall include modeling of non-linear material properties in accordance with the online help for the FEA code used or equivalent source. The non-linear material properties shall be derived from conservative values of basic mechanical material properties (Young's modulus, yield and ultimate stress strain) as appropriate to the model.

8. A description of all the major assumptions used in the stress analyses.

9. A description of how analyses results shall be correlated with test results.

10. A list of all connections deemed "potentially critical," e.g. all corner and collision post connections, all connections of the end underframe to the carbody and the underframe.

11. A list of all structural tests to be conducted on carbody and truck along with acceptance criteria.

12. Diagrams displaying all boundary conditions including symmetry and asymmetry boundary conditions.

13. An introduction page referencing all the related stress analysis documents to be submitted.

14. A configuration control plan ensuring design changes are tracked and ensured between the stress analysis, 3D solid models, and structural drawings. The plan should also address the integration control of subsystems utilizing carbody structure to analyze each subsystem's structural requirements.

15. Description and examples of methods for analyzing and evaluating different welded joints.

16. A description of the fatigue analysis approach and methods used to evaluate all types of welding joints in fatigue. A design fatigue stress range testing plan shall be included if such testing is deemed necessary for the project.

17. A list of primary load cases to be evaluated first and reported in the Preliminary Stress Analysis Report.

18. Descriptions and examples of past methods used to evaluate and justify stress singularities and stress concentrations in the FEA results.

19. A table of all vehicle equipment over 150 lbs shall be provided with their respective mass and locations.

20. Description of how the FEA model will add mass to achieve AW0.

21. A list highlighting truck-to-carbody attachment load cases.

C. The stress analyses and tests plan shall be approved prior to submittal of the Stress Analysis Report required by this specification. The Plan shall be made a volume of the Stress Analysis Report. The Plan shall follow the general requirements of the report as identified herein.

4.19.03 Periodic Finite Element Model Update Reports

A. The Contractor shall start submitting Periodic Finite Element Model Update Reports outlining the FEA work prior to performing any stress analysis simulations and shall continue submitting revisions until the Final Stress Analysis is submitted. Periodic updates shall be resubmitted on intervals dependent on the progress of the design, the magnitude of changes, and at the discretion of the Engineer but no more frequently than monthly. The report, FEA model, and underlying 3D solid model shall be revision

controlled and follow the configuration control plan submitted in the Stress Analyses and Test Plan. For prominent design changes presented in the periodic updates, analysis results justifying the changes may be required at the discretion of the Engineer.

B. The element mesh details, all assumptions, loads, boundary conditions, detailed list and drawings of mounting connections for all vehicle equipment over 150 lbs, summed totals of reactions forces and moments from the mesh at AW0, area properties and material properties, and consistent units used shall be included as part of the periodic submittals. Each periodic update submittal thereafter shall also include diagrams of areas of mesh refinement. Separate images shall be provided highlighting all components, and only components of each individual material type.

C. The periodic update shall include a structural diagram (layout) of the carbody (including sheathing) and truck showing the locations of all members and shapes, and indicating the material and dimensions of each in accordance with APTAPR-CS-S-034-99. Methods of joining shall be completely defined. As a minimum, the following views shall be included on the carbody structural sketch: side elevation, top view of the roof and the underframe, and typical cross-sections of the carbody at a window, side doors and full-height side-frame posts. For the truck, the following views shall be included in the structural sketch: side elevation, top and bottom views and typical cross sections at key changes of geometry and weld types. Cross-sections of the structural members with shape, dimensions, material and thickness shall be shown.

D. The periodic update shall be supplemented with illustrations, sketches, drawings, or the 3D models, with revision levels, to detail changes made to the FEA model. As the drawings or the 3D solid model are revised, the FEA model shall be updated to reflect the changes, or there shall be documentation to indicate that the drawing changes do not affect the FEA results to be included with the next FEM submittal.

E. The final periodic update shall fully describe the final model configuration used for the Final Stress Analysis Report, with descriptions of component connection methods, contact surface parameters, friction, equipment representations, 1D elements, and meshing composition for critical structural connections.

F. Critical stress plots should be included to provide justification and status updates of the design progress to meet required structural requirements. Plots deemed appropriate for the periodic update shall be presented per the guidelines of section 4.19.5.

G. At the discretion of the Engineer, Finite Element Models (FEM) with results, underlying 3D solid model, and applicable drawings may be compared and audited to ensure configuration control during conferences conducted within two weeks of a Periodic Finite Element Model Update Report.

4.19.04 Carbody and Truck Stress Analyses

A. The stress analysis shall show the calculated and allowable stresses and Margins of Safety for all elements, for all specified load conditions.

B. The stress analysis shall include calculations of stresses in joints, joint elements, and other important elements. It shall include FEA results, connection, buckling, natural frequency, and fatigue analyses.

C. In computing the shear strength of a beam, only that portion of the beam, which is in line with the force vector, shall be considered as resisting the force. If the force is skewed to the web of the beam, the force vector shall be divided into components, one in line with the web and the other in line with the flange. The shear resistance shall then be computed separately for each component. There shall be a table showing geometric properties, such as area and section moduli.

D. Finite element analysis

1. As part of the stress analysis, a linear-static finite element analysis (FEA) of the complete carbody and truck shall be performed. The stress analyses shall include Finite Element Analyses (FEA) using recognized computer programs, supplemented as necessary by manual or computer calculations of stresses at joints. The FEA shall be a recognized computer program. The purpose of the carbody and truck FEA, along with other supporting analyses, calculations, shall be to show that the design meets the requirements of the Specification.

2. The input and output shall be submitted electronically and have each page numbered and columns of data shall be clearly labeled on each page using terms, symbols, abbreviations, and units defined in the analysis report.

3. Upon completion and approval of the final design, the FE model and analysis report shall be updated to represent the final configuration of the structure, or documentation shall be submitted to the Engineer for approval, indicating that the differences do not affect the FEA results.

E. Connections

1. Structural connections shall be, in general, analyzed through the FEA process and supplement as necessary by manual calculations. Critical connections which cannot be adequately analyzed shall be prototyped and tested to demonstrate compliance with the requirements of the design and the Specification.

2. The analyses of all critical and highly loaded connections shall prove that the joint is stronger than the weakest member being joined.

3. The FEA shall be supplemented as necessary by manual or computer calculations of stresses at joints.

F. Buckling

1. The inelastic buckling strength of structural members subjected to any combination of compression and shear shall be calculated. The variation in the stainless steel compression modulus with stress shall be considered in calculating compressive stability of stainless steel members.

2. The buckling values shall be used as the basis for the allowable stress values for the specified load cases. Any member in any of the elastic static analyses with a calculated compressive stress equal to, or greater than, 35% of its material's yield strength shall be included.

G. Natural frequency

The natural frequency of the carbody under AW0 and AW3 load, and supported at the bolsters, shall be calculated. The natural frequency of the carbody under AW3 load, and rigidly supported at the bolsters, shall be no less than 2.5 times the natural frequency of the car's secondary suspension system.

H. Fatigue

1. An analysis of fatigue life of the car and truck shall be included in the stress analysis report as required herein and in Chapter 5. It shall include a tabulation of the Contractor's selection of allowable fatigue stresses, with data sources and assumed fatigue stress ranges, for structural members which are critical in fatigue.

2. The minimum allowable fatigue stress range for the carbody is computed by multiplying the static stress at the AW3 load by the dynamic factor. The dynamic factor shall be determined by the Contractor but shall not be less than ± 20%. The allowable fatigue stress range shall be based on

a calculated car shell lifetime of 10 million cycles. This stress range must be within the design fatigue stress range obtained from one of the following sources as approved by the Engineer:

a. For carbon and low alloy steel members, the stress range shall be obtained from AWS Standard D1.1.

b. For aluminum members, the stress range shall be obtained from Aluminum Association Aluminum Design Manual, Specifications and Guidelines for Aluminum Structures, 2000 Edition, Section 4.8.

c. For spot welded structures, the Contractor shall conduct a sufficient number of fatigue tests to determine the fatigue properties of the welded structure. The Contractor shall consider the effect of multiple spot welds and different spot weld arrays when planning the test program.

d. The Contractor shall conduct fatigue tests to determine allowable fatigue stresses for materials or joint designs not covered by the above requirements.

3. For design fatigue stress range testing conducted after NTP the Contractor shall supply testing and QA plans as well as applicable certification documentation, such as weld procedure specifications, weld procedure certification test reports, and machine qualification test reports 30 days before testing begins. Design fatigue stress ranges calculated from testing shall be calculated with a minimum 97.5% confidence level.

4. The fatigue stress range and acceptance criterion for the trucks is detailed in Chapter 5 and Chapter 19.

5. The fatigue analysis section of the stress analysis report shall include table(s) showing the minimum static and fatigue strength limits of single and multiple spot welds. Values shall be given for each material, temper, weld size and thickness combination used in the carbody. The source of the data shall be provided.

I. Manual analysis

1. A manual analysis may be conducted to closely examine details of the carbody and truck (weld connections, welded and/or bolted joints and fatigue conditions) that are not readily handled by the FEA in accordance with APTA Standard SS-C&S-034-99. Load cases that the Contractor prefers to analyze by manual methods shall be listed in the Carbody and Truck Stress Analyses and Tests Plan as required herein. The manual analysis format shall consist of a title, sketch of item to be analyzed with dimensions and applied forces, drawing reference, material properties, allowable stress, detailed stress analysis and conclusions.

2. The following are examples of stress calculations for which manual analysis may be used:

3. An analysis of the critical connections of the major structural elements and the critical loading conditions

4. An analysis of the strength of the connections of the trucks to the carbody including calculated vertical and horizontal connection load limits

5. An analysis of the truck equalizer beams

6. An analysis of the axles

7. An analysis of the coil springs

8. An analysis of primary and secondary suspension

9. An analysis of equipment hangers

4.19.05 Validation of Stress Analyses

A. Validation of the FEM shall be accomplished by comparing the carbody and truck structural test results for each test required by Chapter 19 with the corresponding stress analysis results. This information shall be tabulated and submitted with the carbody and truck structural test reports for each test.

B. In the test procedure for each test to be used for validation, there shall be a pre-selected list of strain gauges to be used for the comparison, which shall not be less than half of the total number of strain gauges used during the test. This table shall include gauge number, element number, location, stress analysis strain value in the direction of the gauge, direction of gauge on carbody and truck, a column for the strain gauge value, and a column for notes.

C. The test report shall include tables that compare stresses calculated from the test strain gauge readings with analytical stresses from the FEA and shall include the test stress value and its equivalent allowable utilization, the calculated stress value and its equivalent allowable utilization, the percent difference between the two values, the gauge number and its corresponding FEA element or node number, and a space for annotation.

D. The percent difference between the two values of chosen strain gauges for a test shall be within 20% for 75% of the compared values of the test results and analytical results when either reads more than 25% of the allowable.

E. If the analyses results do not agree with the test results within the above-specified tolerance, the Contractor shall revise the stress analyses, update the FEM, and re-run all FEA. All manual analyses using data from the FEA shall be recalculated using the corrected values. This process shall be repeated until agreement of results is within the specified tolerance. The stress analysis report shall be revised and re-submitted. All results from re-analysis shall meet specification requirements. The design shall be corrected if such requirements are not met.

F. The camber requirements of Section 4.4.2 shall be validated at structure only, AW0, AW1, and AW3 loading conditions during structural testing and compared to the predicted values with consideration of manufacturing tolerances. If the camber requirements are not met during structural testing, a detailed explanation of the reasons for the variance shall be include in the carbody test report and must be accepted by the Engineer for approval of the testing.

G. Approval of the carbody and truck test report shall depend, in part, on the adequacy of the analyses of excessive variance between analytical and test stress values.

4.19.06 Stress Analysis Report

A. The Contractor shall submit the required Stress Analysis report in compliance with the format and content specified herein. If a cited reference is not readily available to the Engineer, the Contractor shall provide the reference or copies of the pertinent pages. All references shall be in English. If an English reference cannot be found, an English translation shall be provided, and both the original and the translation shall be included in the report.

B. The report shall demonstrate that all structural members satisfy the requirements of this Specification in compliance with each design load and condition and of good practice in the rail transit industry. The report shall be organized and in sufficient detail so that the Engineer can readily follow the theory and its application to the car. The Contractor shall certify that the analysis and calculations have been reviewed and checked before the report is submitted to the Engineer.

C. A summary of the results of calculations of stresses in all structural framing members, shear panels, connections, and welded joints shall also be included. The locations where calculated stress levels

equal or exceed 80% of the allowable stress criteria shall be shown in a separate table along with the design and operating conditions (loads) which precipitate them.

D. The report shall include detailed calculations of stresses with Margins of Safety (MS) in all structural framing members, sheathing, connections, and welded joints. There shall be a summary table listing the Margin of Safety of all major members and any other member where the MS is less than 0.20 together with the affected joints under all specified loads. The table shall include:

1. The identity of the member
2. Its location
3. The load condition
4. The MS
5. The page on which the analysis can be found
6. The material of that member
7. The allowable stress of the members

E. Color plots shall be prepared showing the following:

1. Deflections in all three axes
2. Von Mises or other approved combination stresses
3. Maximum and minimum principal stresses
4. Direction of maximum and minimum principal stresses Meshing accuracy index
5. Maximum shear stress

F. All plots shall easily show the maximum and minimum values, and all values which are greater than 80% of the specified maximum value. All drawings and plots shall include a triad showing the direction of the global axes. Plots at high magnification, or locations of multiple material types, shall be keyed to a plot showing the structure to an extent sufficient to orient the high-magnification plots or different material types.

G. The report shall include all reaction forces, summed totals of reaction forces and moments, and a table to show static equilibrium for each load case.

H. Introduction to each load case shall be provided in the report where the loads and boundary condition sketch from the Stress Analyses Plan is referenced by document, revision, page, and section number. Detailed images of the load and boundary condition mesh application site shall be included or similarly referenced. Conclusions shall be included for each load case to report if the load case passes or fails, its criticality, areas of interest, areas of criticality, and any justifications for stress singularities.

I. Camber shall be detailed per the requirements of section 4.4.2 for the structure only, AW0, AW1 & AW3 load cases. Door frame and door pocket deformation shall be analyzed between structure only, AW0, AW1 & AW3 to ensure the door systems will operate under all conditions and shall be certified as such in the report by the door system lead engineer.

J. The passenger seat analysis and/or testing to show compliance with seat mounting requirements of section 9 must be submitted before and referenced inside the Final Stress Analysis.

K. In the submittal of the Preliminary and Final Stress Analysis Reports, the Contractor shall certify that the reports were peer-reviewed, quality assured, and 100% complete.

L. The Final Stress Analysis shall tabulate document numbers and revisions of all subsystem analysis reports which utilize the structure.

M. In addition to the body of the analysis, the stress analysis report shall include, at a minimum, the following:

1. A Table of Contents

2. The algebraic statement of all formulas and equations before the related calculations are performed, along with the definitions of all terms and the values and units to be applied to these terms. In addition, the pages that show the development and interpretation of the formulas or data shall be included.

3. Units with all quantities.

4. References for all formulas, calculation procedures, buckle coefficients, material strengths, fatigue strengths and other physical and mechanical properties where these items appear in the stress analysis.

5. Each page, including all stress analysis sheets, shall be numbered, identify the load case to which it applies, dated, and initialed by the author, or analyst and checker, and in the event of a revision, the revision letter, date, and initials of the analyst and checker.

6. Particular reference to, but not limited to, the following:

   a. Side sill

   b. Body sills (if used)

   c. End sill

   d. Anti-climber

   e. Draft sills

   f. Coupler supports

   g. Side frame rails

   h. Side frame posts

   i. Transverse and longitudinal sections at doorways

   j. Body bolster

   k. Floor and floor beams

   l. Collision posts

   m. Corner posts

   n. Structural shelf Roof structure

o. Equipment supports

p. Connections between structural elements

q. Truck frame

r. Truck bolster

s. Truck equalizer beam

t. Axle

u. Bolster anchor rod and bracket

v. Snowplow Pilot

w. Truck and attachments

7. If tests are conducted to provide the necessary data, the entire test report shall be submitted. This report shall show the test procedure, raw data as well as reduced data, and summary, with detailed discussion of the results.

8. A table listing and defining all symbols and abbreviations used in any analysis shall be included.

9. A table providing the physical properties of each material (grade and temper) used for the carbody and truck. This table shall include yield strength, ultimate strength, elongation, and tension, compression, and shear moduli. Minimum-acceptable values shall be used and shall be selected from the ASTM (or equal) material specification. Separate images shall be provided highlighting all components, and only components of each individual material type.

10. A tabulation of the Contractor's selection of allowable fatigue stresses for the carbody and truck material and each type of weld joint and assumed applied fatigue stress ranges for members and weld joints which are either highly or critically loaded.

4.20 Contract Deliverable Requirements List

CDRL #	Title	Car Type
04-001	Arrangement, Mounting Details, and Maintenance Schedules for Equipment Greater than 150lbs.	All
04-002	Ancillary Equipment General Arrangement	All
04-003	Protective Devices Locations	All
04-004	Carbody Sealant Type and Location	All
04-005	Carshell Cross Sectional Views	All
04-006	Carbody Materials and Locations	All
04-007	Corrosion Prevention Technique	All
04-008	External Surface Specifications	All
04-009	Carbody Structure Mechanical Fasteners	All
04-010	Finished Vehicle Construction Tolerances	All
04-011	Carbody Shims	All
04-012	Tapping Plates	All
04-013	Anti-climbing Arrangement	All
04-014	Structural Joints	All
04-015	Floor Panel Material	All
04-016	Floor Covering Details	All
04-017	Exterior Finishes Samples	All
04-018	Roof Drainage Equipment	All
04-019	Lifting Eyes Procedures, Special Tools, and Designs	All
04-020	Safety Appliance Compliance	All
04-021	Safety Appliance No Exceptions Letter	All
04-022	Completed Car Thermal Analysis	All
04-023	Exterior Surface Treatment Plans and Specifications	All
04-024	Final Stress Analysis Report	All
04-025	Periodic Finite Element Model Update Reports	All
04-026	Carbody and Truck Stress Analysis and Test Plan	All

* End of Chapter 4 *

Technical Specification

CTDOT Single-Level Passenger Rail Cars

Chapter 5

Trucks

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5.00 Trucks

5.01 Overview

Each car shall be equipped with two four-wheel trucks. Trucks shall be designed for operation at all speeds up to 125 mph (201 kph). Truck frames may be either cast or fabricated. The trucks shall incorporate braking via tread and disc brakes. Truck design shall be proven for safe and reliable operation on all FRA Classes of track up to and including Class 7.

5.02 General Requirements

A. The truck assembly shall be a four wheel, roller bearing truck designed for operations specified in Chapter 1 (Track Geometry). A comfortable ride shall be provided at all permissible speeds under normal operating conditions. Truck designs must have a proven service history in North American intercity or commuter rail service, or must be demonstrated as being compliant with all Specification requirements through finite element analysis, truck dynamic behavior through computer simulation (validated as defined by the Engineer) and instrumented testing at an approved test track facility. [CDRL 05-001] The car must meet the requirements of 49 CFR Part 213.329 (c) and (d) and 49 CFR Part 345. The truck dynamic characteristics shall be suitable for a single-level car and must demonstrate appropriate response for all speeds, curves, spirals, switches and turnouts, and for all typical track perturbations found within defined safety limits of FRA track geometry standards and as described in this Specification. The truck design must meet this level of suitable performance for up to 5 in. (12.7 mm) of cant deficiency.

B. Truck wheelbase shall be 8 ft 6 in. (2,591 mm). Truck centers shall be spaced 59 ft 6 in. (18,136 mm) apart, equal distance from the car's lateral center line. Trucks shall be designed to operate under the environmental and operating conditions identified in PRIIA Specification 305-912, including track configurations. All truck-mounted equipment shall conform to the clearance requirements of drawing numbers MNR-NO. 8 Rev. B, M-8 Static Clearance Line, and MNR-NO. 9 Rev. C, M-8 Dynamic Clearance Line. [CDRL 05-002] Trucks shall be interchangeable from one end of the car to the other, and all trucks and bolsters shall be directly interchangeable between all car types addressed in this Specification.

C. The truck shall be equipped with the brake equipment specified in Chapter 7. The disc brake arrangement shall be inboard mounted and utilize two discs per axle. Brake equipment shall provide braking rates as identified in Chapter 7.

D. Unsprung mass (between the track and the primary suspension) shall be as low as practical.

E. The truck frame and all components shall be retained to the truck bolster and to the carbody in accordance with the requirements of 49 CFR Part 238.219 and APTA-PR-CS-S-034-99 Revision 2. A locking center pin is required. A means shall be provided for retaining the bolster and truck frame with the carbody during vertical jacking or lifting of the carbody. [CDRL 05-003] These safety straps shall be designed to provide a safety factor of two, based on the yield strength of the material. The ultimate strength of the truck and the truck-to-carbody connection shall be sufficient to secure the entire truck to the carbody in a manner which will prevent truck separation during derailments, collisions, or other events in which a horizontal load of 250,000 lbs (1.1 MN) is applied in any direction at any point on the truck frame. This load may be transmitted from the truck frame through structural members, positive stops, or other rigid, mechanical safety devices and/or combinations thereof to the carbody bolster.

F. Bolster locating radius rods shall not be used to provide any part of this strength. Vertical safety hangers shall be provided to secure the truck to the carbody.

G. Provisions shall be made for use of CTDOT's wheel truing machine, for reprofiling wheels while mounted on a car; without requiring any degree of truck disassembly. Access to the ends of the axle, for wheel truing, shall be available without the removal of any additional parts, including roller bearing end caps (with the exception of cover plates, plugs or axle tachometer generators.)

H. All truck assembly parts shall be designed to withstand maximum stresses as called out in APTA-PR-M-RP-009-98. See Chapter 19 for stress analysis requirements.

I. Truck components without fixed stops shall be designed to have sufficient clearance but no less than 1.0 in. (25.4 mm) to prevent unintended contact of truck-to-truck or truck-to-carbody components under all loading and track conditions including worn wheels and failed springs.

J. Truck components with fixed stops shall be designed to have sufficient clearance to prevent unintended contact of truck-to-truck or truck-to-carbody components under all loading and track conditions including worn wheels and failed springs.

K. The Contractor shall provide instructions in the appropriate Maintenance and Heavy Repair Manuals for future field repair welding procedures for the truck.

5.03 Ride Quality and Performance

A. Ride quality for all proposed truck designs shall be demonstrated analytically and through actual track testing (at an approved test facility) per the requirements of Chapter 19. Truck designs with proven service history on North American intercity or commuter railroads may be validated analytically, if the validation methodology is approved by the Engineer. Some or all portions of the required design validation tests may be waived at the sole discretion of the Engineer if design adequacy can be proven by submittal of existing engineering analysis and demonstration of successful service history of the truck design. [CDRL 05-004]

B. A comfortable ride shall be provided at all permissible operating speeds for each FRA track class, up to the vehicle rated speed. A comfortable ride is defined as weighted root mean square (rms) acceleration less than 0.032 g and a crest factor less than 9. Weighted rms acceleration and crest factors shall be calculated according to ISO 2631.

5.04 Truck Design

5.04.01 Truck Frame

A. Truck frame and truck bolster shall be of cast or fabricated steel construction. They shall be heat stress-relieved after all primary welding is completed, unless otherwise approved by the Engineer. Critical areas of all welds and castings shall be magnetic-particle inspected per ASTM E709-01, radiographically inspected per ASTM E94-04 or ultrasonically inspected per AWS D.1.1.

B. Rotational range and lateral range of motion shall be limited by stop blocks with replaceable wear surfaces mounted to the center sill. The truck shall not contact any other part of the carbody or suspension throughout its range of motion.

C. All wearing parts or surfaces shall be provided with renewable liners or bushings. Truck frame pedestals, if used, shall be lined with low-friction polycarbonate components to minimize wear. Truck design shall permit replacement of pedestal liners without requiring the removal of the wheelset.

D. This truck design shall provide sufficient restraints to prevent hunting of the truck at all speeds up to 125 mph (201 kph), with worn wheels and other components at their condemning wear limits, in accordance with 49 CFR Part 213.333, 49 CFR Part 238.227 and APTA-PR-M-RP-009-98.

E. The design of the trucks shall be analyzed and validated in conformance with the requirements stated in Chapter 19, to verify that the truck design meets all safety, ride quality, durability and maintainability requirements.

F. A centering bearing or pivot shall be located between the truck bolster and the truck frame at its center.

5.04.02 Bolster Anchor

Longitudinal forces shall be transmitted between the truck and the carbody through bolster anchors. The bolster anchors shall be designed to accommodate longitudinal, swiveling and vertical forces encountered during operation on all classes and conditions of track identified in PRIIA Specification 305-912. At the Engineer's request, yaw dampers (i.e. Bolsterless Truck Design) may be proposed in lieu of the anchor rods for damping swiveling motion. See Chapter 4 for other requirements for the bolster anchor and related mounting points.

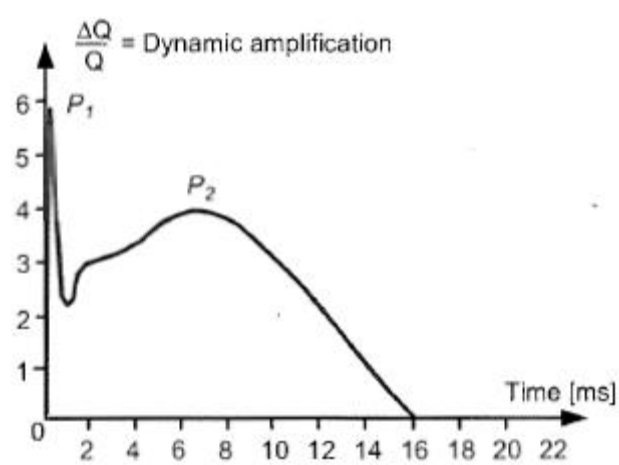
5.04.03 Suspension

A. Primary and secondary suspension arrangements must be of proven arrangement for application on a single-level car. [CDRL 05-005]. Coil springs, if used, as part of the primary or secondary suspension shall not be rubber coated.

B. Vertical suspension elements shall be designed for a minimum functional service life of eight years. Primary vertical suspension elements shall have a minimum functional life of eight years. Deflections in primary suspension due to asymmetric forces from tread brakes shall not result in an unacceptable level of influence on wheelset angle of attack. The carbody secondary suspension shall be provided by coil springs located at each end of the bolster.

C. At the Engineer's request, air springs or other alternative secondary suspension arrangements may be proposed in lieu of steel coil springs. Alternative arrangements must meet all criteria set for this Specification for acceptance. Lateral and vertical motion of the bolster shall be damped by hydraulic shock absorbers and/or air orifices (if air suspension is used). Longitudinal and swiveling motion of the bolster shall be prevented by bolster anchors between the carbody and bolster. At the Engineer's request, yaw dampers may be proposed in lieu of the anchor rods for damping swiveling motion.

D. Vertical P_2 forces shall not exceed 68,000 lbs (302,479 N) with a 1° dip angle using the Esveld equation.



E. Esveld Equation:

$$P_2 = P_0 + 2\alpha v \sqrt{\frac{m_u}{m_u + m_{T2}}} \left[1 - \frac{c_T \pi}{\sqrt{k_{T2}(m_u + m_{T2})}} \right] \sqrt{k_{T2} m_u}$$

F. The parameters in the P_2 force calculation are:

1. P_0 is the nominal static vertical wheel load (pounds)
2. 2α is the total dip angle at a joint, weld dip or other rail discontinuity (radians)
3. v is the speed (inches/sec)
4. m_u is the unsprung mass of the wheelset (pounds-sec2/inch)
5. m_{T2} is the equivalent track mass (pounds-sec2/inch)
6. C_T is the equivalent track damping (pounds-sec/inch)
7. K_{T2} is the vertical track stiffness (pounds/inch)

G. The assumed values of selected parameters are:

1. 2α = 0.017 rad, (1 degree) with half of this (α) on either side of the dip.
2. m_{T2} = 1.1335 pounds-sec$_2$/inch, for nominally stiff concrete tie track
3. C_T = 671 pounds-sec/inch, from literature for nominal track conditions
4. K_{T2} = 330,000 pounds/inch, for nominally stiff concrete tie track which corresponds to a track modulus of 4000 pounds/in/in [assuming a track deflection of 0.1 in. (2.5 mm) under a wheel load of 33,000 lbs (146,791 N)]

H. A safe ride shall be provided in the event of a broken spring, inoperative damper or collapsed or over-inflated air spring (if used).

I. A minimum of 0.75 in. (19 mm) of vertical free travel shall be provided for the range of normal load conditions. Free travel is defined as the change in vertical displacement between the axle center and a carbody reference point as measured under static load conditions with an empty car (AWO) and a fully loaded car (AW3). Sound and vibration deadening inserts shall be provided for all spring seats.

J. Springs and chevrons, if used, shall be designed for ease of replacement and maintenance. Chevrons shall be secured to the truck frame when axle assemblies are removed. Chevrons shall be color-coded for spring rate and shall be installed in matching pairs on each axle assembly of the truck.

K. Coil springs, if used, shall be thoroughly shot-peened after grinding and then coated in accordance with an Engineer-approved paint type.

L. Unless otherwise noted, all coil springs shall meet the latest revision of AAR Standard M-114.

M. Retainers must be provided to prevent an axle from leaving the truck and to also prevent any primary suspension element from leaving its proper position when the car is lifted with the trucks attached, or in the event of a derailment.

5.04.04 Stops

Rubber stops limiting vertical and lateral motion shall be designed with a progressive compression rate and shall not exceed 90% of their design compression under any condition that can be developed in the truck. Lateral stops shall limit the motion of the carbody to stay within the clearance in either direction. Stops that limit truck over-rotation shall be equipped with a replaceable liner to prevent metal-to-metal contact.

5.04.05 Truck-Mounted Brake Equipment

Truck-mounted brake equipment requirements are specified in section 7.6 of Chapter 7.

5.04.06 Handbrake Linkage

Truck-mounted handbrake linkage shall be provided on the B-end truck per the hand brake requirements contained in Chapter 7. All trucks shall be equipped with necessary attachment points for handbrake linkage as specified in Chapter 7. [CDRL 05-006]

5.04.07 Adjustments

Provisions shall be made for adjusting the carbody height up to 0.75 in. (19.05 mm) in either direction from nominal [1.5 in. (38 mm) total adjustment range], in increments of 0.25 in. (6.35 mm), to compensate for wheel wear or other variations. Suspension design shall permit adjustments to be made without disconnecting the truck from the carbody. Air spring leveling valve adjustment shall not be used for adjusting carbody height. [CDRL 05-007]

5.05 Wheel and Axle Assembly

5.05.01 General

A. The wheel and axle assembly shall consist of an axle, two wheels, two outboard journal bearings, two inboard brake discs, speed sensor gear at each journal and associated materials. This wheel and axle assembly shall be fully interchangeable in form, fit and function with Amtrak standard wheel assembly for single-level cars. Mounting graphs and inspection records shall be included in each vehicle history book for all components.

B. All wheelset components shall be manufactured and assembled by a supplier currently certified under the Association of American Railroads (AAR) Manual of Standards and Recommended Practices, M-1003.

5.05.02 Axles

The axle shall be of solid, forged, Grade "F", carbon steel furnished to AAR Standard M-101 or SAE/AISI Standard 4140, normalized, oil quenched and tempered to Brinell 220-270, minimum ultimate tensile strength of 100,000 pounds per square inch (psi) (689,475,729 Pa) elongation of 20% in 2 in. (51 mm) minimum, reduction of area at 50% minimum, yield strength of 80 ksi (551,580,583 Pa) minimum. Axle design and application to be confirmed with theoretical calculations to approved standards for high-speed operation. Axles are to be designed to meet or exceed performance and applicable safety standards. Material and heat treat certification to be provided with vehicle history final reports. It shall have dimensions as specified for a Class F axle according to APTA-PR-M-RP-008-98 and PRIIA Drawing 305-805 for a four-wheel (per truck) configuration.

5.05.03 Wheels

The wheels shall be 36 in. (914 mm) diameter (nominal) Class B, multiple-wear type, conforming to AAR Standard M-107-84 and APTA-PR-M-S-012-99 Rev. 1, and shall have a 1 in 40 tapered tread.

5.05.04 Discs

Brake discs shall be of self-ventilated split disc design that allows the friction ring to be removed and replaced without removing the wheelset. The disc shall meet the performance criteria outlined in Chapter 7. If the removal and replacement of the friction ring requires special tools or process, details must be provided during the proposal phase. Alternate disc configurations may be proposed if the benefits can be shown to outweigh possible increase in maintenance burden.

5.05.05 Journal Bearings

The journal bearings shall be fully enclosed, grease lubricated, Timken Type "F" roller bearings configured for No Field Lubrication (NFL), AAR Class "F" 6.5 in. (165.1 mm) by 12 in. (305 mm), with HDL seals (or equivalent). The service life of the journal bearing shall be at least 1,000,000 miles (1,610,000 km) under AW3 loading. The Contractor shall provide design analysis to verify the use of the type "F" roller bearing.

5.05.06 Journal Bearing Housings

A. Removable journal bearing housings (journal boxes) shall be provided. Pressing shall not be required to remove the journal box from the bearing. Journal boxes shall be common for all locations, or may be common for all right-hand sides and left-hand sides, respectively.

B. Each journal box shall be drilled and tapped in four locations, two locations to the left and two to the right of top-dead-center, to accommodate up to two speed sensors, and a hot bearing temperature sensor probe, per PRIIA Drawing 305-804.

5.05.07 Hot Journal Bearing Monitoring System

A. Each car shall be equipped with a hot journal bearing detector monitoring system similar to UTE Inc., Model 14020, or another Engineer-approved supplier.

B. Upon detection of a hot journal bearing, the system shall locally annunciate the suspect bearing and energize COMM trainline 21C. The trainline will illuminate an indicator in the operating cab of the train. This may be a dedicated indicator light or an indication on a Driver's Operating Screen; an alarm in the driving cab shall sound upon detection and annunciation of a hot journal bearing.

C. The system shall be capable of interfacing with either the conventional 27-point COMM trainline or a vehicle data network and digital trainline, as specified in PRIIA Specifications 305-919 and 305-920.

5.06 Shock Absorbers and Shock Mounts

A. Lateral and vertical motion of the trucks and carbody shall be damped through the use of shock absorbers and/or air orifices (if air suspension is used). Shock absorbers, if used, shall be of a hydraulic type terminating in elastomeric bushed connections to eliminate metal to metal contact. All shock absorbers shall be accessible for replacement without requiring the removal of the trucks from the carbody.

B. Shock mounting brackets on the trucks and carbody shall be designed to last the life of the carbody without wearing, deforming, loosening or otherwise requiring repair.

C. Durability of the shock absorbers, shock mounting brackets and bushings shall be demonstrated analytically and through accelerated life cycle testing simulating actual shock absorber functional service life. Test plan for the shock absorbers and shock mounts shall be submitted to the Engineer for approval as part of the Contractor's proof of design testing (see Chapter 19).

D. The shock absorbers shall be appropriately rated for a service life of no less than five years.

5.07 Electrical Wiring

5.07.01 Speed Sensor

A speed sensor cable shall be provided on each truck to provide a signal from the speed sensor gear located on each axle to the wheelslip control system (see Chapter 7). One end of the speed sensor cable shall be hardwired to the speed sensor itself and the opposite end of the cable shall have an IP-68 rated, watertight circular connector that meets the requirements of Section 18.25.05. and the sensor cable connector shall be placed at or near the physical speed sensor. The design of the speed sensor cable assemblies shall be submitted to the Engineer for review and approval. As guidance, the Contractor shall reference Amtrak drawings D-00-1365 and D-00-1359. The speed sensor cable assemblies shall be attached to the truck frame using rubber coated steel clamps that provide secure attachment while not abrading or pinching the cable. Each clamp shall secure no more than one cable. Clamps shall be securely fastened to the truck frame. Appropriate slack shall be incorporated into the cable length to allow free movement of trucks and truck components while providing adequate securement for the cable. Cables shall be routed to prevent damage from pinching, stretching or catching on adjacent equipment. The electrical connection from the truck to the carbody shall utilize an IP-68 rated, MS-watertight connector onto a watertight junction box located at the side sill adjacent to the centerline of the truck. [CDRL 05-008]

5.07.02 Grounding

An electrical ground path using highly flexible cables or straps shall be provided from each axle to the car body. Grounding paths shall be run from each axle to the journal boxes, from the journal boxes to the truck frame, from the truck frame to the truck bolster and from the truck bolster to the car body. Grounding brushes, cables or straps shall not restrict the movement of truck components, and shall remain slack under all operating conditions. Axle ground brush assembly arrangements shall be submitted to the Engineer for review and approval and shall be not interfere with the vehicle undercar clearance envelope.

5.07.03 Odometer System

All cars shall have an odometer system for registering accumulated mileage, regardless of direction of travel. This system shall sense wheel rotation (and thereby calculate distance) from a magnetic gear tooth located on the end of one axle, such as used for the wheelslide control system and the cab car speed indicator. The odometer sensor and associated electronics shall be isolated from all other car control systems. An average wheel diameter of 34.5 in. (876 mm) shall be used for the distance algorithm. The odometer mileage display shall be located in the electric locker and shall be readable through a window in its cover. A test button shall be easily accessed without opening the door. Mileage shall be stored in memory and will not automatically reset or be lost under any duration power outage, and shall be readable when the car is powered from the Low-Voltage Power Supply (HEP shall not be required to determine the vehicle's mileage).

5.08 Painting

A. The truck manufacturer shall apply at least one coat of a metal primer on all exposed surfaces of the trucks immediately after final assembly cleaning, repairs, and inspection.

B. Final coat of paint will be applied in accordance with exterior graphics requirements in Chapter 23.

5.09 Contract Deliverable Requirements List

CDRL #	Title	Car Type
05-001	Truck Design Details and Verifications	All
05-002	Truck Clearance Diagram	All
05-003	Truck Bolster Retaining Method	All
05-004	Ride Quality Mathematical Model	All
05-005	Primary and Secondary Suspension Arrangements	All
05-006	Truck-Mounted Hand Brake Linkage	All
05-007	Truck Adjustment Method	All
05-008	Speed Sensor Cable Assembly Design	All

* End of Chapter 5 *

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Technical Specification

CTDOT Single-Level Passenger Rail Cars

Chapter 6

Couplers and Draft Gear

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6.00 Couplers and Draft Gear

6.01 Overview

Each car shall be equipped on both ends with an energy absorbing coupler with associated draft gear, coupler carrier, uncoupling mechanism and centering device. The couplers shall be designed to be physically compatible with, couple to, and operate with standard Type H Tightlock couplers and components conforming to MCSCM drawings and APTA standards. The coupler head and knuckle shall conform to the Type H Tightlock pattern as per corresponding MCSCM drawings and specifications. The coupler and draft gear assembly shall be compliant with the requirements of APTA-PR-M-RP-003-98. The design and arrangement shall be submitted for Engineer review and approval. [CDRL 06-001]

6.02 General Requirements

Couplers, draft gear and associated components shall conform to the strength requirements specified in all applicable APTA and AAR standards and recommended practices. Coupler carriers shall be capable of withstanding the vertical forces identified in 49 CFR Part 238.207. All components shall be designed to operate properly under the operational and environmental conditions defined in PRIIA Specification 305-912. It shall be possible to remove or install a coupler and draft gear assembly without requiring lifting of the carbody or removal of the truck.

6.03 Performance Requirements

A. Couplers and associated apparatus shall be designed to meet buff and draft strength requirements as specified by AAR. The strength of the knuckle and head shall be equal to or greater than the strength of an MCSCM/APTA Type H tightlock knuckle and head. Under normal operating conditions, couplers and associated apparatus, including coupler carrier, shall be capable of withstanding for any horizontal position of the coupler, a vertical load of 100,000 lbs (444,822 N) applied in either direction to the coupler as near to the pulling face as practical without deformation to coupler carrier, supporting car body structure and intervening connections

B. Each car shall be capable of operating satisfactorily while coupled to any other car or locomotive used in passenger service under the operational and environmental conditions defined in PRIIA Specification 305-912. Coupler swing shall be such that a car shall be able to negotiate a 250 ft radius (76,200 mm radius) (23 degree) curve while coupled to other cars and/or locomotives as specified without damage to trucks, draft gear, carbody, diaphragms, air hoses or car-to-car connections.

C. The centering mechanism shall maintain the coupler on the vehicle center line when in the uncoupled condition.

D. Car-to-car and coupler-to-carbody air connections shall be designed in conformance with APTA-PR-M-RP-001-97. See Chapter 7 for details regarding car-to-car air connections.

6.04 Coupler, Yoke and Radial Connector

Couplers shall use Type H –MCSCM/APTA standard Tightlock heads and knuckles. Material for couplers and yokes shall conform to AAR Specification M-201 Grade E cast steel, or other cast steel of equivalent or improved properties as approved by the Engineer. Couplers shall comply with the requirements of APTA-PR-M-RP-003-98.

6.05 Draft Gear and Yoke

A. Draft gear shall be two (2) Waughmat, double acting, twin-cushion WM-5-6-DP draft gear packs or approved equal. They shall be designed for 24 5/8" pockets, type WM 6 DP, including followers.

B. Two (2) APTA-approved high tensile steel tight lock coupler yokes, type SY 271 HT2 or approved equal, as shown on Buckeye Drawing No. D 14197 C, shall be provided on each car for use with the draft gear and APTA "H" type short shank coupler. Yokes shall be complete with bushings and yoke pin. No paint shall be applied to the yoke, bushing, or pin.

C. Material for the coupler and yoke shall be Grade E, or better, conforming to AAR Specification M-201 and shall withstand the loads and stresses specified by APTA-PR-M-RP-003-98.

6.06 Coupler Carrier

A. The coupler carrier shall be designed to adequately and consistently support the coupler through its full range of vertical and horizontal movement, and shall maintain the coupler at a nominal 34.5 in. (876 mm) Above Top of Rail (ATOR) height (as measured at the center of the coupler) when uncoupled.

B. A means shall be provided to allow removal and replacement of wear plates, carrier springs and carrier stops. The top surface of the coupler carrier shall be equipped with a replaceable nylon (or other low friction material) wear plate - the coupler shall not rest on a metal surface.

C. The coupler carrier shall provide for adjustment of coupler height of 1.0 in. (25.4 mm) in either vertical direction from the nominal 34.5 in. (876 mm) ATOR coupler height standard. The coupler carrier shall comply with the vertical force requirements specified in 49 CFR Part 238.205 and 238.207.

6.07 Uncoupling Mechanism

All uncoupling levers and hardware shall meet the safety requirements of 49 CFR Part 238. An uncoupling mechanism shall be installed at each end of each car, in conformance with section 5.10 of APTA-PR-M-S-016-06. Minimum clearance of 2 in. (51 mm) shall be maintained between uncoupling mechanism and all other components on the end of the car (including jumper cables, receptacles and carbody structural elements such as collision posts) when car is either coupled or uncoupled. The uncoupling levers shall seat firmly when locked in place and will not rattle or vibrate.

6.08 Mounting Arrangement

The proposed mounting arrangement of the coupler assemblies (cab and non-cab ends) will be submitted for Customer approval during design review.

6.09 Contract Deliverable Requirements List

CDRL #	Title	Car Type
06-001	Coupler Design and Arrangement	All

* End of Chapter 6 *

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Technical Specification

CTDOT Single-Level Passenger Rail Cars

Chapter 7

Brakes

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7.00 Brakes

7.01 Overview

This chapter describes the design and functionality of the pneumatic and mechanical braking systems that shall be provided on each passenger rail car. The braking systems shall include an Electro-Pneumatic system with the ability to operate under conventional pneumatic signals for service and emergency brake applications for all cars in the train. Control equipment to be installed on the cab car to provide braking control for the train brakes and a pneumatic parking/holding brake for the cab car. All cars shall include a wheel slide control system and a mechanical hand brake.

7.02 General Requirements

A. All air brake equipment shall be completely compatible with Type 26C/26L air brake equipment, currently in use in intercity rail passenger service, and conforming to APTA-PR-M-S-020-17. The air brake system shall be capable of running in conventional service in graduated release or direct release mode.

B. Nominal air pressures in the air brake system shall be:

Main Reservoir:	140 psig (9.65 bar g)
Brake Pipe:	110 psig (7.68 bar g)
Brake Cylinder:	100 psig (6.89 bar g) maximum

C. All cars shall be equipped with provision for an Electrically Controlled Pneumatic (ECP) brake system. This provision shall consist of a discrete conduit and wiring per APTA-PR-M-S-022-19, , for redundant implementation of ECP cable-based system in this Specification. The Contractor shall provide a wiring diagram showing connections of brake controls with the two car end junction boxes to implement ECP braking. [CDRL 07-001]

D. The cab car shall be equipped with a Positive Train Control (PTC) system consistent with 49 CFR Part 236, Subpart I – *Positive Train Control Systems* and fully compatible with the latest revisions of ACSES II.

7.03 Performance

A. The system shall be designed for operation at all speeds up to 125 mph (201 kph) in train consists of between 3 and 10 cars with any combination of intercity rail passenger locomotives and single-level cars as specified.

B. The air brake system shall be designed for operation and maintenance in conformance with all applicable Amtrak air brake rules.

C. A train consisting of five single-level cars built to this Specification (in any combination of car types) and one P40, GP40, or P42 locomotive or equivalent shall have a minimum full service braking rate of 1.35 miles per hour per second (mphps) (2.17 kph/s) at 125 mph (201 kph) increasing to and maintaining an average of 2 mphps (3 kph/s) at speeds of 70 mph (113 kph) or less. The instantaneous full-service deceleration rate shall not exceed 2.75 mphps (4.43 kph/s) nor be less than 1.25 mphps (2.01 kph/s). The emergency brake rate shall not be less than 2.5 mphps (4.0 kph/s) at speeds below 70 mph (113 kph). The cars shall be loaded to AW2 condition. The Contractor shall verify that the brakes are fully functional under all operating and environmental conditions found in PRIIA Specification 305-912. Locomotive dynamic braking shall not be used to determine compliance

with specified brake rates. The brake rates shall be adjustable +/-5% through hardware/software changes with final rate selection to occur during pilot car acceptance testing.

D. The maximum jerk rate (the change in the rate of deceleration) during initial service brake application shall be limited to 1.5 miles per hour per second per second (mphpsps) (2.4 kph/s/s) under all normal conditions. There shall be no jerk limit for emergency brake applications. The brake jerk rate shall be adjustable +/-5% through hardware/software changes with final rate selection to occur during pilot car acceptance testing.

E. The Contractor shall determine the brake system delay/dead time, build-up time, response time and equivalent deceleration rates for all speeds from maximum speed to full stop. This information shall be provided to the Engineer during the brake system design review. [CDRL 07-002] The Contractor shall use *Mass Transit Brake System- Performance Requirements* per DIN EN Standard 13452-1 as the method to measure dead time response time and deceleration rate where applicable.

7.04 Design Review

A. Design review shall address the following subjects, describing operator actions and indications and also providing detailed technical design and performance analysis for the following subjects [CDRL 07-003]:

1. Concept:
    a. Concept and operation of friction brake system
    b. Thermal capacity of brake system
    c. Calculations showing that the system's performance requirements will be met
    d. Graduated release setting of control valve
    e. Direct release setting of control valve
    f. Graduated release mode of automatic brake valve operation
    g. Direct release mode of automatic brake valve operation
    h. Lead/trail (cut-in/cut-out of automatic brake valve)
    i. Feed valve setting
    j. Safety control interface (cab signal, overspeed, alerter, PTC)
    k. Forestall pending restriction – positive and accurate interlock with suppression
        i. Penalty application
        ii. Recovery from penalty
        iii. Compliance with Amtrak daily and periodic test requirements
    l. Power knockdown: brakes and traction
        i. Penalty
        ii. Emergency
    m. Wheel slide control
    n. Parking brake interface with brake system, both before and after parking brake application/release, penalty application and automatic brake application
2. Operating:

a. Push-pull operation with locomotive in either leading or trailing position
b. Stopping on a grade
c. Starting on a grade
d. Penalty brake application
e. Operator-initiated emergency brake application
f. Conductor- or passenger-initiated emergency brake application
g. Train separation (break-in-two)
h. Operation of short trains (three cars or less)
i. Operation of long trains [six to 24 cars including the locomotive(s)]
j. Dead engine movement (with and without Main Reservoir (MR) to cab car)
k. Transition between ECP Emulation mode and ECP Operation mode
l. Cab car parking brake function

B. Design and performance analysis will be evaluated during design review, First Article Inspection (FAI) and proof of design testing.

C. Expected COT&S interval for brake valves and applicability for extended COT&S cycles.

7.05 Car Body Components

7.05.01 Piping and Fittings

A. The inside diameter of the trainline MR pipe shall be 1.00 in. Iron Pipe Size (IPS). The Brake Pipe (BP) shall be 1.25 in. IPS. All pipes and fittings in Main Reservoir pipe and Brake Pipe lines shall be extra-heavy schedule 80 steel pipe in accordance with ASTM Standard A-53, or an alternate as approved by the Engineer.

B. Brake pipe trainline must pass AAR Standard S-471.

C. Piping practices shall conform to AAR Standard S-400 and S-402.

D. AAR type branch pipe tees shall be provided and shall be orientated at a 45-degree slope upwards or higher to prevent moisture from being drawn into the branch pipes. The trainline MR branch pipe shall be routed to the main reservoir tanks before being routed to the brake manifold. As much as possible, piping shall be routed to avoid traps and avoid draining moisture toward brake valves.

E. Unless the main reservoir pipe is not routed below the car, the low point of the MR pipe shall be equipped with a heated drain valve, to rid the pipe of moisture buildup; moisture drain shall be in response to either brake release cycle or timed cycle. The air supply system shall conform to APTA-PR-M-S-011-99 Rev. 2 for compressed air quality for passenger locomotive and car equipment.

7.05.02 Angle and Cut-out Cocks

A. Locking, ball type, cut-out cocks shall be provided in the MR Pipe and the BP at each end of the car. The MR pipe cutout cock shall be vented toward the hose end, oriented below horizontal.

B. A locking vented ball-type cut-out cock shall be provided in the brake cylinder line to each truck for venting brake cylinder pressure. The cutout cock shall be a 3-way type, vented downstream. The vent port of the cut-out cock shall be tapped for 0.25 in. (6.35 mm) National Pipe Thread (NPT).

C. All cut-out cock handles, except end of car BP angle cocks, shall be arranged so that the handles are parallel to the air pipe in the closed position. Closed "end of car" BP cut-out angle cock handle shall be perpendicular to the air pipe.

D. All valves and cocks shall be identified including the cut-in and cut-out positions. A "flow bar" cast or stamped into cock handles shall be acceptable for cut-in/cut-out position labeling. All air brake angle cocks and cutout cocks are to be clearly labeled using engraved and color-coded stainless steel, aluminum tags.

7.05.03 Hoses and Couplings

A. All connecting hoses, except BP trainline hoses, shall be AAR Standard M-618 double wire braid reinforced hose. Brake Pipe trainline hoses shall be AAR Standard M-601 braided hose. All hose material, when installed on the car, shall be less than one year old from date of manufacture. Trainline hose connections shall be in accordance with APTA-PR-M-RP-001-97- MR and BP hoses shall be supported near the glad hand end from the coupler using rubber suspenders. Trainline hose locations shall be in conformance with APTA-PR-M-RP-001-97.

B. Two dummy couplings, one "F" type and one "E&L" non-vented type, shall be provided at each end of the car. The dummy coupling shall be secured to the car with chains in a manner which will prevent the trainline hoses at the ends of the car from dragging when the couplings are connected to the hoses.

7.05.04 Emergency (Conductor) Brake, Application and Vent Valves

A. Manually operated conductor's valves, Wabtec B-3-B emergency brake valve, or approved equivalent, shall be provided as follows:

   1. On both ends of the car, just inside the body end door, right side of the door facing outward (except the F-end of cab cars).

   2. On the F-end of the cab car, on the passenger side of the bulkhead separating the cab from the passenger area, to the right of the door when facing the cab area.

B. These emergency brake valves, when used in conjunction with a Wabtec E-3 brake valve, or approved equivalent, shall cause an emergency brake application when activated.

C. The valves shall be located in a conspicuous location for ease of operation. The operating handles shall be red and shall be clearly labeled, in accordance with PRIIA Specification 305-909.

D. A Wabtec emergency brake valve p/n 535026, or approved equivalent, shall be located in the cab on the Observer's console.

E. Vent valves shall be provided along the BP in accordance with air brake system design requirements. Vent valves shall be positioned such that they can be readily accessed either from the side of the car to be plugged for testing or due to equipment failure.

F. Ready access shall be provided to all valves to facilitate inspection, replacement and maintenance.

G. The emergency brake valves shall meet the requirements of APTA-PR-M-S-007-98.

7.05.05 Reservoirs

Reservoirs of sufficient capacity for a minimum of three full-service brake applications without recharging shall be provided. ASME-certified main and auxiliary (brake cylinder) supply reservoirs shall be drilled as described in 49 CFR Part 229 to eliminate the need for hammer and hydro-static testing. When installed, they shall be sloped toward one end, where a manual purge valve with locking handle shall be provided to

drain accumulated moisture. Main reservoirs and air supply reservoirs used for water raising shall be coated internally with a suitable paint to prevent corrosion. All reservoirs shall comply with the ASME Boiler and Pressure Vessel Code as applicable.

7.05.06 Control Manifold and Valves

A. Control valves shall use stainless steel springs and spool valves where appropriate. The control valve shall include the control reservoir charging cable or equivalent functionality.

B. The air brake control valve and cab control manifolds shall be located inside the carbody, above the level of brake pipe. If necessary, the cab control manifold may be located undercar, provided it is protected from weather and mechanical damage and its location provides easy access for maintenance. Branches will leave the brake pipe at a 45-degree slope upwards or higher, and shall utilize an AAR "branch pipe tee". The Air Brake Control Valve manifold shall include test fittings for main reservoir, brake pipe, brake cylinder and #16 air pipes. In addition, the relay valve exhaust and #10 air pipe exhaust shall have a threaded exhaust outlet to permit mounting a gauge. Alternate methods for completing tests associated with these ports may be proposed.

C. Full-face gaskets or O-ring gaskets shall be used for valve portion interface sealing. All stud mounted components shall be designed to allow installation or removal with standard socket wrenches.

D. Electronic modules, pneumatic modules, cutouts, test points and electrical connections shall be front-plate mounted on the manifold. Front-plate mounting is not required if the manifold is oriented so that access is provided to both sides. All power, input and output connections, external to the manifold, shall be provided with multiple pin connectors or a screw-type terminal block. Individual spade-type or threaded connectors are not permitted. Ring terminals shall be used if connected to a screw-type terminal block.

E. All valves on the manifold, as well as the manifold itself, shall be easily removable for servicing. All valves shall be individually replaceable with the manifold installed on the car without removing any additional valves or components.

F. Valves shall be acoustically isolated from the car interior areas to minimize exposure of passengers and crew to noise generated by the air brake components. Exhausted air shall be piped to the underside (exterior) of the car. All valves that have an exhaust port shall be equipped with a wasp excluder.

G. Brake cylinder pressure shall be supplied and maintained by a relay valve with a 1:1 ratio. Alternate relay valve configurations may be provided as an option with Engineer approval.

H. All devices shall be clearly and permanently labeled on the manifold body, including cut-in and cut-out positions of all valves and cocks. Etching or silk screen printing during the machining process is acceptable for labeling manifold items. Stamped aluminum tags may be used on valve handles.

I. The minimum brake cylinder pressure shall be established to provide adequate adjustment from minimum service to full service for proper train operation. The brake cylinder pressure (full service and emergency) shall be preliminarily approved as part of the design review process with final setting determined during pilot car acceptance testing.

7.05.07 Penalty Brake Application

The controlling brake system shall develop a full-service brake application when actuated by the alerter, overspeed or PTC to create a penalty brake application. The functionality should be equivalent to a Wabtec P-2-A penalty application valve portion and pipe bracket.

7.05.08 Auxiliary Air Equipment

A. MR air will be used for air-operated auxiliary devices. BP air shall not be used. Auxiliary functions shall be isolated from air brake functions and shall be disabled when MR pressure falls below 80 psig (5.52 bar g). Auxiliary valves shall regulate air pressure for MR-supplied functions such as water raising and toilets. Air for the horn and bell on the cab car shall be supplied from the first main reservoir.

B. The water raising air valves shall be mounted above the water level of the water storage tank to prevent backflow of water into the air system during normal operation or when the air system is depressurized. The valves shall be readily accessible for maintenance and replacement.

7.06 Truck Components

7.06.01 General

A. The car shall be equipped with a combination disc and tread brake equipment. The actuators for both the disc brakes and the tread brakes shall operate at the same air pressure from the same air source. Brake effort contributions from disc and tread brakes shall be specified to avoid wheel thermal cracking and brake disc damage. Under all circumstances the brake rates defined in this chapter and in this Specification shall be achieved.

B. The Contractor may propose alternate components for Engineer approval if the components as specified cannot achieve the specified braking rates, or if superior braking performance can be achieved through the use of other brake system components.

7.06.02 Disc Brake Actuator

A. An air actuated caliper mounted on the truck frame shall be used in conjunction with each disc to develop braking effort. Suspension of caliper assembly shall follow lateral movement of the wheel assembly without restriction. Automatic slack adjusters shall maintain an adequate clearance between disc and pad to prevent friction heating while brakes are released.

B. The disc brake system shall use pads compliant with PRIIA Specification 305-900 testing requirements. Performance of brake disc friction material shall be suitable for the speeds, route brake duty cycle and overall train braking performance and shall not induce temperatures that may result in long or short term thermal damage as to disc friction ring as defined by brake disc manufacturer. Where possible pads already in service with CTDOT shall be tested to verify suitability to permit usage on both the new and existing fleets.

C. Pad holders and disc pads shall be UIC Type for 400 cm^2 with an approved locking device or approved equivalent. The slack adjuster shall have sufficient capacity to maintain nominal shoe clearance and piston travel through the full range of new to worn discs and brake pads.

D. The disc actuator shall be capable of handling pressure up to 150 psig without damaging the actuator, disc, brake rigging or any other system or component on the vehicle.

7.06.03 Brake Discs

A. The brake disc supplier shall determine the optimal disc brake configuration to achieve the required operational performance without exceeding the thermal capacity of the disc brake or disc brake pad. Brake disc supplier shall provide an analysis of the thermal capacity of the discs based on the planned train operational pattern including frequency of braking for various braking initial speeds and station stopping patterns as provided by the Engineer.

B. The fatigue life of the connection between the hub and friction ring must take into account cyclic loading from thermal and shock environments that are separately considered and are encountered in

normal service. The shock environment due to wheel/rail interaction at normal revenue speeds is known to result in disc response in the form of a "bending out of plane" vibrational mode. The natural resonance frequency of the disc, for this bending mode, shall be demonstrated (by analysis or test) to be greater than 350 Hz. The frequency analysis is to be performed under the assumption that the disc is fixed to the axle. The fatigue life at the most highly stressed location in the connection between the hub and spoke, due to combined strains from thermal and shock load, shall be equal to or greater than the projected service life of the friction ring or 1,000,000 miles (1,610,000 km), whichever is greater.

C. All brake discs must be cast within a facility located in either North America or Europe, unless approved by the Engineer. The disc shall comply with the following requirements in this Chapter during design review.

D. Design Criteria

1. The brake discs (including friction ring and spokes) shall have adequate mechanical and thermal capacity for service on and off the Amtrak Northeast Corridor (NEC), under the environmental and operating conditions identified in PRIIA Specification 305-912. CTDOT service includes NEC operation so the NEC verification will be used to validate the disc performance. The discs shall be designed to withstand the mechanical loads arising from track-generated accelerations defined in Table 7-1 and thermal loading from friction braking from initial installation through the projected service life of the disc friction ring. This shall be verified by Finite Element Analysis (FEA) and a fatigue life estimate based on the results of the analysis performed by the brake disc supplier. The brake disc supplier shall also confirm by analysis that the brake disc natural frequency for all disc bending modes is greater than 350 Hz.

2. Data in Table 7-1 identify the distribution of peak vertical and lateral shock loads observed on the Northeast Corridor during one round trip between Washington, DC and Boston, approximately 1000 miles of normal operation. An analysis shall be conducted to predict the fatigue performance of the proposed brake disc per the data provided in Table 7-1, and from the thermal loading measured from the dynamometer testing performed pursuant to the requirements of Chapter 19, and submitted to the Engineer for approval. [CDRL 07-004] For mechanical loading, each shock event shall translate into a minimum of two full bending stress reversals when evaluating the fatigue life of the disc, to account for the damping of the excitation in the disc. A moment arm shall be taken into account for the distance from the axle box to the center of the disc for vertical shock loads, based on the worst-case condition. The fatigue analysis of the disc shall take into account fatigue damage from in-service thermal and mechanical loading combined.

3. The fatigue limit shall be selected based on at least a 50% probability of survival and shall account for manufacturing technique, surface finish, metallurgical properties, etc. as specified in recognized industry standards. The factor of safety shall be at least 1.50. The factor of safety shall be applied to the stresses obtained from the FEA which are incorporated in the fatigue estimate to reduce the predicted fatigue life.

E. Brake Disc FEA Report

The brake disc supplier shall submit a brake disc FEA report, for approval by the Engineer. [CDRL 07-005] The maximum stress from the FEA at the specified loads, with a factor of safety of at least 1.50, shall be less than the allowable fatigue limit. The Contractor may elect to simplify the load cases into stepped increments, provided the methodology and the data utilized to establish equivalency is found acceptable to the Engineer. The FEA report must include an analysis for fatigue life and must include a Miner's rule calculation showing the damage factors due to loads imposed by vertical and lateral axle box acceleration and thermal loads resulting from friction between the disc and brake shoes. The Miner's sum must not exceed 0.3 for the service life of the disc for the hub-friction ring connection. The FEA report shall include, but not be limited to, the following:

1. Introduction
2. Table of Contents
3. Summary
4. Physical properties of each material used for the disc. This table shall include, but not be limited to:
    a. Yield strength
    b. Ultimate strength
    c. Elongation
    d. Tension modulus
    e. Compression modulus
    f. Shear modulus
5. Minimum values shall be used, and shall be selected from ASTM (or equal) material specifications, as approved by the Engineer. The brake disc supplier may propose alternate material specifications for Engineer approval.
6. Views of key structural areas (spokes, hub-friction ring connections, etc.) showing member locations and geometry, and indicating the material and thickness of each. Other FEA views may be required where critical stress areas are identified.
7. A tabulation or fatigue curve justifying the Contractor's selection of allowable fatigue stresses for the disc material for each transition or joint, and the fatigue-critical stress ranges. The FEA report shall include a description of how this process is carried out.
8. The complete test report must be submitted including procedure, raw and reduced data, and summary of results, including:
    a. Structural sketches and/or layouts of the critically stressed locations showing locations and shapes depicted in scale, thickness, section properties and material. Methods of joining (if appropriate) shall be defined.
    b. Diagrams displaying externally applied loads and boundary conditions.
    c. Color plots of the stress under each load condition for critically stressed areas.
    d. Natural frequencies of the disc.

7.06.04 Tread Brake Units

A. A truck mounted air actuated tread brake unit, with integral slack adjuster shall be applied at each wheel. The tread brake unit shall operate in conjunction with the adjacent disc brake caliper from the same air source.

B. Composition brake shoes 2 in. (51 mm) thick, of a size and type in general used by CTDOT shall be provided. Performance of brake shoe friction material shall be suitable for the speeds, route brake duty cycle and overall train braking performance and shall not induce temperatures at the wheel tread that may result in long or short term thermal damage, as defined in 49 CFR Part 238. Where possible shoes already in service with CTDOT shall be tested to verify suitability to permit usage on both the new and existing fleets. A brake key shall secure the brake shoe to the brake heads, and shall not require the use of specific tools for installation or removal.

C. The design of the tread brake shall accommodate a new wheel with a diameter 0.625 in. (15.88 mm) greater than nominal wheel diameter.

D. The slack adjuster shall have sufficient capacity to maintain nominal shoe clearance and piston travel through the full range of new to worn wheels and brake shoes, and shall provide sufficient clearance to install a 2 in. (51 mm) brake shoe against a new wheel oversize by 0.625 inches in diameter (0.25 inches radius).

E. A minimum of one tread brake unit on each axle of the B-end truck shall be equipped with hand brake linkage sufficient for a 5% grade.

7.07 Wheelslide Control System

7.07.01 General

A. The wheelslide control system shall modulate the application of the pneumatic brakes to prevent sliding of the wheels through the use of a microprocessor design. The system for each car shall include:

1. System unit/controller with pre-wired connector plugs
2. Modulation type dump valves (two per car)
3. Molded T-harness cable, or equivalent protected cable type (two per car)
4. Speed sensors (one per axle)
5. Download any diagnostic software for Portable Test Equipment (PTE) (test unit itself is not required)
6. Adapter cable to connect a PTU to the wheelslide control unit

B. The system shall continuously measure the speed of each axle and take corrective action should a sliding wheel be detected. The wheel slide system shall operate under all braking conditions and shall not permit the jerk limit to be exceeded on reapplication of brakes following a slide correction. The system shall be designed to prevent permanent thermal damage to the wheel tread as evidenced by spalling, under all adhesion conditions.

C. The wheelslide system components, including controller and dump valves shall be equipped with an identification plate or tag which includes:

1. Vendor
2. Vendor part number
3. Date of manufacture
4. Serial number
5. Car type

7.07.02 Control Unit

A. The control unit shall be mounted in the electric locker.

B. The wheelslide control equipment is subject to the following conditions:

1. The wheel slip function shall be automatically self-calibrating to continuously adjust for the difference in wheel circumference from nominal new wheel to fully worn wheel rim thickness.

2. The system software shall be designed to account for the rotational inertia properties of the wheel set assembly.

3. Wheel slide corrections shall not occur at normal deceleration rates on dry, level tangent track. System logic and criteria for detection and correction of wheel slide and instantaneous deceleration rate shall be submitted for review and approval.

4. The system software/control electronics shall possess features to prevent inappropriate wheel slide correction function from transient signals arising from one damaged or missing gear tooth. This requirement includes provisions for intelligent interpretation of transient changes in signal amplitude at all speeds due to axle gear run-out, vibration of sensor mounting bracket or sensor/gear clearance settings.

5. Wheel slide protection shall be retained on all remaining axles should the control unit fail to receive one or more axle speed signals. It is recognized the system performance for the axle with the defective sensor is compromised under these conditions.

6. A safety timing function shall be provided to cancel wheel slide corrections exceeding a specified duration to be determined based on final system design. Protection shall be locked out on the affected truck until car is at zero speed.

7. The system shall utilize software that is at the current revision at the time of installation.

C. Auxiliary Functions

The system shall supply two auxiliary zero speed signals, provided for door control, as described in Chapter 8, as follows:

1. A zero-speed switching device shall close below 3 mph (5 kph), and shall open above 3 mph (5 kph).

2. A 20 mph (32 kph) speed switching device shall close below 20 mph (32 kph) and shall open above 20 mph (32 kph).

3. Logic shall be fail-safe, such that zero-speed and 20 mph (32 kph) relay drop out in the event of any component failure or loss of power. Speed signal logic shall meet the requirements of EN 50126 SIL 2. The speed signal shall incorporate separate relays that break both the positive and negative components of the zero and 20 mph (32 kph) signals. Both the normally open and normally closed contacts shall be made external to the unit. Contact rating shall be 0.25A @ 80VDC. Contacts shall be high reliability to reduce the probability of welding.

D. Diagnostics

1. The wheelslide control unit shall include integral diagnostic indications (at a minimum) of the following system states with the vehicle moving:

   a. Open, shorted or grounded speed sensor circuit

   b. Open, shorted or grounded dump valve circuit

   c. Electronics fault identified at component level

   d. Power loss/low supply voltage during car deceleration

   e. Software logic fatal error or program lockup

   f. Time out of safety timer

g. Weak/missing speed sensor signal

2. When the car is stationary with adequate power and air, it shall be possible to conduct a self-test that shall verify the following functions in addition to those above:

   a. Ability of magnet valves to release and apply brake cylinder pressure

   b. Ability to test magnet valve time-out

   c. Ability to exercise zero-speed relays

E. Faults

1. Faults detected shall be retained in the fault memory and displayed on the front of the controller using a numerical display that indicates proper system operation, or a fault code. The readout shall:

   a. Be able to identify defects down to printed circuit board, individual speed sensor or magnet valve level.

   b. Include transient faults detected while the car is in motion.

   c. Provide sufficient information to enable maintenance personnel to determine if the unit is working properly, and if not, whether the system can be repaired while on the car or must be removed for repairs.

2. A permanent label shall be fixed to or near the controller that identifies the numerical codes for faults represented by numerical display. It shall also provide instructions for initiation of self-test program and the clearing of faults from memory. The chart shall be positioned so that it can be easily referenced in seated or standing position (as appropriate) while reading the display or manipulating button.

F. Circuit Boards

1. All circuit boards shall be identified with:

   a. Vendor name

   b. Vendor part number

   c. Date of manufacture

   d. Revision level

   e. Serial number

G. Test Equipment and Software

1. The Contractor shall provide five electronic copies of wheelslide system diagnostic software to be used on a PTE. Operating instructions for this software shall be included in the vehicle maintenance manuals. [CDRL 07-006]

2. The Contractor shall provide 10 cables to connect a PTE to the wheelslide control unit to allow on-car troubleshooting. [CDRL 07-007]

7.07.03 Dump Valves

When a slide condition is detected by the controller, it shall be relieved on a per truck basis, by controlled reduction of brake cylinder pressure by an electro-pneumatic modulating type dump valve. Braking shall be reapplied after correction is made at a rate designed to take maximum advantage of prevailing adhesion but shall not exceed the jerk rate. Air consumption shall be minimized during slide correction. The dump valve porting and internal capacity shall be optimized for car dead and displacement brake

cylinder volumes. All valve and relay coils, except anti-skid valves, shall be suppressed with passive electronic devices.

7.07.04 Speed Sensors and Wiring

A. Axle speed shall be determined from an active speed sensor mounted on a journal bearing adapter. The sensor shall detect speeds of 0 mph (0 kph) unless otherwise approved. The sensor gap shall not require adjustment during installation. The speed sensors shall connect to the wheelslide control unit through a T-harness, or equivalent protected cable system. The T-harness or equivalent protected cable system shall connect to the carbody wiring through a MIL standard circular connector, mounted to an electrical box on the carbody. Terminal and junction boxes shall not be mounted on the trucks.

B. The speed sensor cables and T-harness, or equivalent protected cable system, shall be attached to the truck frame using coated clamps that provide secure attachment while not abrading or pinching the cable. Each clamp shall secure no more than one cable. Clamps shall be attached to the truck frame using fasteners and lock washers in tapped holes. There shall be sufficient slack in the speed sensor wiring to allow the bearing adapter to move to the bottom of the pedestal opening without stressing the cable (such as when the truck is lifted with axles installed). Cables and harnesses shall be accessible for replacement while the car is in service.

7.08 Brake Indication Devices

7.08.01 Pneumatic Indicators

If required to perform brake system inspections on trucks where the brake shoes cannot be seen from the side of the vehicle, pneumatically operated indicators, one on each side of the carbody at each truck, shall be connected to the brake cylinder air supply line between the brake cylinder cut-out cock and the brake cylinder. These indicators shall provide a positive visual status of the brake system to crewmembers.. The indicators shall be readily visible from station platforms as well as track level, and from both ends of each side of the car.

7.08.02 Pressure Switches and Brake Status Lights

A pressure switch shall be provided for each truck, monitoring the brake cylinder pressure downstream of the truck cutout cock. A test fitting shall be provided in each brake cylinder line to the trucks, downstream from cutout cock and dump valve. In addition, a test fitting shall be provided for each pressure switch to check calibration. These pressure switches operate the brake applied/released indicator lights, as well as provide a signal to the Operator's console in the locomotive or cab car (via pins 10 and 18 of the 27-point communication trainline) to display brake system status (applied or released). Trainline function is as follows:

A. Brake released: continuity when brake cylinder pressure on both trucks is less than one-half of a minimum service application, and handbrake is released.

B. Brake applied: continuity when brake cylinder pressure on both trucks is applied at one-half of a minimum service application or greater or handbrake is applied.

C. The exterior of each car shall be equipped with two 3-lamp indicator assemblies, as specified in Chapter 11. Indicators shall display the following aspects:

   1. Green: All brakes released, and handbrake released

   2. Yellow: Brakes applied, and handbrake released

   3. Flashing Yellow: Handbrake applied (with air brakes applied or released)

7.08.03 Cab Car Air Gauges

A. Two Engineer-approved duplex air gauges, at least 3.5 inches (88.9 mm) in diameter, shall be provided in the cab car operator's cab. The gauges shall be illuminated, and have a black dial with white lettering. Both gauges shall be graduated from 0 to 200 psig (0 – 14 bar). One gauge shall indicate Main Reservoir and equalizing reservoir pressures, and the other gauge shall indicate brake cylinder and Brake Pipe pressures. If pneumatic, air gauges shall be equipped with gauge test fittings and be arranged for testing in place. If electronic gauges, a means for testing and calibrating the gauges must be available to be compliant with 49 CFR 229. Alternative configurations compatible with the cab design may be submitted for consideration as options to the base configuration.

B. A weatherproof micro-switch shall be provided to indicate handbrake status to the car's exterior brake status lights, and to the locomotive and cab car via pin 20 of the 27-point communication trainline. The switch shall be weatherproof to prevent damage from environmental conditions.

7.09 Handbrake

7.09.01 Handbrake Unit

A handbrake with lever-type handle shall be provided at the B-end of each car accessible from the passageway between collision posts. The handbrake shall be compliant with APTA-PR-M-S-006-98 Rev 3. The hand brake unit shall be capable of generating enough holding force for a 5% grade and ready-to-run car mass per APTA standard requirements.

7.09.02 Handbrake Linkage

The handbrake linkage shall connect the handbrake operator to one tread brake actuator on each axle on the B-end truck. All handbrake linkage, chain or cable guides, lever pivots and carriers shall be adequately designed to prevent wear or binding throughout the life of the vehicle, including due to corrosion, abrasion or close clearances. The handbrake system shall not rattle during car motion, and shall not inhibit proper operation of the brake cylinder slack adjusters. A return spring shall ensure that adequate slack is in the handbrake linkage when released, so that the tread brakes do not drag on the wheels when the handbrake is released. Alternate handbrake arrangements such as using the disc brake actuator in place of the tread brake actuator may be proposed for review and approval.

7.10 ECP Brake Control System

7.10.01 General

A. All cars shall be equipped with an Electronically Controlled Pneumatic (ECP) Brake System per APTA-PR-M-S-021-17. The cars shall be equipped with discrete conduit and wiring configured per APTA-PR-M-S-022-18. This shall include the installation of trainlines, an electrical terminal box at each end of the car, a terminal box at the brake manifold, conduit connecting them, as well as armored cable wiring. The Contractor shall provide appropriate clearance on brake manifolds and adjacent structure to permit the, servicing, removal, and installation of ECP modules. The end of car arrangement shall include provision for the ECP trainline cable and junction connections per ATPA-PR-M-RP-001-97. The Contractor shall provide wiring diagrams for connections of brake controls with the two junction boxes at the car ends, to implement ECP braking. Design, arrangement and installation shall be subject to Engineer approval during design review. [CDRL 07-008]

B. The ECP system shall include emulation operation per APTA-PR-M-S-020-17. The ECP system shall incorporate an emergency brake backup control of 16 pipe using only pneumatic control valves, if a malfunction of the electronic brake system occurs, if the car battery is depleted, or if no electrical power is present on the car.

C. The ECP system shall be verified as compliant with APTA standards per the requirements of APTA-PR-M-S-025-18 and APTA-PR-M-S-026-18. Certification of successful validation of these tests submitted to the Engineer for review and approval. [CDRL 07-009]

D. Alternative electro pneumatic brake systems can be proposed that must:

1. The system shall be powered by the vehicle low voltage power system.
2. The controller shall interface with the above denoted communications trainline for transmission of brake demand signals.
3. The system shall revert to control of BC via BP pressure in absence of trainline commands for use in consists with legacy cars. In the case where the controller is utilized for BP response control, the controller shall emulate 26C response for compatibility with legacy cars in the same consist.
4. The system shall incorporate a backup control of 16 pipe using only pneumatic control valves, if a malfunction of the electronic brake system occurs, if the car battery is depleted, or if no electrical power is present on the car.
5. The system shall incorporate interior mounting of pneumatics and electronics within a single module.
6. The system shall incorporate component standardization in accordance with current PRIIA Requirements documents.

7.10.02 ECP Display

The cab car shall have provisions for an ECP display or display screens associated with other cab displays. The ECP display shall provide pertinent data of ECP status and allow initialization and end change functions associated with ECP Operation. The Contractor shall provide the location of the ECP display for review and approval. [CDRL 07-010]

7.10.03 ECP Event Recorder Interface

The ECP system shall interface the Event Recorder of the Cab Car (Chapter 16) for recording of ECP Control Details. The dataset and transitions protocols between the Event Recorder and the ECP system to be determined between the Event Recorder supplier and the ECP System Supplier.

7.10.04 ECP Power Supply

The ECP Power Supply per APTA-PR-M-S-023-18 shall be mounted inside an interior electrical locker. Exterior mounting may be proposed if a suitable enclosure is provided to properly protect the power supply from the elements and road debris.

7.11 Brake Control Handle

7.11.01 General

A. The brake control handle for installation in the cab car shall be a two-handle console mount type situated to the right of the propulsion controller. The left handle shall provide brake control for the train's automatic air brake. The right handle shall generate a full service or greater brake application for the cab car only for use as a park or holding brake.

B. The brake controller handle positions shall match standard 26C with release closest to the Operator and emergency furthest from the Operator, and minimum service, suppression, full service and handle off positions in between.

C. The parking brake handle, normally used for independent brake control, will only move forward and backward with the handle locked in the bail off (rotated sideways) position. This arrangement is to distinguish it from a standard independent handle found in a conventional locomotive.

D. Cut-in and cutout controls shall be provided with the brake control handle which will enable the brake control handle to control the trains automatic air brakes. There shall also be a test position that will cut off equalizing reservoir from brake pipe to test for leakage.

E. A protection mechanism shall be provided to prevent inadvertent cut-in or cut-out of the brake control handle while the train is in motion.

F. Cut-in and cut-out procedures for both ECP and traditional 26C type brake control shall be submitted for review and approval.

G. The brake controller may have an integrated display, or the Operator information associated with the brake control may be integrated into the cab display.

7.11.02 Park Brake Function

A. When the park brake handle is moved 60% or more of its travel, a full service or greater brake application will be generated on the cab car only. All indicators and interlocks such as brakes applied or power knock out will function normally associated with the application of brake cylinder pressure.

B. The park brake handle function will be inhibited when the brake control handle is cutout.

C. The park brake handle will be marked with "PARK" and an arrow pointing towards the application region of the brake control handle assembly.

Table 7-1: Communication Acceleration Summary: Washington, DC - New York City - Boston

ACCELERATION SUMMARY -- WAS-NY

Acceleration Threshold: 50 g (Vertical), 30 g (Lateral)

Acceleration Threshold: 50 g (BUMP), 50 g (TILT)

LBOXVERT											
Num	MP	Feet	MPH	LVert(g)	RVert(g)	LLat(g)	RLat(g)	Location(s)	Duration(s)	Latitude	Longitude
021908-02 Washington to Baltimore											
1	135	74	44	50.66	-13.92	11.82	7.32	73.747	0.0003	38.91	-77.00
2	132	196	114.52	51.76	-30.64	23.44	13.18	196.168	0.0003	38.92	-76.95
3	128	308	100.53	54.93	-18.55	17.33	14.45	307.592	0.0003	38.93	-76.89
4	128	320	107.2	63.6	-25.27	27	7.81	319.076	0.0003	38.94	-76.89
5	999	354	121	54.44	-24.9	-17.77	15.97	354.508	0.0003	38.95	-76.87
6	113	776	125.36	74.34	22.83	-14.65	-10.64	775.692	0.0017	39.10	-76.70
7	103	1050	125.48	52.25	-16.72	-6.88	7.03	1050.669	0.001	39.24	-76.69
021908-03 Baltimore to Wilmington											
1	89	398	108	97.66	47.24	25	22.07	398.95	0.002	39.31	-76.50
2	75	808	124.54	72.88	32.96	-14.6	-18.75	808.947	0.002	39.41	-76.30
3	75	812	124	54.44	42.24	-15.04	-19.87	812.209	0.0003	39.41	-76.30
4	75	812	125.44	60.18	19.04	15.97	12.84	812.266	0.001	39.41	-76.30
5	75	814	126	70.43	32.96	31.74	17.48	814.439	0.0003	39.42	-76.29
6	72	915	119	87.65	47.49	-20.12	-20.41	915.764	0.002	39.44	-76.24
7	66	1079	125.86	52.49	-35.64	-15.92	12.45	1079.542	0.0003	39.50	-76.17
8	38	1895	134.18	66.04	33.33	21.19	19.53	1895.627	0.0013	39.67	-75.75
021908-04 Wilmington to Philadelphia											
1	26	51	75	108.03	-41.26	-19.34	24.32	51.948	0.002	39.74	-75.53
2	26	59	80	59.45	26.86	23.1	-25.83	59.513	0.0003	39.74	-75.53
3	20	232	125.04	90.33	-28.69	19.87	-14.7	232.492	0.002	39.79	-75.46
4	168	412	87	85.82	-26.98	-19.09	16.36	412.28	0.0013	39.82	-75.41
5	12	584	109	55.3	62.13	21.24	-25	584.382	0.0007	39.87	-75.33
6	12	586	110	69.82	-33.45	-17.58	19.09	586.73	0.0017	39.87	-75.33
7	4	846	102.78	77.76	-22.95	17.19	-17.58	846.559	0.001	39.93	-75.22
8	4	846	102.9	77.76	-22.95	17.19	-17.58	846.565	0.0013	39.93	-75.22
9	4	851	93.2	74.34	58.47	25.68	-23.88	851.296	0.0003	39.93	-75.22
10	4	851	93.29	74.34	58.47	25.68	-23.88	851.299	0.0003	39.93	-75.22
11	4	851	93.35	74.34	58.47	-25.05	-23.88	851.301	0.0007	39.93	-75.22
12	4	851	93.45	74.34	58.47	-25.05	-23.88	851.304	0.001	39.93	-75.22
13	2	964	44	71.66	-33.45	-14.31	15.09	964.577	0.0013	39.95	-75.19
14	2	964	44	55.54	-28.81	-21	-16.31	964.62	0.0007	39.95	-75.19
021908-05 Philadelphia to Newark											
1	872	332	30	80.08	-28.44	18.8	-8.98	332.955	0.0017	39.98	-75.19
2	855	498	60	58.23	30.15	-19.19	-19.43	498.93	0.001	40.00	-75.16
3	73	1038	102.64	55.3	-25.02	18.21	20.46	1038.153	0.0003	40.07	-74.97
4	65	1274	124.84	84.96	-30.4	25.54	23.73	1273.282	0.001	40.12	-74.84
5	65	1274	125.48	84.96	-30.4	25.54	23.73	1273.299	0.002	40.12	-74.84
6	58	1548	102	57.86	-42.24	24.22	-18.75	1547.83	0.0003	40.21	-74.77
7	555	1658	77.11	79.22	-30.76	24.71	17.38	1658.478	0.0013	40.23	-74.74
8	41	2072	135	113.16	-44.07	-31.35	-25.15	2071.67	0.002	40.37	-74.55
9	41	2072	135	113.16	-44.07	-31.35	-25.15	2071.673	0.0007	40.37	-74.55
10	41	2072	135	113.16	-44.07	-31.35	-25.15	2071.674	0.0003	40.37	-74.55
11	41	2074	135	87.28	27.34	-20.61	16.99	2073.569	0.001	40.38	-74.55
12	26	2530	98.72	66.77	27.34	12.94	-12.11	2530.06	0.001	40.54	-74.36
13	26	2534	98	75.68	31.98	-15.72	15.77	2534.325	0.001	40.54	-74.36
14	26	2534	98.8	54.44	29.3	-11.62	-14.31	2534.359	0.0007	40.54	-74.36
15	20	2722	109.17	55.79	-25.39	-21.63	18.02	2722.637	0.0003	40.60	-74.29
16	20	2722	109.17	55.79	-25.39	-21.63	18.02	2722.638	0.0003	40.60	-74.29
17	20	2724	109.84	148.19	62.38	-31.1	-25.29	2723.832	0.0023	40.60	-74.29
18	20	2724	109.84	148.19	62.38	-31.1	-25.29	2723.835	0.0007	40.60	-74.29
19	20	2724	109.83	148.19	62.38	-31.1	-25.29	2723.836	0.0007	40.60	-74.29
20	20	2724	109.59	-58.47	-44.56	28.47	20.65	2723.844	0.0003	40.60	-74.29
21	20	2724	109.39	55.79	30.52	28.47	20.65	2723.851	0.0003	40.60	-74.29
22	20	2732	110.68	56.15	-33.33	26.12	17.58	2732.747	0.0003	40.60	-74.28
23	20	2732	110.89	56.15	-33.33	26.12	17.58	2732.749	0.0003	40.60	-74.28
24	20	2742	109.48	98.51	-42.24	-41.55	31.93	2741.051	0.0017	40.60	-74.28
25	20	2742	109.64	82.89	-32.35	-13.57	13.23	2741.116	0.0017	40.60	-74.28
26	20	2742	109.2	60.91	-27.1	22.75	-21.44	2742.38	0.0003	40.60	-74.28
27	20	2744	110	68.36	120.61	33.64	-65.19	2743.337	0.001	40.60	-74.28
28	15	3002	61	53.96	-21.61	-21.58	15.19	3002.328	0.0003	40.66	-74.22
29	12	3140	58	59.33	-26.49	-16.16	11.52	3140.617	0.0003	40.69	-74.20
30	12	3140	58	59.33	-26.49	-16.16	11.52	3140.621	0.0007	40.69	-74.20
31	12	3146	59	60.06	-24.05	-20.26	18.7	3146.64	0.0007	40.69	-74.20
021908-06 Newark to New York Penn Station											
1	7	219	66	54.93	-24.9	30.03	-23.63	218.194	0.0003	40.75	-74.11
2	6	302	60	52.25	29.3	26.12	-17.48	301.637	0.0003	40.76	-74.09

ACCELERATION SUMMARY -- WAS-NY

Num	MP	Feet	MPH	LVert(g)	RVert(g)	LLat(g)	RLat(g)	Location(s)	Duration(s)	Latitude	Longitude
RBOXVERT											
Num	MP	Feet	MPH	LVert(g)	RVert(g)	LLat(g)	RLat(g)	Location(s)	Duration(s)	Latitude	Longitude
021908-02 Washington to Baltimore											
1	134	120	75	-29.3	58.72	-22.07	-28.32	120.125	0.0003	38.92	-76.99
2	134	120	75	-29.3	58.72	-22.07	-28.32	120.127	0.0003	38.92	-76.99
3	999	348	118.5	33.94	71.9	-29.88	-35.55	347.615	0.0007	38.95	-76.87
4	999	348	119	-24.05	82.28	-13.92	-41.65	347.764	0.0007	38.95	-76.87
5	999	348	119	-19.41	54.2	-13.43	-19.92	348.129	0.0003	38.95	-76.87
6	999	354	121	54.44	52.49	-17.77	-23.73	354.486	0.0007	38.95	-76.87
7	127	366	123.5	33.2	79.71	21.97	-35.16	365.283	0.001	38.95	-76.87
8	127	366	123.2	33.2	79.71	21.97	-35.16	365.289	0.0007	38.95	-76.87
9	127	366	122.68	31.62	56.76	13.33	-21.39	365.297	0.0007	38.95	-76.87
10	113	774	126	-20.39	50.17	-10.64	-14.75	773.053	0.0003	39.10	-76.70
11	113	774	124.72	36.01	50.42	-19.09	-19.14	774.145	0.0003	39.10	-76.70
12	113	774	124.86	33.69	72.75	16.7	-23.54	774.196	0.002	39.10	-76.70
13	112	776	126.04	-27.83	54.08	-15.28	-14.89	776.594	0.0007	39.10	-76.70
021908-03 Baltimore to Wilmington											
1	90	376	108.16	31.74	63.6	15.82	-20.51	376.01	0.0013	39.30	-76.52
2	89	396	108.39	33.57	60.06	16.06	19.09	396.788	0.0007	39.31	-76.51
3	87	477	124.22	-24.41	58.23	-10.94	-30.42	477.761	0.0003	39.33	-76.47
4	87	477	124	-21.73	53.83	-10.55	-21.14	477.87	0.0003	39.33	-76.47
5	87	477	124	-21.73	53.83	-10.55	-21.14	477.874	0.0003	39.33	-76.47
6	77	764	125.48	-36.74	94.97	15.58	-33.01	764.336	0.0017	39.40	-76.32
7	77	764	124	25.51	63.6	10.6	-17.92	764.393	0.0007	39.40	-76.32
8	75	807	124.54	20.87	53.34	-8.64	-15.28	807.549	0.0007	39.41	-76.30
9	72	917	119.48	-31.25	54.32	-11.33	-17.14	917.785	0.0003	39.44	-76.24
10	66	1091	125.46	33.57	54.08	-13.87	-22.51	1091.683	0.0003	39.51	-76.16
11	66	1091	124.94	33.69	62.38	17.19	-24.41	1091.714	0.0013	39.51	-76.16
12	66	1092	125.14	-15.38	51.27	-8.94	-17.68	1092.79	0.0003	39.51	-76.16
13	63	1173	124.54	-42.11	110.11	18.12	-32.47	1173.05	0.0007	39.53	-76.12
14	63	1173	124.9	-42.11	110.11	18.12	-32.47	1173.065	0.0017	39.53	-76.12
15	60	1286	90.93	-26.37	51.88	-19.29	-21.24	1286.339	0.0003	39.56	-76.08
16	39	1891	134.32	37.48	87.16	16.75	-25.78	1891.685	0.0017	39.67	-75.75
17	39	1891	135.24	37.48	87.16	16.75	-25.78	1891.693	0.0003	39.67	-75.75
18	39	1893	133.78	-47.36	81.79	19.92	-33.06	1893.627	0.0013	39.67	-75.75
19	30	2136	69	-15.01	50.05	-8.15	-22.36	2136.573	0.0003	39.71	-75.60
021908-04 Wilmington to Philadelphia											
1	26	65	80	30.64	52.61	-12.74	-13.53	65.215	0.0007	39.74	-75.53
2	20	234	125.48	-46.51	90.94	-15.92	-34.33	234.568	0.002	39.79	-75.46
3	20	234	124.6	17.58	50.54	10.3	-11.82	234.624	0.0003	39.79	-75.46
4	12	584	109	55.3	62.13	21.24	-25	584.383	0.0003	39.87	-75.33
5	12	584	109.11	55.3	62.13	21.24	-25	584.388	0.0003	39.87	-75.33
6	12	584	109.29	24.05	62.13	14.31	19.58	584.394	0.0007	39.87	-75.33
7	12	584	109.39	24.05	62.13	14.31	19.58	584.397	0.0007	39.87	-75.33
8	4	848	97.74	40.89	82.89	-17.33	-27.93	848.371	0.0017	39.93	-75.22
9	4	851	93.35	74.34	58.47	-25.05	-23.88	851.301	0.0007	39.93	-75.22
10	4	851	93.42	74.34	58.47	-25.05	-23.88	851.303	0.001	39.93	-75.22
11	4	851	93.64	74.34	58.47	-25.05	-23.88	851.31	0.0003	39.93	-75.22
12	4	855	85	36.13	70.68	13.18	-17.04	855.204	0.0017	39.94	-75.22
021908-05 Philadelphia to Newark											
1	855	496	60	12.82	62.62	7.08	-20.17	496.089	0.001	40.00	-75.16
2	83	666	69	-21.73	57.13	-13.43	-26.27	665.021	0.0003	40.00	-75.10
3	78	892	109.84	-29.54	61.65	-9.23	-24.17	892.548	0.0007	40.03	-75.03
4	77	902	109	-20.14	54.93	9.13	-13.18	902.063	0.0003	40.03	-75.03
5	77	902	109	-20.14	54.93	9.13	-13.18	902.064	0.0003	40.03	-75.03
6	65	1272	124.39	27.71	52.49	17.33	27.93	1271.629	0.0003	40.12	-74.84
7	555	1660	79.18	-18.19	53.71	-15.67	-20.41	1660.285	0.0003	40.23	-74.74
8	555	1668	84.07	-30.15	71.41	-10.5	-26.56	1668.219	0.0013	40.23	-74.74
9	42	2068	133.82	-31.74	127.93	-18.46	-38.04	2068.991	0.0023	40.37	-74.55
10	42	2068	133.68	-31.74	127.93	-18.46	-38.04	2068.994	0.001	40.37	-74.55
11	42	2068	133.96	-31.74	127.93	-18.46	-38.04	2068.999	0.0003	40.37	-74.55
12	41	2076	135	31.25	71.66	17.29	-23	2076.792	0.002	40.38	-74.55
13	36	2210	133.98	-19.04	52.86	-8.45	-16.94	2209.79	0.001	40.44	-74.50
14	28	2446	108.86	35.64	69.58	-20.02	-22.85	2445.577	0.0007	40.53	-74.40
15	28	2446	109	35.64	69.58	-20.02	-22.85	2445.582	0.0013	40.53	-74.40
16	26	2526	96.15	21	55.3	-9.57	-17.92	2525.629	0.0003	40.54	-74.36
17	26	2526	96.26	21	51.03	-9.57	14.01	2525.64	0.0003	40.54	-74.36
18	26	2534	97.24	-18.92	69.09	11.72	-35.64	2534.524	0.0007	40.54	-74.36

ACCELERATION SUMMARY -- WAS-NY

Num	MP	Feet	MPH	LVert(g)	RVert(g)	LLat(g)	RLat(g)	Location(s)	Duration(s)	Latitude	Longitude
19	26	2538	99	-28.81	55.91	-10.16	-16.94	2537.494	0.0017	40.54	-74.36
20	23	2632	109.07	-29.05	55.42	-12.45	-25.63	2631.608	0.0007	40.57	-74.33
21	20	2722	109	30.4	58.47	10.79	-29.83	2721.037	0.0003	40.60	-74.29
22	20	2724	109.84	148.19	62.38	-31.1	-25.29	2723.836	0.0007	40.60	-74.29
23	20	2742	109.86	-23.68	62.13	-16.41	-29.39	2741.512	0.0007	40.60	-74.28
24	20	2744	110	68.36	120.61	33.64	-65.19	2743.328	0.001	40.60	-74.28
25	20	2744	110	68.36	120.61	33.64	-65.19	2743.331	0.0023	40.60	-74.28
26	20	2744	110	68.36	120.61	33.64	-65.19	2743.334	0.0007	40.60	-74.28
27	20	2744	110	25.39	53.22	-15.87	20.85	2743.353	0.0007	40.60	-74.28
28	20	2744	109	-29.66	71.17	-15.72	-35.3	2743.421	0.0003	40.60	-74.28
29	15	3002	62.87	-17.94	54.81	10.69	-23	3001.228	0.0003	40.66	-74.22
30	15	3002	62	-30.15	60.3	11.18	-23.05	3001.456	0.001	40.66	-74.22
31	15	3012	54	24.54	63.96	13.09	13.67	3011.719	0.001	40.66	-74.22
32	15	3012	54	24.54	63.96	13.09	13.67	3011.72	0.0003	40.66	-74.22
33	11	3244	69	-20.63	53.71	-14.99	-23.34	3244.918	0.0003	40.71	-74.19
34	10	3246	69	-43.7	148.68	24.76	-62.21	3245.463	0.0023	40.71	-74.19
35	10	3246	69	-43.7	148.68	24.76	-62.21	3245.466	0.0013	40.71	-74.19
36	10	3246	69	-43.7	148.68	24.76	-62.21	3245.467	0.0003	40.71	-74.19
37	10	3246	69	-43.7	148.44	24.76	-62.21	3245.471	0.0007	40.71	-74.19
38	10	3246	69	22.58	-50.9	15.33	17.63	3245.482	0.0003	40.71	-74.19
021908-06 Newark to New York Penn Station											
1	7	228	71.51	27.22	64.82	-14.99	-34.72	227.113	0.0003	40.75	-74.11
2	7	228	71.38	27.22	64.82	-14.99	-34.72	227.118	0.0003	40.75	-74.11
3	3	432	60	-25.39	56.76	19.68	18.55	431.066	0.0003	40.77	-74.04
4	3	450	59.33	-23.32	72.51	-18.6	-28.27	450.264	0.0007	40.77	-74.04

LBOXLAT											
Num	MP	Feet	MPH	LVert(g)	RVert(g)	LLat(g)	RLat(g)	Location(s)	Duration(s)	Latitude	Longitude
021908-02 Washington to Baltimore											
021908-03 Baltimore to Wilmington											
1	75	814	126	70.43	32.96	31.74	17.48	814.438	0.0003	39.42	-76.29
2	75	814	126	70.43	32.96	31.74	17.48	814.439	0.0003	39.42	-76.29
021908-04 Wilmington to Philadelphia											
021908-05 Philadelphia to Newark											
1	41	2072	135	113.16	-44.07	-31.35	-25.15	2071.669	0.0003	40.37	-74.55
2	22	2660	109.55	-32.1	-29.66	-40.87	-22.12	2660.404	0.0003	40.58	-74.31
3	22	2660	109.57	-32.1	-29.66	-40.87	-22.12	2660.405	0.0003	40.58	-74.31
4	22	2660	109.59	-32.1	-29.66	-40.87	-22.12	2660.406	0.0003	40.58	-74.31
5	22	2660	109.62	-32.1	-29.66	-40.87	-22.12	2660.407	0.0003	40.58	-74.31
6	22	2660	109.64	-32.1	-29.66	-40.87	-22.12	2660.407	0.0003	40.58	-74.31
7	22	2660	109.66	-32.1	-29.66	-40.87	-22.12	2660.408	0.0003	40.58	-74.31
8	22	2660	109.68	-32.1	-29.66	-40.87	-22.12	2660.409	0.0003	40.58	-74.31
9	22	2660	109.73	-32.1	-29.66	-40.87	-22.12	2660.41	0.0003	40.58	-74.31
10	22	2660	109.75	-32.1	-29.66	-40.87	-22.12	2660.411	0.0003	40.58	-74.31
11	22	2660	109.77	-32.1	-29.66	-40.87	-22.12	2660.412	0.0003	40.58	-74.31
12	22	2660	109.79	-32.1	-29.66	-40.87	-22.12	2660.412	0.0003	40.58	-74.31
13	22	2660	109.84	-31.98	-29.66	-40.87	-22.12	2660.415	0.0003	40.58	-74.31
14	22	2660	109.84	-31.98	-29.66	-40.87	-22.12	2660.418	0.0003	40.58	-74.31
15	22	2660	109.84	-31.98	-29.66	-40.87	-22.12	2660.419	0.0003	40.58	-74.31
16	22	2660	109.83	-31.98	-29.66	-40.87	-22.12	2660.42	0.0003	40.58	-74.31
17	22	2660	109.78	-31.98	-29.66	-40.87	-22.12	2660.421	0.0003	40.58	-74.31
18	22	2660	109.76	-31.98	-29.66	-40.87	-22.12	2660.422	0.0003	40.58	-74.31
19	22	2660	109.74	-31.98	-29.66	-40.87	-22.12	2660.423	0.0003	40.58	-74.31
20	22	2660	109.72	-31.98	-29.66	-40.87	-22.12	2660.423	0.0003	40.58	-74.31
21	22	2660	109.67	-31.98	-29.66	-40.87	-22.12	2660.425	0.0003	40.58	-74.31
22	22	2660	109.52	-30.4	-21.97	-37.45	-21.04	2660.43	0.0003	40.58	-74.31
23	22	2660	109.45	-30.4	-25.63	35.35	-19.48	2660.432	0.0003	40.58	-74.31
24	22	2660	109.43	-30.4	-25.63	35.35	17.33	2660.433	0.0003	40.58	-74.31
25	22	2660	109.41	-30.4	-25.63	35.35	-14.65	2660.434	0.0003	40.58	-74.31
26	22	2660	109.38	-30.4	-25.63	35.35	-14.16	2660.435	0.0003	40.58	-74.31
27	22	2660	109.36	-30.4	-25.63	35.35	-14.16	2660.435	0.0003	40.58	-74.31
28	22	2660	109.34	-30.4	-25.63	35.35	-14.16	2660.436	0.0003	40.58	-74.31
29	20	2724	109.84	148.19	62.38	-31.1	-25.29	2723.832	0.0003	40.60	-74.29
30	20	2742	109.44	98.51	-42.24	-41.55	31.93	2741.051	0.0003	40.60	-74.28
31	20	2742	109.88	98.51	-42.24	-41.55	31.93	2741.054	0.0003	40.60	-74.28
32	20	2744	110	68.36	120.61	33.64	-65.19	2743.336	0.0003	40.60	-74.28
021908-06 Newark to New York Penn Station											
1	7	219	66	54.93	-24.9	30.03	-23.63	218.194	0.0003	40.75	-74.11

RBOXLAT											
Num	MP	Feet	MPH	LVert(g)	RVert(g)	LLat(g)	RLat(g)	Location(s)	Duration(s)	Latitude	Longitude
021908-02 Washington to Baltimore											
1	999	348	118.48	33.94	71.9	-29.88	-35.55	347.616	0.0003	38.95	-76.87
2	999	348	119	-24.05	82.28	-13.92	-41.65	347.765	0.0003	38.95	-76.87
3	127	366	123.5	33.2	79.71	21.97	-35.16	365.283	0.0003	38.95	-76.87

ACCELERATION SUMMARY -- WAS-NY

Num	MP	Feet	MPH	LVert(g)	RVert(g)	LLat(g)	RLat(g)	Location(s)	Duration(s)	Latitude	Longitude
021908-03 Baltimore to Wilmington											
1	87	477	124.24	-24.41	58.23	-10.94	-30.42	477.761	0.0003	39.33	-76.47
2	77	764	125.48	-36.74	94.97	15.58	-33.01	764.336	0.0003	39.40	-76.32
3	63	1173	124.92	-42.11	110.11	18.12	-32.47	1173.065	0.0003	39.53	-76.12
4	39	1893	133.9	-47.36	81.79	19.92	-33.06	1893.625	0.0007	39.67	-75.75
021908-04 Wilmington to Philadelphia											
1	20	234	125.48	-46.51	90.94	-15.92	-34.33	234.568	0.0007	39.79	-75.46
021908-05 Philadelphia to Newark											
1	42	2068	133.78	-31.74	127.93	-18.46	-38.04	2068.992	0.0017	40.37	-74.55
2	26	2534	97.22	-18.92	69.09	11.72	-35.64	2534.524	0.0003	40.54	-74.36
3	20	2742	109.84	98.51	-42.24	-41.55	31.93	2741.054	0.0003	40.60	-74.28
4	20	2744	110	68.36	120.61	33.64	-65.19	2743.331	0.0007	40.60	-74.28
5	20	2744	110	68.36	120.61	33.64	-65.19	2743.332	0.0013	40.60	-74.28
6	20	2744	110	68.36	120.61	33.64	-65.19	2743.334	0.0007	40.60	-74.28
7	20	2744	109	-29.66	71.17	-15.72	-35.3	2743.421	0.0003	40.60	-74.28
8	10	3246	69	-43.7	148.68	24.76	-62.21	3245.463	0.001	40.71	-74.19
021908-06 Newark to New York Penn Station											
1	7	228	71.5	27.22	64.82	-14.99	-34.72	227.114	0.0003	40.75	-74.11

BUMP											
Num	MP	Feet	MPH	LVert(g)	RVert(g)	LLat(g)	RLat(g)	Location(s)	Duration(s)	Latitude	Longitude
021908-02 Washington to Baltimore											
021908-03 Baltimore to Wilmington											
1	89	398	108	97.66	47.24	25	22.07	398.95	0.0003	39.31	-76.50
2	77	764	125.48	-36.74	94.97	15.58	-33.01	764.336	0.0007	39.40	-76.32
3	63	1173	124.92	-42.11	110.11	18.12	-32.47	1173.065	0.0007	39.53	-76.12
4	39	1893	133.78	-47.36	81.79	19.92	-33.06	1893.627	0.001	39.67	-75.75
021908-04 Wilmington to Philadelphia											
1	26	51	75	108.03	-41.26	-19.34	24.32	51.948	0.0007	39.74	-75.53
2	168	412	87	85.82	-26.98	-19.09	16.36	412.28	0.0007	39.82	-75.41
021908-05 Philadelphia to Newark											
1	42	2068	133.84	-31.74	127.93	-18.46	-38.04	2068.991	0.0013	40.37	-74.55
2	41	2072	135	113.16	-44.07	-31.35	-25.15	2071.67	0.001	40.37	-74.55
3	20	2724	109.84	148.19	62.38	-31.1	-25.29	2723.832	0.0007	40.60	-74.29
4	20	2742	109.48	98.51	-42.24	-41.55	31.93	2741.051	0.0003	40.60	-74.28
5	20	2744	110	68.36	120.61	33.64	-65.19	2743.331	0.001	40.60	-74.28
6	20	2744	110	68.36	120.61	33.64	-65.19	2743.334	0.0007	40.60	-74.28
7	10	3246	69	-43.7	148.68	24.76	-62.21	3245.463	0.0017	40.71	-74.19
8	10	3246	69	-43.7	148.68	24.76	-62.21	3245.465	0.0003	40.71	-74.19
021908-06 Newark to New York Penn Station											

TILT											
Num	MP	Feet	MPH	LVert(g)	RVert(g)	LLat(g)	RLat(g)	Location(s)	Duration(s)	Latitude	Longitude
021908-02 Washington to Baltimore											
021908-03 Baltimore to Wilmington											
1	89	398	108.06	97.66	47.24	25	22.07	398.951	0.0007	39.31	-76.50
2	63	1173	124.9	-42.11	110.11	18.12	-32.47	1173.065	0.0003	39.53	-76.12
021908-04 Wilmington to Philadelphia											
1	26	51	75	108.03	-41.26	-19.34	24.32	51.948	0.0003	39.74	-75.53
2	20	232	125.04	90.33	-28.69	19.87	-14.7	232.492	0.0003	39.79	-75.46
3	20	234	125.48	-46.51	90.94	-15.92	-34.33	234.569	0.0003	39.79	-75.46
4	4	851	93.35	74.34	58.47	-25.05	-23.88	851.301	0.0007	39.93	-75.22
021908-05 Philadelphia to Newark											
1	42	2068	133.8	-31.74	127.93	-18.46	-38.04	2068.991	0.0013	40.37	-74.55
2	41	2072	135	113.16	-44.07	-31.35	-25.15	2071.67	0.0003	40.37	-74.55
3	20	2724	109.84	148.19	62.38	-31.1	-25.29	2723.832	0.002	40.60	-74.29
4	20	2724	109.84	148.19	62.38	-31.1	-25.29	2723.836	0.0003	40.60	-74.29
5	20	2742	109.6	98.51	-42.24	-41.55	31.93	2741.052	0.0003	40.60	-74.28
6	20	2744	110	68.36	120.61	33.64	-65.19	2743.332	0.0017	40.60	-74.28
7	10	3246	69	-43.7	148.68	24.76	-62.21	3245.463	0.0017	40.71	-74.19
021908-06 Newark to New York Penn Station											

ACCELERATION SUMMARY -- NY-BOS

Acceleration Threshold: 50 g (Vertical), 30 g (Lateral)

Acceleration Threshold: 50 g (BUMP), 50 g (TILT)

LBOXVERT											
Num	MP	Feet	MPH	LVert(g)	RVert(g)	LLat(g)	RLat(g)	Location(s)	Duration(s)	Latitude	Longitude
021908_07 NY Penn Station to 2500 E of MP E4											
1	0	216	62	56.52	21.12	19.58	-19.78	215.71	0.0003	40.752185	-73.99748
2	0	232	58	57.37	-21.48	-21.58	16.26	232.705	0.0007	40.752185	-73.99748
021908_08 2500 W of MP E4 to 1420 SE of MP E19											
Missing Data											
021908_13 1952 W of MP MN55 to MP MN60											
1	56	131	39	52.37	66.89	-11.82	-25.78	131.602	0.0007	41.182658	-73.186218
2	56	131	39	52.37	66.89	-11.82	-25.78	131.602	0.0003	41.182658	-73.186218
3	56	134	39	99.12	164.43	-27.39	-52.2	134.064	0.0023	41.183066	-73.185932
4	56	134	38.97	99.12	164.43	-27.39	-52.2	134.069	0.0003	41.183066	-73.185932
5	56	134	39	58.84	-44.19	24.66	-25.59	134.428	0.0003	41.183066	-73.185932
6	56	134	39	58.84	-44.19	24.66	-25.59	134.434	0.0007	41.183066	-73.185932
7	56	134	39	58.84	-44.19	24.66	-25.59	134.436	0.0003	41.183066	-73.185932
8	57	211	65	61.89	37.23	14.65	-20.7	211.605	0.0013	41.18566	-73.169873
9	57	211	65	61.77	-24.41	-15.43	12.94	211.708	0.001	41.18566	-73.169873
10	57	213	66	85.21	81.79	34.18	-38.28	213.588	0.0003	41.185625	-73.16919
021908_14 1556 NE of MP MN66 to 1177 NE of MP MN72											
021908_15 1645 SW of MP MN73 to 1900 NE of MP AB106											
021908_16 1876 NE of MP AB106 to MP AB115											
021908_17 MP AB115 to MP AB183											
021908_18 MP AB183 to Providence Station											
021908_19 Providence Station to Rte 128 Station											
1	186	79	41	73.97	33.45	22.95	-12.6	79.028	0.0017	41.83471	-71.413788
2	186	93	56.68	71.04	30.76	16.11	-16.02	93.255	0.0013	41.837274	-71.415442
3	188	225	66	71.9	32.47	-22.12	21.39	225.01	0.001	41.869456	-71.401033
4	189	246	58.68	65.43	-24.41	33.35	17.87	246.468	0.0003	41.874136	-71.39813
5	189	250	56.08	-51.76	79.83	-15.62	-21.92	250.903	0.0003	41.874967	-71.397581
6	204	749	146.14	57.74	111.57	23.05	-38.82	749.848	0.0003	42.034688	-71.218569
021908_20 Rte 128 Station to Boston											
1	218	38	90.8	65.67	30.52	24.9	-18.8	38.379	0.0013	42.225771	-71.139678
2	218	42	91.6	80.81	37.72	-31.64	23.93	42.576	0.0033	42.227141	-71.139017
3	219	58	102.42	65.06	-25.27	-32.81	27.39	58.985	0.0003	42.233006	-71.136195
4	219	60	103.7	51.15	117.31	31.64	-32.76	59.779	0.0003	42.233392	-71.13601
5	220	86	117.74	76.29	32.35	-40.23	27.25	86.541	0.0017	42.244577	-71.130562
6	223	204	121.27	56.64	-34.18	16.36	-15.58	203.469	0.0007	42.297781	-71.11574
7	223	204	121.25	61.89	-32.23	17.48	-10.89	203.518	0.0013	42.297781	-71.11574
8	224	230	116.81	82.28	-22.71	24.71	12.11	230.279	0.0017	42.309537	-71.107972

RBOXVERT											
Num	MP	Feet	MPH	LVert(g)	RVert(g)	LLat(g)	RLat(g)	Location(s)	Duration(s)	Latitude	Longitude
021908_07 NY Penn Station to 2500 E of MP E4											
021908_08 2500 W of MP E4 to 1420 SE of MP E19											
Missing Data											
021908_13 1952 W of MP MN55 to MP MN60											
1	56	131	39	52.37	66.89	-11.82	-25.78	131.604	0.0017	41.182658	-73.186218
2	56	134	39	25.76	76.29	6.93	-22.07	134.028	0.002	41.183066	-73.185932
3	56	134	39	99.12	164.43	-27.39	-52.2	134.068	0.003	41.183066	-73.185932
4	56	134	38.92	99.12	164.43	21.09	-52.2	134.071	0.0013	41.183066	-73.185932
5	56	134	38.47	44.92	57.98	11.23	-16.65	134.086	0.0017	41.183066	-73.185932
6	57	213	66	-42.11	81.79	28.96	-38.28	213.607	0.0007	41.185625	-73.16919
7	57	215	68	-37.96	85.69	-22.75	-33.59	215.422	0.0007	41.18559	-73.168485
8	57	215	68	-37.96	85.69	-22.75	-33.59	215.423	0.0003	41.18559	-73.168485
9	57	215	68	-37.96	85.69	-22.75	-33.59	215.428	0.0003	41.18559	-73.168485
10	57	215	68	-27.1	59.57	-20.26	-30.32	215.522	0.0003	41.18559	-73.168485
11	59	304	75	-22.58	55.05	-11.91	-26.76	304.517	0.0003	41.191248	-73.135846
021908_14 1556 NE of MP MN66 to 1177 NE of MP MN72											
021908_15 1645 SW of MP MN73 to 1900 NE of MP AB106											
1	81	473	56.02	-19.9	61.52	-12.55	-27.64	473.283	0.0007	41.275562	-72.81271
2	81	476	56	-24.05	50.05	-15.33	-25.34	476.373	0.0003	41.275888	-72.811908
3	84	602	120.12	-27.1	53.47	-16.7	-17.72	602.277	0.0003	41.271709	-72.757757
4	105	1434	101.38	-20.87	58.84	-9.62	-25.73	1434.902	0.0007	41.302895	-72.371313

ACCELERATION SUMMARY -- NY-BOS

Num	MP	Feet	MPH	LVert(g)	RVert(g)	LLat(g)	RLat(g)	Location(s)	Duration(s)	Latitude	Longitude
021908_16 1876 NE of MP AB106 to MP AB115											
021908_17 MP AB115 to MP AB183											
1	163	2338	142.48	38.82	58.23	6.93	-14.45	2338.774	0.001	41.540097	-71.511881
2	167	2428	148	22.95	87.16	-13.96	-21.73	2428.692	0.0023	41.590141	-71.486633
021908_18 MP AB183 to Providence Station											
021908_19 Providence Station to Rte 128 Station											
1	189	250	56.24	-51.76	79.83	-15.62	-21.92	250.901	0.0017	41.874967	-71.397581
2	189	250	56	17.33	51.88	-8.74	-21.09	250.922	0.0003	41.874967	-71.397581
3	192	417	105.75	21.24	54.57	-18.75	-28.42	417.59	0.0003	41.898291	-71.352126
4	192	417	106.1	25.15	54.57	-18.75	-28.42	417.592	0.0003	41.898291	-71.352126
5	204	736	147.2	-34.18	65.19	-21.24	-21.58	736.941	0.0007	42.027832	-71.223426
6	204	749	146.57	-33.81	62.5	-18.95	-29.25	749.59	0.0003	42.034688	-71.218569
7	204	749	146.14	57.74	111.57	23.05	-38.82	749.846	0.001	42.034688	-71.218569
8	204	753	146.41	26.73	51.51	-4.88	-11.33	753.175	0.001	42.036774	-71.21709
9	205	764	139.68	-24.66	50.42	13.82	-18.31	764.712	0.0003	42.042395	-71.213086
021908_20 Rte 128 Station to Boston											
1	218	40	93.6	-32.84	74.46	-15.28	17.92	40.951	0.0017	42.22645	-71.13935
2	218	42	90.92	-27.95	60.18	-17.53	-30.13	41.795	0.0007	42.226795	-71.139184
3	219	60	103.56	51.15	117.31	31.64	-32.76	59.777	0.0007	42.233392	-71.13601
4	219	60	103.64	51.15	117.31	31.64	-32.76	59.778	0.0013	42.233392	-71.13601
5	219	60	103.2	-29.66	67.38	19.92	-30.32	59.794	0.0007	42.233392	-71.13601

LBOXLAT											
Num	MP	Feet	MPH	LVert(g)	RVert(g)	LLat(g)	RLat(g)	Location(s)	Duration(s)	Latitude	Longitude
021908_07 NY Penn Station to 2500 E of MP E4											
021908_08 2500 W of MP E4 to 1420 SE of MP E19											
Missing Data											
021908_13 1952 W of MP MN55 to MP MN60											
1	57	213	66	85.21	81.79	34.18	-38.28	213.588	0.0003	41.185625	-73.16919
021908_14 1556 NE of MP MN66 to 1177 NE of MP MN72											
021908_15 1645 SW of MP MN73 to 1900 NE of MP AB106											
021908_16 1876 NE of MP AB106 to MP AB115											
021908_17 MP AB115 to MP AB183											
021908_18 MP AB183 to Providence Station											
021908_19 Providence Station to Rte 128 Station											
1	189	246	58.7	65.43	-24.41	33.35	17.87	246.469	0.0003	41.874136	-71.39813
021908_20 Rte 128 Station to Boston											
1	218	42	92.14	37.96	-30.64	-31.64	23.93	42.595	0.0003	42.227141	-71.139017
2	219	58	102.54	65.06	-25.27	-32.81	27.39	58.987	0.0003	42.233006	-71.136195
3	219	60	103.68	51.15	117.31	31.64	-32.76	59.779	0.0003	42.233392	-71.13601
4	219	60	103.8	51.15	117.31	31.64	-32.76	59.781	0.0003	42.233392	-71.13601
5	220	86	117.56	76.29	32.35	-40.23	27.25	86.543	0.0003	42.244577	-71.130562

RBOXLAT											
Num	MP	Feet	MPH	LVert(g)	RVert(g)	LLat(g)	RLat(g)	Location(s)	Duration(s)	Latitude	Longitude
021908_07 NY Penn Station to 2500 E of MP E4											
021908_08 2500 W of MP E4 to 1420 SE of MP E19											
Missing Data											
021908_13 1952 W of MP MN55 to MP MN60											
1	56	134	39	99.12	164.43	-27.39	-52.2	134.068	0.001	41.183066	-73.185932
2	57	213	66	-42.11	81.79	28.96	-38.28	213.607	0.0003	41.185625	-73.16919
3	57	213	66	-42.11	81.79	28.96	-38.28	213.609	0.0003	41.185625	-73.16919
4	57	215	68	-37.96	85.69	-22.75	-33.59	215.422	0.0007	41.18559	-73.168485
5	57	215	68	-27.1	59.57	-20.26	-30.32	215.522	0.0003	41.18559	-73.168485
021908_14 1556 NE of MP MN66 to 1177 NE of MP MN72											
021908_15 1645 SW of MP MN73 to 1900 NE of MP AB106											
021908_16 1876 NE of MP AB106 to MP AB115											
021908_17 MP AB115 to MP AB183											
021908_18 MP AB183 to Providence Station											
021908_19 Providence Station to Rte 128 Station											
1	204	749	146.14	57.74	111.57	23.05	-38.82	749.846	0.0007	42.034688	-71.218569
2	204	749	146.14	57.74	111.57	23.05	-38.82	749.848	0.0003	42.034688	-71.218569
021908_20 Rte 128 Station to Boston											
1	218	42	90.96	-27.95	60.18	-17.53	-30.13	41.795	0.0003	42.226795	-71.139184
2	219	60	103.58	51.15	117.31	31.64	-32.76	59.777	0.0003	42.233392	-71.13601
3	219	60	103.12	23.68	67.38	19.92	-30.32	59.795	0.0003	42.233392	-71.13601

7.12 Contract Deliverable Requirements List

CDRL #	Title	Car Type
07-001	Brake Control Wiring Diagram	All
07-002	Brake System Performance Data	All
07-003	Brake System Design and Drawings	All
07-004	Brake Disc Fatigue Performance Analysis	All
07-005	Brake Disc FEA Report	All
07-006	Wheelslide System Diagnostic Software	All
07-007	Wheelslide Control Unit PTE Cables	All
07-008	ECP Brake Control System Details	All
07-009	ECP System Validation Test Results	All
07-010	ECP Display Location	All

* End of Chapter 7 *

Technical Specification

CTDOT Single-Level Passenger Rail Cars

Chapter 8

Door Systems

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8.00 Door Systems

8.01 Design Objectives

A. Door systems have a demonstrated history of complexity and inconsistent performance that can affect the operation of passenger service and hinder maintenance and repairs. In order to maximize safety, system functionality and equipment availability, while minimizing the potential for degraded service or system performance, the side and end door systems shall be specified, designed and manufactured with an emphasis on addressing the following areas of concern:

1. Unsafe conditions for passengers or crewmembers;
2. Train delays from malfunctioning side door equipment;
3. Poor system reliability in adverse operational and environmental conditions;
4. Accumulation of dust and dirt that affects system performance and cause failures;
5. System complexity that increases the time and effort required for troubleshooting and repairs; and
6. Requirement for frequent adjustment and component replacement.

B. The door system shall be designed with great attention to details so that it is safe, very reliable, requires little maintenance, is easy to service, has support parts available and will have a long service life. A positive means of mechanical locking for each powered door when closed, not dependent on continuous electrical power, shall be provided as part of the door control system design.

8.02 Door Construction and Design

A. The carbody end door, exterior side doors, and vestibule sliding end door panels shall be of stainless steel construction bonded with aluminum honeycomb core. The door panel's structure shall be a spot-welded stainless steel construction with reinforcements. The hardware, operating mechanism and window glazing shall be within the door thickness maximum dimension to allow the doors to operate in the door pockets freely without obstruction. Their design shall match the carbody profile, meet the environmental requirements of CTDOT, meet the materials and workmanship requirements of Chapter 18 and have a smooth true finish. The exterior surface finish of the side and end door panel shall match that of the exterior of the carbody.

B. Each door leaf travel shall be easily adjustable, with only a single adjustment each to set open and close positions. Door travel adjustment shall not be required between car overhaul. Limit switches used in the operator shall be easily replaceable. No adjustment for switch replacement shall be necessary to achieve proper functioning. Operation of switches by cams on the operator shaft is not permitted. Switch arrangement shall be such that if a switch fails to operate, no major damage to the door operator can occur.

C. Each door leaf shall incorporate a window as specified in Chapter 4. The window opening shall be blanked out of the inside and outside door sheets and the edges formed inward for welding together. The cutout shall have proper radii for approved glazing and molding. Each door leaf shall be as thin as possible, of hollow lightweight construction, internally reinforced, thermally and acoustically insulated and joined into an integral unit by resistance welding.

D. All doors shall comply with the requirements of 49 CFR Part 37 Transportation Services for Individuals with Disabilities (ADA), 49 CFR Part 38 Americans with Disabilities Act (ADA) Accessibility Specifications for Transportation Vehicles, and APTA-PR-M-S-18-10 Standard for Powered Exterior Side Door System Design for New Passenger Cars.

8.02.01 Exterior and Vestibule Doors

A. For the trailer car, each vestibule end of each carbody shall have two exterior side entrance doors for high level boarding, an exterior body end door to close off the inter car walkway, and a vestibule sliding end door between the vestibule entranceways and passenger seating area.

B. For the cab car, the non-cab vestibule end of each carbody shall have two exterior side entrance doors for high level boarding, an exterior body end door to close off the inter car walkway, and a vestibule sliding end door between the vestibule entranceway and passenger seating area. The cab end of each carbody shall have two exterior side entrance doors for high level boarding located directly behind the cab, and windscreens between the vestibule entranceways and passenger seating area.

C. The exterior and vestibule door operators shall hold the door, without oscillation, in either a fully open or closed position during all train operating conditions, including stationary on 7 in. (178 mm) of track super elevation.

D. Each door leaf supported only at the top and bottom shall not deflect more than 0.25 in. (6.35 mm) under a 200 lbf (890 N) load applied perpendicularly over an area of 4 in. by 4 in. (102 mm by 102 mm) to the door along its closing edge, or have any resulting deformation once the load is removed. This requirement only applies to sliding door systems to ensure clearance in the door pocket.

E. All joints and edges shall be thoroughly sealed against moisture and drain holes shall be located in the bottom of the doors to allow the escape of condensed moisture. All doors and their associated hardware such as operators, hangers, tracks, thresholds, etc. shall be jig-drilled to allow interchangeability between similar types. All hardware mounting points shall be reinforced. Doors shall be rigid, have high quality appearance, meet the design life requirements of Chapter 1 and be free of dimples, warping and spot weld depressions. Similar doors of the same hand shall be interchangeable.

F. A complete side door and vestibule mockup with power operating side door and vestibule sliding door shall be supplied by the Contractor as part of the design review. All doors and their hardware shall be approved by the Engineer. [CDRL 08-001]

G. Weather sealing

1. CTDOT will operate the cars in 125 mph (201 km/hr) intercity service. The very high operating speeds of the cars combined with frequent winter exposure to snow, freezing rain and ice, as well as heavy rain conditions, makes it of extreme importance that exceptionally high levels of weather sealing be applied to the door systems.

2. Each side door and vestibule sliding end door panel shall be equipped with a full height neoprene elastomeric nosing which shall interlock with the nosing on the mating door post or door leaf, so as to provide a tight seal against the passage of air, water or sound to the vehicle interior. The nosing shall prevent injury to human extremities if caught in the path of the closing door and will permit withdrawal of objects trapped by the closing door.

3. The full height of the side door pocket, the side door step threshold seal and the side doorway header must be completely sealed airtight and watertight, both on the outer face and the inner face of the door panel, when the door is closed. The trailing (door pocket) edge of each door panel shall have robust elastomer seals which contact door pocket entrance edge seals on both outer and inner faces when the door is closed. The door nosing elastomer shall also incorporate projecting flanges on both the outer and inner face of the door panel, so as to provide sealing of the door pocket when the door is open, such as in the yard or in stations.

4. Each door pocket shall be fully lined with stainless steel material, be completely sealed from the car interior and arranged for drainage of any collected water. Deicing heaters shall be applied to the entire door system, including sliding end vestibule doors, to allow reliable winter operation in extreme conditions.

5. The trailing (door pocket) edge of the door shall be weather-stripped and designed to form a positive seal against the opening of the door pocket when the door is in the closed position. The door and door post seals shall be applied in an approved manner which enables each to be easily replaced with the door in place. The neoprene leading edge nosing of the door shall interlock with door post neoprene nosing when the door is in the closed position and with the edge of the door pocket opening when the door is in the open position.

6. Heavy duty brush type seals or an Engineer-approved alternate design shall be installed on the interior and exterior of the door frame of all sliding doors on the car which shall fully contact the door panel elastomer seals when the door is closed. The brush seals shall be located within 0.25 in. (6.35 mm) of the face of the door panel to provide a tactile warning to passengers that may have their hands against the door panel prior to opening.

7. All fasteners used to attach any hardware to the doors (for example, door nosing or weather-stripping) shall be countersunk to prevent premature wear of door frame weather-stripping.

8. The car sides shall have minimum projections which could trap snow. Door operation shall be unaffected by snow, ice or freezing rain.

9. All exterior doors shall be provided with suitable weather stripping and tight sealing edges, including the bottom, so that when closed they will positively prevent the entrance of outside weather, snow, rain, ice, winds, drafts and wind noise to the interior of the car, or into the door pocket, at speeds up to 125 mph (201 km/hr). Special emphasis shall be placed on the sealing of the side doors. The vestibule sliding doors shall be sealed in a similar manner to prevent noise, drafts or odors from the vestibule or restrooms from entering the passenger seating area.

10. All weather stripping shall have a minimum ten-year design life, be of neoprene or approved equivalent material meeting the relevant specifications in Chapter 18 and mechanically attached without adhesives to allow easy replacement. If applications require the use of adhesives this has to be approved by the Engineer. The doors shall not rattle when encountering changing pressure differentials, such as when entering or exiting a tunnel, or passing another train. All parts of any latches or locks shall be nickel bronze or stainless steel of robust design and capable of long wear. Each body end door lock shall have a keyhole cover on the exterior. Wedge type latches and hinges on body end doors shall prevent injury to fingers.

H. Maintenance access

1. Ease of maintenance access to all components of the door system is of significant importance to CTDOT, and the Contractor must give special consideration to complete accessibility and ease of servicing of all door tracks, hardware, motors, hangers and controls as installed in the car.

2. Maintenance access shall be based upon the servicing work being performed by a single employee in the yard using simple hand tools. This shall include, but not be limited to, the ability to completely replace all door system weather-stripping and door pocket seals, complete access to all maintenance points such as all door operators, limit switches, door hangers, rollers, protective heaters, etc., complete access all lubrication points, complete access to the bottom of the door pockets for pocket and track cleaning and heater replacement, the ability to easily free a frozen door in both the closed and open positions, and similar maintenance functions.

3. The door track for the sliding doors shall be designed and installed so that a door can be removed from the track intact, or so that a track can be removed by disengaging the fasteners securing the door to the hanger and the track to the car. Removable gasketed access covers and hatches shall be provided to completely allow all door servicing and maintenance to take place with the door system installed on the car. This shall include full length maintenance access covers for both the exterior and interior faces of the bottom of the side door pockets, and the exterior face of the door pocket at the sliding high platform threshold track. All covers shall use replaceable mechanical fasteners.

4. All weather-stripping and nosing edges shall be removable to allow for maintenance and replacement without door removal. All doors shall be arranged to prevent elastomer abrasion against other surfaces to avoid wear, or from burnishing the door surface. Door adjustments shall be simple to accomplish and shall use self-locking adjustment hardware. These maintainability features shall be a key part of the design review process, and must be demonstrated to the Engineer's satisfaction.

5. The design of the nosing shall meet the requirements of Chapter 18 and shall be easily removable to allow for maintenance and replacement without door removal. Weather seals are required at the top of each side and end door panel, and the bottom of each door panel shall be sealed against the threshold.

8.02.02 Carbody End Doors

A. Each end of each car, except the cab end of the cab car, shall be equipped with a stainless steel, single leaf, full height, piano hinged inward swinging car body end door panel. The clear opening of the doorway shall meet the ADA requirements and the requirements of Chapter 4.

B. Each carbody end door shall be a flat panel, and when opened shall swing through an arc of 180° and be latched in the open position into a recess in the carbody vestibule wall lining.

C. A hand operated slam latch with bumper to prevent rattling shall be provided to secure the door in the open position. In all cases the door frame shall suitably match the door profile and shall fully support the door when closed.

D. The end door design shall be coordinated with the intercar passageway. The interior surface of the doors shall be finished to match the interior surface of the vestibule and shall be equipped with an

approved weather seal arrangement applied to the door perimeter using mechanical fasteners. The weather seal shall prevent air, rain, snow and noise from entering the car body at the interface of the end door and door frame of a lead car traveling at 125 mph (201 km/hr). A secondary weather seal shall be used at the interface of the bottom door edge to threshold plate if necessary to meet this requirement. The weather seal joints at the four corners of the door shall be vulcanized to ensure continuity of the seal.

E. Each end door shall have a flush mounted stainless steel threshold with an integral anti-skid surface and color stripe. Beneath the threshold shall be provided a drain trough under the end door bottom edge, which shall have stainless steel drain tubes to drain off water through the underframes and down onto the track.

F. The drain water shall be routed so that it does not contact any coupler equipment and that the threshold is neither a tripping hazard nor a trap for spiked heels. The threshold shall overlap the floor covering. A heating element may be required. All attachments shall be made with flush mounted stainless steel hardware, suitably protected for dielectric material use. Below the threshold there shall be a watertight channel member that shall collect the runoff from the end door and drain it to the outside of the car. Once the door is closed and latched, the weather seal shall not obstruct the end door drain. The weather seal shall be located on the door side of the drain. The arrangement shall be approved by the Engineer. [CDRL 08-002]

G. A full length, heavy duty, continuous stainless steel piano hinge having a stainless steel hinge pin shall be provided for each door. The ends of the hinge shall be closed to preclude the hinge pin from sliding out of the hinge barrel. Hinges shall be attached by stainless steel fasteners, not welded, and shall ensure that each door closes smoothly, without binding or sagging. Two approved wedge, or jam type latches and matching door frame plates, both of stainless steel or nickel-plated nickel bronze construction, shall be provided on all end doors.

H. The latches shall have handles for operation from both inside and outside the car, except that they shall only operate from the inside at the cab end of the cab car. Where the handle could contact an interior surface, a mechanically attached elastomer cushion shall be provided. An approved deadbolt lock of standard transit car quality shall be provided to hold each door securely locked in the closed position and be operated on both sides of the door with the standard coach key. The key shall not be required to open the door, except when the door has been key locked. A self-closing keyhole cover shall be mounted on the exterior of the lock to prevent draft or moisture from entering the lock. The design of the body end doors shall be approved by the Engineer. [CDRL 08-003]

8.02.03 Vestibule Sliding End Doors

A. An electrically powered stainless steel sliding door shall be located between the passenger seating area and the vestibule at each end of the trailer car and at the non-cab end of the cab car with maximized window panes. Doors shall be vibration free and well insulated against heat and sound transmission as approved by the Engineer.

B. A recessed stainless steel handle shall be provided on either side of the door panels to allow manual opening or closing of the door. This handle shall be accessible when the door is open. Door panels shall be equipped for emergency escape per 49 CFR Part 238.112 and labeled for emergency egress in accordance with APTA-PR-PS-S-002-98 Revision 3 Standard for Emergency Signage for Egress/Access of Passenger Rail Equipment.

C. The door track shall be designed and installed so that a door can be removed from the track intact or so that a track can be removed by disengaging the fasteners securing the door to the hanger and the track to the car. The track shall be adjustable to accommodate both carbody and door leaf tolerances. Adjustments shall not be required between car overhauls. The door track shall be readily accessible for maintenance and adjustment.

D. The door assembly shall be completely weather-stripped, including both sides of the door pocket to the door panel, to provide complete sealing from vestibule noise or bathroom odors to seated passengers.

E. The trailing edge seal shall be attached to the door leaf rather than the door frame, so as to eliminate chafing against the leaf as it moves. The top of the door leaf, along with the interface between the bottom of the door and the threshold, shall form a weather seal. The entire door seal arrangement is subject to Engineer approval.

F. A door guide with corresponding threshold shall be provided at the bottom of the door, and shall be flush mounted to the floor. Wear strips, if provided, shall be easily replaceable without removing or readjusting the door panel. The bottom guide arrangement shall ensure a low friction operation with no binding or rattling. The door threshold shall form part of the door weather seal. Easy access shall be provided to the door threshold for cleaning and maintenance. The complete door operator system, all door panels, hangers, tracks and associated apparatus shall be completely accessible for inspection, repair and replacement from adequately dimensioned access hatches in the car vestibule.

G. The following alternatives may be proposed:

   1. Obstruction detection without using sensitive edge

   2. Alternative door opening switch and sensor arrangements

8.03 Side Door Thresholds and Protective Heaters

A. Each side door shall have a threshold with anti-skid surface and lower door track designed to guide the bottom edge of the side door during operation over its complete range of travel. It shall not project above the surface of the step tread or floor, and shall completely seal the door bottom edge when the door is in the closed position, so as to exclude water, snow and drafts from entering the car.

B. Each threshold and door pocket shall be provided with adequate drainage to prevent the buildup of water and debris in the track. An easily removed panel may be provided on the car interior to allow access to the door pocket and lower door hardware for maintenance and repair, and to allow access to the bottom door track for clearing obstructions and removal of debris.

C. The perimeter of each sliding door panel and its stepwell threshold for each exterior side doorway shall be equipped with a protective heating system designed to prevent freezing of the side doors in either high or low platform service, whenever the exterior ambient air temperature is below 45°F (7.2°C). Terminal test points shall be provided for checking the resistance of each heater.

D. The system shall consist of 120VAC automatic self-regulating heating cable or element mounted in the area of the lower door guideways in the threshold plate, on the exterior side of the door pocket

openings and overhead header openings, and if necessary on the matching door jambs. An alternate design can be proposed to the Engineer for approval.

E. The system shall operate whenever a control signal from the Heating, Ventilation and Air Conditioning (HVAC) control system (per Chapter 10) indicates that the ambient temperature is below 45°F (7.2°C). It shall also operate whenever the layover heating system is in operation. No heated surface which could be contacted by a passenger or be in contact with any nonmetallic door seal or guide shall exceed a temperature of 125°F (51.7°C). Access shall be provided for ease or replacement and to all electrical terminations for maintenance. The heater system shall be approved by the Engineer. [CDRL 08-004]

8.04 Gap Filler

A. The Contractor shall provide a revenue service proven gap filler for all side doors on all cars, as a method of eliminating the platform gap between the doorway threshold and station platform.

B. The gap filler shall be designed to be fitted into the doorways to provide a continuous walking surface or operation of wheelchairs between car vestibules and passenger loading platform.

C. The gap filler shall be robust, easily deployable and stowed and constructed with lightweight and high strength materials conforming to the requirements of 49 CFR Part 38 Subpart E for Commuter Rail Cars, latest version, for ADA compliance.

D. The gap filler shall be interlocked with the propulsion and door systems in a fail-safe manner and operate with all the safety provisions, functional interlocks, and isolation devices. The Contractor shall ensure that the car cannot be moved when the gap filler is not stowed or retracted and the gap filler cannot be deployed unless the interlocks are engaged.

E. The gap filler shall deploy automatically on door opening, when the doors are operated from a door control panel. It shall deploy only when the train is stopped and shall fully retract and stow when the door is closed. It shall not deploy if the door leaf is cut out or out of service. It shall also not deploy when the door is operated via the crew key switch.

F. The gap filler shall be provided with a lock/cutout device and shall be easily deployed and stowed when it is mechanically jammed without the use of special tools. The details of the gap filler design shall be submitted to the Engineer for review and approval. [CDRL 08-05]

8.05 Door Control Panel

A. A Door Control Panel (DCP) shall be provided on both sides of the car, at each side door location and on either side of the operator's cab adjacent to the drop/sliding sash window. The design of the DCP shall be location-specific (i.e., cab Operator's side, cab Observer's side, vestibule side door Left/Right) and shall be non-interchangeable between sides. The arrangement of the pushbuttons and indicators shall be identical to those provided on MNR's M-8 Cars with additions noted herein. Specific location of the DCPs shall be approved during design review.

B. Each DCP shall be energized by insertion and rotation of the Standard Car Key, making the open and close pushbuttons operative and splitting the unlock, open, and close trainlines, thus establishing separate control zones forward and rearward of the energized panel to the next adjacent active

DCPs. When the key is removed from the DCP, the doors shall remain in their current position and it shall then be possible to operate the doors from a different DCP on a trainline basis or locally at any door from a crew switch.

1. The switch cover plate for the master door key shall have a vertical slot, requiring the key to be inserted and removed with the switch in the OFF position.

2. The cover plate shall have arrows engraved above the keyhole, indicating the direction of key movement for control action. The arrows shall indicate:

   Clockwise: Door controls and communication system activated

   Center: Off

   Counterclockwise: Communication system only activated

C. Each DCP shall include provisions for six recessed, momentary contact-type, pushbutton door control switches. Each pushbutton shall be clearly identified by engraved painted letters and arrows.

1. Six pushbuttons, arranged in two rows of three pushbuttons each, shall be used for door control.

   a. The left and right pushbuttons shall operate the doors forward and rearward (within the same zone) of the control panel, respectively. The center pushbuttons shall operate the local door next to the control panel. The button orientation shall be submitted for approval. The cab side DCP pushbutton arrangement shall be the mirror image of that provided for the Observer's side.

   b. DCPs shall be designed specific for, and located at, each door location. The mounting and orientation of the side door DCPs shall mimic that of the cab mounted DCPs and shall be incorporated into the vestibules and windscreens.

   c. The first row of pushbuttons shall initiate Door Open commands. The second row of pushbuttons shall initiate Door Close commands.

   d. Arrows shall be provided adjacent to each door control pushbutton to indicate the direction of the zone which it is controlling.

2. The remaining two pushbuttons shall be placed in a row below the door control pushbuttons and shall be used to operate the communication buzzer (left pushbutton) and a panel light test function (right pushbutton). The control scheme shall be designed in such a way that a depressed button is verified as being received by all doors in the zone.

D. The exposed face of the DCP shall have a brushed, stainless steel finish consistent with interior finishes of the car body.

E. Two white LED indicators shall be provided for each DCP. One indicator shall be on the DCP centered above the master door key slot. The other shall be on the exterior of the car in close proximity to each respective DCP as approved by the Engineer. The indicators shall be illuminated whenever the door control panel has been activated.

F. Two green LED indicators shall be provided on each DCP in line with the columns of pushbuttons controlling the forward and rear doors and slightly below the DCP active indicator. When the panel

has been activated, the indicators shall illuminate whenever all of the doors in the respective zones are closed and locked, or manually locked-out.

G. A green LED No Motion indicator shall be provided on each DCP immediately above the left column of door control pushbuttons. The indicator shall illuminate on an activated DCP whenever the door No Motion signal is present.

H. A red LED Door Override indicator shall be provided on each DCP immediately above the right column of door control pushbuttons. The indicator shall illuminate on an activated door control panel whenever the door override signal is present as controlled by the operator.

I. Door operators and controls shall be considered to be safety critical functions. It is desired that the door control circuits be arranged to still permit the door control system to function for crew access to the wayside when a car is placed in layover or storage mode, provided that the door system can be arranged to not consume electrical power when in an idle state. Details shall be presented to the Engineer for approval. [CDRL 08-006]

J. The door control circuit logic shall be carefully reviewed in detail during design review with the Engineer to avoid nuisance faults from inconsistent train crew operation of the system, and all actions which could generate a fault condition shall be individually listed. Repetitive pushing or prolonged pushing of a door control pushbutton by a train crew member or pushing a button after its commanded action has been successfully completed, shall be tolerated by the control circuitry, and not be considered a fault condition.

K. No single point failure in the door system internal to the car shall cause any door to unlock or open, a door open command to be transmitted or responded to when the train is in motion, a door closed indication to be transmitted when any door is unlocked or open, or a door closed indication to be transmitted when an unlock or opening command is stored anywhere in the system.

L. The entire door system, including interlocks, control drive and mechanical mechanisms, indicators, bypasses, cutouts and all connected wiring shall be subjected to a Failure Mode and Effects Analysis (FMEA) for hardware as well as a fault tree analysis for circuit design and the results presented to the Engineer for approval during design review. [CDRL 08-007] The system shall be so constructed that any malfunction will be self-detecting by failure to function properly in a manner detectable by operating personnel and such that no single point failure (other than major mechanical failure) can result in a hazardous condition.

M. The detailed design of the door system, door operators, controls and installation shall be submitted to the Engineer for review and approval during the design review process. [CDRL 08-008] The Contractor during design review shall establish a logic table to be approved by the Engineer listing every possible combination of door control station and crew key switch status within a train, including consists with and without existing CTDOT cars, and the resulting status of door control to ensure positive understanding of the design of the door system. Controlling logic shall be supplied such that no single door operator or control failure shall disable both side doors on one side of the car, and both sliding end vestibule doors in a car. Regardless of the method of door control used on a train, information on side door closed status shall always be communicated to the active control station and to the cab providing control of the train's propulsion and braking.

8.06 Exterior Side Doors

A. Each end of each car shall be equipped with a stainless steel side door on each side that extends below the roof rail to the threshold and shall be mounted as close to the outside of the car as construction permits and its design shall be coordinated with the interior vestibule and the cab.

B. The side doors shall be supported at the top and guided at the bottom. The hanger shall be of a type in which there is no change in magnitude or direction of load path through the bearing when a misalignment occurs. The hanger shall be adjustable for height, and ready access to these adjustments shall be provided. All door hangers and tracks shall be of heavy-duty robust construction and protected from the weather, but shall be accessible for inspection, adjustment and removal by access through interior panels above the door openings. The bottom edge of each leaf shall be equipped with a guiding device which matches the design of the door threshold.

C. The side doors shall be controlled both locally and remotely through trainlines and operated by a door control panel located in each car vestibule. Each door shall also be locally operated by an exterior crew switch. All door control panels and crew switchers shall be operated by CTDOT's standard coach key.

D. The door control commands and indications shall be transmitted through discrete hard-wired trainlines. All door circuits and controls on each side of the car (left-side and right-side) shall be both electrically and physically isolated from each other, to positively eliminate the possibility of an incorrect side door opening from what is commanded.

E. On an individual car basis, when a signal is received from the car friction brake wheel slide control system (see Chapter 7) that the train is moving at 3 mph (5 km/hr) or more, the local car no-motion circuit shall prevent the side doors in that car from being electrically opened, by removing the power from the door controls. The no-motion controls shall ensure that the train is stationary (below the 3 mph (5 km/hr) detection threshold) before the doors can be opened. There shall be provision to permit the no-motion controls to be bypassed if the no motion signal output is defective. Use of the no-motion bypass feature shall be recorded in the car level door diagnostic system. The design shall be submitted for Engineer approval during the design review process. [CDRL 08-009]

F. The failure mode of all door system apparatus shall be such that in the event of failure the doors will remain closed. Door control inputs and interfaces shall be protected against transient and spurious signals and shall be properly filtered to provide noise immunity. Each side door operator shall be controlled by a separate door controller to assure independent door operation in the event of a single component failure. An access point (interface connector) to the door diagnostic shall be located in the car electrical locker. Each side door operator shall be controlled through a separate solid state door controller to assure independent door operation in the event of a single component failure. An access point (interface connector) to the door diagnostic shall be located in the car electrical locker.

8.06.01 Side Door Operators

A. Each side door shall be actuated by an electrically powered door operator system with a successful North American transit or commuter rail experience and shall use a service proven motor with a service lifetime of at least 20 years. The operator shall be overhead mounted, readily accessible for maintenance and well protected from wind-driven snow, rain, dirt and other environmental factors.

B. Arrangements shall be provided to cushion the movement of the door at each end of its travel. The door operators shall be capable of withstanding stall current indefinitely without thermal overload or reduction in service life.

C. Emergency manual operation of the door system shall comply with the requirements of 49 CFR Part 238, APTA-PR-CS-S-012-02, and APTA-PR-M-S-18-10. Details of the access and operation of the door operator and emergency release shall be submitted to the Engineer for review and approval. [CDRL 08-010]

D. The door operator and its linkage shall be designed with sufficient internal damping to prevent the door from bouncing at its opening and closing stops. The time from energizing the door operator to the completion of the door operation, including cushioning, shall be as follows:

   Opening: 2.5 seconds - Adjustable 2.0 to 4.0 seconds

   Closing: 3.0 seconds - Adjustable 2.0 to 5.0 seconds

E. The door operator, control circuitry and operating linkage for each door shall be designed such that the closing force measured at the leading edge of the door panel comply with the requirements of APTA PR-CS-S-012-02 and APTA PR-M-S-18-10.

F. An integral encoder to determine door position, door timing, push back and any other parameter involving speed or position of a door panel shall be utilized. Opening and closing profiles, each of which shall be differently programmed to incorporate a soft start, soft stop, linear, or non-linear velocity profile, shall be possible. Obstruction detection shall be indicated by failure of a door to achieve its profile. Only one limit switch shall be permitted to act as a backup to the encoder in the sensing of the fully closed position. After installation, no regular servicing shall be required. It shall be possible to replace the limit switch without adjustment required to attain proper function. All door operator motors shall be interchangeable and shall be replaceable without removal or adjustment of other apparatus. Any door operator motor reset switch, if required to protect the motor, shall be easily accessible to the train crew and be adjacent to its door operator cutout switch. All side doors shall be adjusted to be opened or closed manually with a maximum force of 15 lbs (67 N) with the door operators disconnected.

8.06.02 Side Door Cutout

A. A positive electromechanical lock with an integral cutout switch shall be provided to each side door operator so that in the event of failure, the door operator may be bypassed and secured to the closed and lock position, made inoperative, and not affect the trainline operation of any other door. The side door cutout shall have two positions, NORMAL and CUTOUT.

   1. In the "NORMAL" position, the door control and signal light circuitry shall function in the normal manner.

   2. In the "CUTOUT" position, the door operator shall be in cutout and power is removed to the door operator motor with the door panel is mechanically locked. But the output to the door closed signal light circuitry shall function normally.

B. The electromechanical lock and cutout switch shall be mounted to the door operator mechanism and shall not be visible to passengers and accessible with minimum disturbance to passengers.

8.06.03 Side Door Exterior Crew Switches

A. To allow train crew or maintenance personnel exterior access to a closed car, each side doorway on both sides of the car exterior shall be provided with platform key operated crew access switches.

B. The crew switches shall be speed interlocked on a local car basis expect when the car is placed in layover or storage mode with the car battery switched off.

C. The crew switch panel shall be waterproofed and flush mounted to the carbody. It shall allow the opening and closing of the adjacent door.

D. Each crew switch shall be key operated momentary contact type using the standard coach key, of heavy duty transit quality, spring-loaded to the center position. The key shall be inserted or removed only when the switch is in the neutral center position. Turning to the left shall close the door, and turning to the right shall open the door.

E. All crew switches shall be easily accessible with the doors either open or closed. The exterior keyhole shall be recessed and covered with gasketed top-hinged stainless steel snap covers to ensure weather tightness. Hinges shall be screw-attached for ease of replacement. It shall not be possible to leave the covers in an open position. All exterior portions of the crew access switch shall be of a non-corrosive material. The switch contacts and terminals shall be guarded, and located above the keyway so that any leakage of moisture that may occur will not reach them. The design shall insure that the integrity of the door system will not be jeopardized.

F. It shall be possible to close the door by means of the exterior crew switch at that door. The crew switches shall function to operate the door in all car operating modes. The overall exterior crew switch arrangement and locations shall be submitted for approval by the Engineer during design review. [CDRL 08-011]

8.06.04 Side Door Emergency Release

A. Each side door shall be designed to be manually opened from both inside and outside the car for emergency egress, rescue personnel access and train crew access to an unpowered car, per 49 CFR Part 238.112.b, APTA-PR-M-S-18-10, and APTA PR-PS-S-002-98 Revision 3.

B. The emergency door release handle shall unlock and release the adjacent door by means of a pull cable or other approved mechanism. The emergency release mechanism, when activated, shall unlock the door, disengage or unlock the door isolation lock (if engaged), remove power from the door operator or controls and move the door toward the open position such that there is a minimum of 1.5 in. gap at the leading edge of the door.

C. The interior emergency release for each side door shall be located adjacent to the door in a flush-mounted enclosure recessed in the vestibule wall, located so as to be easily reached by a 5th percentile adult female. It shall provide safe clearance from other parts of the door and door linkage. The exterior emergency release for each side door shall be flush mounted on the carbody exterior, located at a height so that it can be operated while standing on the trackbed or from a high-level station platform. The exterior release shall be housed in an approved watertight and weather resistant stainless steel enclosure. Each emergency door release shall be equipped with identification signs and simple operating instructions, in compliance with FRA and APTA guidelines, which shall be readable when any access covers are being opened. The location of these emergency devices shall be clearly indicated for any approaching rescue personnel.

D. To deter vandalism, each emergency door release shall be equipped with an approved mechanical break-away release mechanism which is simple for the public to use in stressful situations, yet would inhibit casual use by requiring a determined effort to activate. The break-away mechanism must be of a simple, unitized design which is easy to replace and return to service. If a hinged cover is used, it should be top-hinged to keep the cover closed and prevent it projecting outward after door release. It is preferred that the operating handle for the emergency door release not be visible prior to use.

E. In addition, each emergency door release handle enclosure shall be equipped with a hinged captive cover which is easily opened by the standard coach key, to permit periodic inspection and testing and also a means of crew ingress/egress from an unpowered car, without the need to activate any break-away release mechanism. All details of the emergency door release system shall be submitted for approval during design review. [CDRL 08-012]

8.07 Door Indicators

All door control system signal lights shall use approved long life, high intensity LED or LED arrays lamps having a rated life of at least 100,000 hours. The indicator lights shall be extinguished when the master battery switch for the car is in the OFF position.

8.07.01 Exterior Door Open Indicator

A. One red LED indicating light shall be mounted on each side of the car exterior at each doorway, for a total of four per car. The lenses for each indicating light shall be incorporated into a single bi-directional, low clearance, stainless steel or anodized aluminum housing with brushed finish.

B. The light shall be designed and focused so that, at a distance of ten car lengths, on tangent track, a person with normal visual acuity can determine whether the light is on or off in bright sunlight. The lenses shall be shaded to assist in achieving the required visibility. The circuitry shall be designed so that the lights on both sides at each vestibule are illuminated whenever either side door in that vestibule is open or unlocked.

8.07.02 Interior Signal Lights

A small unobtrusive amber LED shall be located in the ceiling adjacent to each exterior side door. It shall be illuminated on an individual door basis whenever that door does not complete the door locked circuit, either due to door position, obstruction sensing, relay status or malfunction. It shall be continuously illuminated when the door operator cutout switch is used.

8.08 Obstruction Detection System

A. Each powered side door and vestibule sliding end door panel shall be provided with a service-proven obstruction detection system for passenger protection.

B. The obstruction detection system shall be sensitive as defined in APTA-PR-M-S-18-10. The obstruction shall be sensed throughout the closing cycle until the door is fully closed and locked. If an obstruction is sensed by the door, that door shall recycle to the fully open position and pause for adjustable time period and reclose. Recycling shall continue until the obstruction is cleared and the door successfully closes, or until the pre-set number of recycles has been reached. The door obstruction recycles shall be adjustable between 1 to 10 cycles, and initially set to 3 recycles.

C. Deflection of the sensitive edge shall have no effect on the door control system after the door has closed and locked. Soft elastomer edges shall be designed to permit the withdrawal of an obstruction that could be undetected between a closed side door and its mating edge.

8.09 Door Opening and Closing Signal System

A. An audible warning device and a visible warning LED signal light shall be provided at each individual side door to alert passengers of closing doors, in compliance with the requirements of 36 CFR Part 1192.113(c) and 49 CFR Part 38.113(c). The audible and visible signals shall activate for an independently adjustable period of 1 to 5 seconds just before the door begins to close and shall be initially set at 2.5 seconds.

B. The audible warning and visible signal shall be connected with an adjustable electronic timing relay or similar device to the door close control switch. The audible signal shall be an electronic type device and shall have an adjustable volume output with a minimum range of 75 to 95 dBA. The audible signal must be located at its affected individual door, so as to act as a steering aid for the blind. All electronic parts shall be isolated from carbody ground and potted to resist moisture. All components shall be easily replaceable. The details of the system shall be presented to the Engineer for approval during design review. [CDRL 08-013]

C. When the DOOR CLOSED push button is activated at a door control panel, the audible and visual warning devices at each door commanded to close shall activate for 2.5 seconds prior to the start of door movement. The warning devices shall then continue to operate during door closing until the door is fully closed and locked. The warning devices shall not activate when doors are opening and shall immediately deactivate if closing doors are commanded to open during a closing cycle. The warning system for the local door shall not operate at the active door control panel, or to a door commanded closed by an exterior crew switch.

D. The audible and visual warnings shall be capable of independent adjustments. The visual warning shall cycle with a 50% duty cycle (equal on and off periods) with minimum adjustable range for the period from 0.5 to 1.5 seconds. The audible warning shall operate on a 50% duty cycle (equal on and off periods) with a minimum adjustment range for the period of 0.5 to 1.5 seconds. The audible warning shall be initially set with an output of 80 dBA measured at the door and shall be user-adjustable. The details of the system shall be submitted to the Engineer for approval during design review. [CDRL 08-014]

8.10 Conductor Buzzer Signal System

A. A trainlined electrical or mechanical buzzer system shall be provided. The buzzer pushbutton shall be designed compatible with the CTDOT's train crews' tendencies and uses such as indicating "two to go" to the Operator by rapidly pressing the buzzer button twice. Buzzer audible sound shall be immediate in response to the conductor's successive and rapid pressing of the button. The buzzer shall be operable and active independent of the DCP status.

B. The buzzer pushbuttons shall be recessed, and their housings shall be designed to prevent sticking and to accidental contact by passenger and shall be located as follows:

1. At each end of each car;
2. One on each DCP.

a. All buzzers in the consist shall sound when any pushbutton in the consist is actuated, even if the location/DCP is not keyed-in.

b. Each buzzer shall produce a sound level of 85 dBA at a distance of 5 feet from the buzzer. The buzzer sound shall be approved by the Engineer. [CDRL 08-15]

c. All mounting fasteners on exposed surfaces of the buzzer assembly shall be tamper-proof and countersunk.

8.11 Vestibule Sliding End Doors

A. A service proven electrically powered sliding door shall be located between the passenger seating area and the vestibule area at each end of the trailer car and the non-cab end of the cab car. Each door leaf shall incorporate a service-proven obstruction sensing system. No door closing warning shall be given. Use of service-proven electro-pneumatic, belt or cable driven door operators shall be allowed if approved by the Engineer. Door panels shall be equipped for emergency escape per 49 CFR Part 238.112.

B. Each door shall be passenger operated on each side by a side door frame mounted push plate electrical switch, provided at both hand and foot height. Approved LED back lighted push plate switches shall be used. The switches shall be back lighted when the door operator is in normal mode.

C. A backup local manual control shall be provided. The doors shall be labeled for emergency egress in accordance with APTA-PR-PS-S-002-98.

D. The door equipment mounting, and internal fasteners shall be such that once adjustments are made, and locked, they need not be disturbed until equipment overhaul or replacement. Access shall be provided from inside the vestibule to all points necessary for service, installation or removal of powered doors and operating apparatus.

8.11.01 Sliding End Door Operator

The end door operator shall have a local electronic control unit which controls the door operation, is self-checking and provides fault identification information. The control unit, as part of its self-diagnosing capability, shall provide performance degradation diagnostics to identify components approaching possible failure. Control circuitry shall be arranged so that a local door failure does not affect the door operator at the other end of the car. A maintenance switch shall be provided to each door operator which will remove power from the motor to prevent operation while maintenance work is in process. All functions will be available, including diagnostics.

8.11.02 Sliding End Door Cutout Switch

A. Each sliding end door shall be equipped with an Engineer-approved waterproof door cutout toggle switch, located on the passenger seating side of the door near the top of the doorway. The switch shall have three positions, DOOR OPEN, NORMAL and MANUAL. It shall be mounted to a stainless-steel faceplate with engraved lettering. The switch functions shall be as specified below. A red toggle switch guard shall be provided, which shall fully close only when the switch is in NORMAL position. There shall be three distinct modes of end sliding door operation, normal, door open and manual. All settings and door timings shall be easily adjustable after delivery by CTDOT.

B. In "DOOR OPEN" mode, the door will automatically open and remain open.

C. In "NORMAL" mode, the end door shall automatically open fully within 2 seconds after the push plate is activated. The door shall remain open for 8 to 10 seconds, then automatically close. If a side door in the same vestibule is opened, the end door shall remain open for 30 seconds before automatically closing. If the obstruction system is activated during closing, the door panel shall automatically fully open and remain open for 8 to 10 seconds before reclosing.

D. In "MANUAL" mode, electrical power shall be removed from the door operator. The force to open or close the doors manually shall not exceed 20 lbs. (89 N). The door shall be held in either the open or closed position with the vehicle subjected to track super elevation up to 7 in. (178 mm).

8.12 Side Door Status Indicators (ADD-ON)

A. Prior to Contract execution, CTDOT will determine if this feature will be included in the Contract.

B. Passenger seating area, side door status indicators shall be installed at the sliding vestibule end door at each end of a car. The side door indicators shall consist of, two 24-inch LED light bars mounted on each interior vertical edge of the vestibule end door frame. These light bars shall show the status of the side doors and meet the following requirements.

C. The LED side door status indicators shall:

1. Show the passengers in the vehicle seating area the status of the doors while approaching a station, prior to the side doors being opened and

2. Signal to the exiting passengers in the vehicle seating area that the side doors are open and when they are beginning to close and/or are closing and

3. The LED light bars shall operate in parallel to the ADA audible and visual indicator located in each vestibule at each side door position.

D. The LED light bars shall be dual color, red and green. The green color shall indicate that the side doors are closed while a train is approaching a station. The red color shall have a dual purpose:

1. Solid red shall indicate the side doors are open and

2. Flashing red shall indicate that the side doors are beginning to close and/or are closing.

3. When the doors are open or locked and closed, the LED light bar shall be turned off.

E. The side door LED light bars shall be operational only when a Conductor activates or keys-in at a Door Control Panel.

F. Command and control of the side door LED light bars shall be through the Digital Trainline (DTL)/Wired Train Bus (WTB) and the Multivehicle Bus (MVB).

1. If a side door has been locked out or cut-out, the adjacent LED light bar at that end of the car shall be disabled, indicating that exiting of the train might have to occur through the opposite end of the car's side door or by crossing over to the adjacent car's vestibule side door.

2. If the opposite side door on the end of a vehicle, from a locked out or cut-out door, is still operational, then the LED light bar shall still function at that end of the car, only if that side of the train's door control panel has been activated or keyed in.

8.13 Contract Deliverable Requirements List

CDRL #	Title	Car Type
08-001	Side door and Vestibule Mockup	All
08-002	Drain Water Routing Arrangement	All
08-003	Carbody End Door Design	All
08-004	Door Threshold Heater System	All
08-005	Gap Filler	All
08-006	Door Control Circuit Logic	All
08-007	Failure Mode and Effects Analysis (FMEA) and Fault Tree Analysis (FTA) for Circuit Design	All
08-008	Door System, Door Operators, Controls and Installation Details	All
08-009	No-Motion Bypass Feature Design	All
08-010	Door Operator and Emergency Release Details	All
08-011	Exterior Crew Switch Arrangement and Locations	All
08-012	Emergency Door Release System	All
08-013	Door Closing Audible Signal System Details	All
08-014	Door Closing Visual Signal System Details	All
08-015	Conductor Buzzer	All

* End of Chapter 8 *

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Technical Specification

CTDOT Single-Level Passenger Rail Cars

Chapter 9

Interior

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9.00 Interior

9.01 Overview

A. This chapter defines the interior design and configuration for the revenue seating areas of the trailer and cab cars, including vestibules, toilet rooms and overhead luggage storage racks. The overall interior layout shall be designed such that it provides a premium feel to the riders, maximizes seating, and is inclusive to passengers with disabilities.

B. All cars shall be equipped with an ADA Accessible Toilet Room, seating areas with overhead luggage racks, workstation tables, convenience outlets, and a bicycle storage area. Cab cars shall have a locomotive control cab at the F-end (see Chapter 16).

9.02 General Requirements

A. This chapter shall describe the basic interior configuration of all car types in this specification, and each car type shall include all requirements for ADA accessibility and general seating arrangements that provide comfort and amenities such as electrical outlets and individual work trays or tables.

B. The interior of the car shall be designed and constructed for maximum safety, comfort, convenience and service to the passenger, and shall be fully ADA compliant. Walls, ceiling panels and window masks shall be designed and constructed to form a safe and attractive environment. Visible fasteners shall be minimized.

C. All systems requiring maintenance shall be easily accessible and removable for cleaning and repair.

D. The Contractor shall provide interior layouts for review and approval by the Engineer during design review. [CDRL 09-001]

E. An analysis of the connection of all interior structures, systems and components to the carbody shall be accomplished per section 4.

9.03 Basic Features of All Car Types

9.03.01 General

A. Whenever possible, common components shall be used in all car types.

B. Strength of all interior fittings and their attachment to the carbody shall meet APTA-PR-CS-S-006-98 and 49 CFR Part 238.233.

C. All car types shall include the following:

1. One Accessible Toilet Room (ATR)

2. Gap fillers (Chapter 8)

3. Wheelchair parking location

4. Pair standard coach seating, facing seat pairs with workstation tables

5. 120 Volt Alternating Current (VAC) electrical outlets and USB charging ports adjacent to each seat or seat pair on the sidewall or other approved location (see Chapter 13)

6. Emergency tool locker
7. Crew storage lockers
8. Electric locker
9. Public Address (PA) system (See Chapter 12)
10. Installation of Onboard Passenger Information System (OBIS/WiFi) (see Chapter 12)
11. Heating, Ventilation and Air Conditioning (HVAC) system (see Chapter 10)
12. Lighting system (see Chapter 11)
13. Low-Level Emergency Path Markings (LLEPM)
14. Emergency lighting (see Chapter 11)
15. Emergency and non-emergency windows (see Chapter 4)
16. Passenger information signage and service markings
17. Racks for promotional materials
18. Overhead luggage racks above the windows suitable for carry-on suitcases
19. Minimum of four bicycle racks
20. Passenger compartment aisle no less than 32 in. wide (813 mm)
21. Nominal seat pitch of at least 32 in. (813 mm)

D. The above configuration will represent the "basic" coach car for this Specification.

E. In addition to paragraphs A to D above, the trailer car shall include:

1. Partition walls with a push-button operated sliding door between entrance areas and passenger areas
2. Two vestibules with side entry doors on each side
3. Two end doors/passageways

F. In addition to paragraphs A to D above, the cab car shall include:

1. Full-width control cab for push/pull operations at the F-end (see Chapter 16)
2. A side entry door on each side that allows passengers to directly enter the passenger area of the vehicle. These doors shall be located near the bulkhead between the passenger area and the control cab.
3. Windscreens on the passenger-area side of the F-end entranceways, separating the entranceways from the seating areas
4. Partition wall with a push-button operated sliding door between the B-end entrance area and passenger area

5. One B-end vestibule with side entry doors on each side

6. One B-end end door/passageway

7. The general seating in the car will follow the trailer configuration except for the space needed for the cab control area

9.03.02 Americans with Disabilities Act (ADA) Provisions

A. Each car shall be fully compliant at the time of manufacture, with all rules and regulations of 49 CFR Part 38 (including subpart F – Intercity Rail Cars and Systems), Americans with Disabilities Act (ADA) Accessibility Specification for Transportation Vehicles, and no part of this specifications alters or changes those requirements. Review of the car's accessible features (including all drawings, calculations and supplier information required to define the proposed installation) shall be conducted with the Engineer as part of the mock-up review. Recommendations from the Rail Vehicle Access Advisory Committee's 2015 report on accessibility are adopted requirements in this Technical Specification, and shall supersede the respective standards and requirements set forth in 49 CFR Part 38 in effect at the time of the issuance of this Solicitation/RFP.

B. Each car shall include one dedicated accessible wheelchair parking location and one additional location that can be used for wheelchair parking or bicycle storage. Both areas shall allow the wheelchair passengers to remain in their wheelchairs while on board the car.

1. Each parking location shall provide for a clear floor space of 32 in. (813 mm) by 59 in. (1499 mm).

2. The clear floor space can be overlapped by a maximum of 6 in. (152 mm) at least 12 in. (305 mm) above the floor.

3. A 60 in. (1524 mm) diameter maneuvering circle must be provided for each space. This circle may overlap with the wheelchair space, the aisle, or any other area that permits free movement for the wheelchair to maneuver into its parking location.

4. Handrails and stanchions will be provided, as needed, to help with maneuvering within this area.

5. The dedicated accessible wheelchair parking location will be oriented such that the passenger can transfer to a nearby seat. Moreover, this seat shall meet all the applicable requirements form 49 CFR Part 38.

C. Each car shall include gap fillers at each side door that will facilitate the boarding of passengers in wheelchairs. (see Chapter 8)

D. Each car shall also include an accessible toilet room. The toilet room door shall be push-button operated and be of the sliding type. Requirements for the toilet and associated equipment are included elsewhere in this Chapter.

E. ADA-compliant car-to-car access is required. Each car shall include end doors and bulkhead doors that have a clear, unobstructed opening of no less than 2 ft 10 in. (864 mm) wide. Overlapping gap closer or bridge plates shall be provided between coupled cars to allow wheelchairs to pass from car-to-car without trapping the wheels in gaps.

9.04 Interior Structure

A. The trailer car shall serve as the base for the interior for all car types. Interior colors, design, patterns and finishes of materials shall be developed by the Contractor as part of the conceptual design and mock-up process to be approved by the Engineer.

B. Easy access shall be provided for all items that require periodic maintenance or replacement. Tape or other material that prevents squeaking or chafing shall be used between linings and any structure to which they are attached or in which they may come into contact. Linings covering apparatus requiring maintenance or servicing shall be fastened with approved fasteners in a manner that permits ready removal and replacement by technicians, but is secure from passengers.

C. All interior surfaces that are of fiberglass shall have a high-gloss finish with a minimum gloss meter measurement of 82. Color shall be applied as a gel coat surface. Interior liners and partitions shall be fiberglass or equivalent using fire retardant resins.

9.04.01 Vestibules

A. Trailer cars shall have a vestibule at each end of the car and cab cars shall have a single vestibule at the B-end. Each vestibule shall include:

1. Two side entrance doors (one on each side of the car) – specified elsewhere

2. Door control panels – specified elsewhere

3. PA system panel – specified elsewhere

4. Gap fillers – specified elsewhere

B. The minimum clear width of the vestibule (exclusive of side and end doorways) shall be 44 in. (1,118 mm).

C. The vestibule ceiling shall be stainless steel. Any access panels in the vestibule ceiling shall be equipped with limit chains, safety catches and quarter-turn removal "T" handle locks (or approved equivalent).

D. The vestibule floor shall be covered with stainless steel diamond pattern plates welded directly to the top of the floor structure. A plasma spray anti-slip treatment shall be applied to the plates.

E. The vestibule interior must be equipped with the necessary handholds, railings and stanchions as required to provide for the safety and convenience of the passengers and crew. The location, installation and arrangement of these items shall be subject to the Engineer's approval. All installations shall be free of rattles and squeaks and shall comply with APTA standards for the attachment of interior fittings.

F. A gap filler shall be provided at all side doors. The gap filler shall have a non-skid walking surface and shall be sufficient to safely span the gap between the car and a high platform while allowing a person in a powered wheelchair to enter or leave the vestibule. (Chapter 8).

G. Bulkheads and partitions in the route of the wheelchairs between the vestibule and the wheelchair positions inside the passenger compartment shall not incorporate any protrusions or wings extending into the wheelchair pathway.

H. Each vestibule shall have at least three LED ceiling-mounted fixtures. The fixtures will be interchangeable with each other and those in the hallway ceilings and toilet room. One fixture shall be located over the door threshold area, as close to the side of the car as practical. Another fixture shall be located over the center aisle in the vestibule. All vestibule fixtures shall be moisture-proof. Emergency light fixtures shall also be installed in each vestibule, with the quantity and location subject to the Engineer's approval. See Chapter 11 for more details.

9.04.02 Cab Car F-end Entranceways

A. Two side entry doors that allow passengers to directly enter the passenger area of the vehicle shall be provided at the F-end of the cab car. These doors shall be located near the bulkhead between the passenger area and the control cab.

B. Each doorway shall include:

1. Door control panel – specified elsewhere

2. PA system panel – specified elsewhere

3. Gap filler – specified elsewhere

C. Windscreens shall be provided on the passenger-area side of the doorway, separating the entranceways from the seating areas. The windscreens, along with the railcar, shall meet all applicable sections of 49 CFR Part 38.

D. The windscreens shall have stainless steel tubular frame, a solid bottom panel faced with 0.5 inch minimum thickness panels having a surface finish on exposed sides, and a upper panel of clear glazing up to a sufficient distance from the ceiling to allow light fixture access. The top of the bottom panel shall be at the same height above the floor as the top of the adjacent passenger seat assembly. The windscreen shall fit aesthetically with the overall interior.

E. The windscreens shall be securely mounted to run from floor to ceiling and be of adequate structural integrity to withstand all normal or extraordinary loading from passenger contact. Attachment points shall use suitable reinforcements. Partitions which face passenger seats shall be provided with an approved stainless steel kick plate from the floor up at least 1 foot high. Floor coving shall be installed on all exposed base surfaces. All corners and edges of partitions shall be rounded. The partition surfaces and trim shall be identical to or harmonize with the appearance of the car interior.

F. Each windscreen shall incorporate a stainless steel horizontal hand rail 2 feet, 10 inches above the floor on the entranceway face, a stainless steel vertical stanchion on the inside edge at the aisle, and a stainless steel full height vertical hand rail adjacent to the side entrance doorway opening. The vertical stanchion shall have a minimum of 3 inches hand clearance, and shall be integral to the lower windscreen panel to provide a smooth transition between the floor and windscreen. Minimum width between stanchions above the seat back height shall be approximately 2 feet 8 inches. The arrangement shall not contain any crevasses which could hold dirt. The handrails shall have 1.5 inch hand clearance, and shall be recessed as necessary to maintain the clear opening width of the doorway. The vertical hand rail shall be used by train crew operating the doors. The handrail design shall be such as to provide minimum interference in the doorways and prevent snagging of clothes, etc., on the ends. All stanchions and hand rails shall be made from 1.25 inch outer diameter stainless steel round tubing or carbon steel pipe shrouded with stainless tubing. All tubing shall be seamless and polished to a number 180 grit circumferential finish. All stanchions, handrails and fittings shall be respectively of similar construction, free of burrs or sharp edges, and designed for easy removal and replacement. The tubing shall be terminated with heavy wall, polished or glass bead finished cast aluminum fittings. All fastenings and fittings shall be designed to prevent rattle or turning.

G. Each stanchion or windscreen shall comply with the testing and design requirements of APTA PR-CS-S-006-98, Rev 1. The design of the entire windscreen, stanchion and handrail system shall be subject to approval by the Engineer. [CDRL 09-002]

9.04.03 Bulkheads

Bulkhead walls at the end of each passenger seating area shall be constructed of melamine-faced aluminum panels or fiberglass panels for durability and to be pleasing to the passenger. All fiberglass material shall be covered with a high gloss gel coat. All seams will be sealed, using appropriate sealing

materials. Fasteners shall not protrude from the wall panels but countersunk to be flush with the wall panels.

9.04.04 Side Walls

A. The sidewalls shall be designed and constructed to minimize the number of joints, with all joints being tight, and meeting manufacturer's requirements for trim, maximum gap and fit-up quality. In addition, the number of unique sidewall panels shall be minimized. Floor heating cover panels shall be designed and installed to withstand the temperatures and maintenance of the heating system without removal of adjacent components. The vendor shall provide recommended cleaning instructions as part of the Service and Inspection manual (see Chapter 22).

B. Window masks

The window masks shall be either Fiberglass Reinforced Plastic (FRP) or thermoformed plastic. The window edge should incorporate openings for heating vents at the window. Sidewall heat vents may be separate powder coated aluminum (as appropriate for the mask to window interface), or integral to the window mask. The window masks must not readily collect dust/dirt, and shall be easy to clean without removal or special tools.

C. Sidewall heat

Passenger seating areas shall be equipped with a heating system as specified in Chapter 10. The sidewall materials, as well as any materials attached to them, shall be of sufficient temperature rating that they do not discolor, become brittle or otherwise deteriorate for the life of the car from exposure to the heating system.

9.04.05 Diffusers and Grilles

A. Supply and return air diffuser grilles shall be stainless steel or extruded aluminum and integrated into the surrounding surfaces. An arrangement using adjustable regulating registers and grilles shall be provided. Regulating registers shall be hidden by these grilles and shall be removable for periodic cleaning without requiring the removal of other items. These grilles shall be configured to be easily removed for cleaning. Diffusers shall be designed to be easily adjusted to set car air balance without having to drop ceiling panels. It shall be possible to drop ceiling panels without having to disturb supply air diffusers.

B. Grilles shall be designed to minimize drafts onto passengers. Regulating registers shall be designed to eliminate rattles and noise levels associated with high velocity air supply systems.

C. Grilles or suitable openings (such as a gap below the door) shall be provided as necessary to provide a return path for air through enclosed spaces, such as the Operator's cab. The restroom doors shall have a grille at a low location to allow air to enter the room, to be exhausted from that space by the exhaust system. Grilles that are subject to impact from luggage, such as that on the electric locker, shall employ a guard for protection.

D. The heater grilles shall be constructed of stainless steel or extruded aluminum, formed and perforated appropriately to perform their ventilating function. Heater grille length should correspond approximately to the heater system specified in Chapter 10. Standardized and interchangeable grille pieces shall be used to the maximum extent possible. The top of the sidewall heater grilles shall be sloped toward the center to discourage the placement of items on top while providing a comfortable foot rest for the passenger in the window seat. The grille openings shall be easy to clean and not readily accumulate dirt. The grilles shall be designed to provide a smooth transition with the side wall and to prevent debris from entering the heating space and contacting the heating system. Heater grille temperatures should not exceed 125°F (52°C) at nominal supply voltage.

9.04.06 120V Outlet Strip with Integrated USB Charging Ports

Convenience outlets utilizing duplex 120VAC receptacles with integrated USB charging ports shall be available in each row and shall be located below the window mask. The conduit base shall be integrated into the surrounding surfaces. A duplex receptacle shall be provided for each seat, including those at tables, in all car types. Receptacles shall be located approximately 24 in. (610 mm) forward from the front of the seat back, 16 in. (406 mm) forward of the seat back for those seats located at tables. Two duplex receptacles with USB capability shall be installed at each table, located such that the table or seat does not interfere with access to the outlet. A 120 VOLTS label shall be installed on the conduit cover at each outlet location, 0.5 in. (12.7 mm) from outlet, between the outlet and the seat facing the outlet. The raceway shall be securely attached to the carbody structure so it does not work loose from repeated use. Refer to Chapter 13 for further requirements. The Engineer shall determine USB port type as required during design review.

9.04.07 Central Ceilings

A. The central ceilings shall cover the main lighting and the blow out to diffusers. The ceilings shall be easily dismountable to access all relevant devices for maintenance and the air ducts for cleaning. All fastenings must be designed in a way that accidental opening is securely inhibited.

B. The ceilings shall be made of a wear resistant and easy to clean material, preferably coated metal sheets.

C. Ceiling panel size shall allow a single person to open/close the panels safely, unaided. Self-engaging safety catches shall be included to prevent accidental panel openings. These safety devices shall be stainless steel and be configured so as not to rattle in service.

9.04.08 Electrical Locker

A. The electrical equipment and switch locker shall be located as appropriate near the cab or at the end of the car.

B. Locker walls shall be of melamine faced aluminum panel construction with substructure as appropriate to support components. Longitudinal walls facing into the vestibule shall be decorated with melamine or other factory-manufactured laminate material.

C. The door lock shall be a coach key style lock with interior release latch.

D. The electrical locker shall be positively pressurized by conditioned air as part of the HVAC system to prevent dust from entering and accumulating in the electrical locker. Sufficient ventilation shall be supplied to the locker to maintain temperature levels required by the equipment contained in the locker. Air shall only be allowed to vent from the electrical locker through gaps and voids where dust may enter. There shall not be a vent or grille in the door to the electrical locker. If the return air path passes through the electric locker space, it shall do so within an air duct and not use the electric locker space as part of the return air system.

E. Locker design will consider proximity to doorways and sliding windows and shall have appropriate measures to mitigate rain and snow intrusion.

F. Each electrical locker shall contain a duplex style outlet as described in section 13.

G. Each locker will also contain a fold out tray to support a laptop-type portable test equipment (PTE) or to act as a writing surface. When not in use, the tray shall have a method of securing so that it will not rattle while in service. The Contractor will propose a solution to the Engineer.

H. The locker shall include a metal pocket or rack, which is approximately 9 in. wide by 12 in. tall by 1 in. thick (229 mm wide by 305 mm tall by 25 mm thick).

9.04.09 Overhead Luggage Storage

A. Overhead luggage storage racks shall be provided above all revenue seating and shall incorporate dividers to prevent excessive shifting/movement of luggage. Satin finished, anodized aluminum luggage rack of open construction with transverse rods and cast aluminum mounting brackets shall be provided on both sides of the car over the passenger seating areas. The rack shall be inclined to prevent luggage from sliding in the transverse direction, towards the center of the car and will also contain stops to prevent luggage from sliding off the rack in the longitudinal direction. The luggage racks shall consist of modular units bolted to the sidewall and roof structure and extend the entire length of the passenger seating compartment. The racks shall accommodate carry-on luggage of up to 14 in. (356 mm) by 18 in. (457 mm) by 22 in. (559 mm) in size. Length of the racks shall match the window pitch so that the bin dividers are located centered on the pillar between windows. Design of the racks shall include as few obstructions as possible for manipulating luggage into and out of the rack. All exposed surfaces shall be highly durable to resist scuffing and heavy usage without visible damage and be smoothly finished to avoid damage to luggage or passenger injury. The bottom of the rack shall have a lip of sufficient height to mitigate the potential of any luggage resting on the bottom surface of the rack from sliding out of the rack. The gap between the rear edge of the luggage rack and the wall lining shall be minimized so as to prevent umbrellas from falling through. The luggage bearing surface shall be durable and not require replacement or refurbishment for the life of the car. The lower edge of the rack at the aisle shall incorporate a smooth convex radius to mitigate passengers bumping their heads against the underside of the luggage bin. An easily reached continuous passenger handhold shall be provided facing the aisle way.

B. The rack structure and attachment to carbody structure shall have sufficient strength to support a load of 250 lbs (114 kg), applied over 6 in. (152 mm) midway between adjacent supports on the inboard edge, with a deflection not to exceed 0.25 in. (6.35 mm) (including rack itself and its attachment to carbody) and without fracture or permanent deformation. The load-bearing surface shall be inclined upward from the horizontal toward the center of the car at a minimum ratio of 1:8 with respect to a horizontal plane.

C. The complete and fully-loaded luggage rack and its attachment to the carbody shall also be designed to resist loads, without failure, due to accelerations of 8g longitudinally 4g laterally and 4g vertically, acting on the mass of the luggage. The minimum mass of the luggage stowed shall be based on a distributed load of 20.5lb/ft^2 (100kg/m^2). The Contractor shall demonstrate the strength and luggage retention capability of the luggage racks during the design review.

9.04.10 Luggage Towers

A. A luggage tower adjacent to the bicycle storage shall be proposed for each car. The Contractor can propose alternate locations of with the goal of improving overall layout of the coach and to maximizing seating. The luggage tower shall be of robust tubular brushed stainless steel construction and include shelves and suitable brackets for hanging garment bags. The tower shall be designed such that there is sufficient visibility for passengers and employees to see and monitor bags. Bumper guards shall be mechanically attached to the wall panels within the luggage rack/tower to prevent damage to walls or luggage.

B. The racks on the tower shall have sufficient strength to support a load of 250 lbs (114 kg) midway between adjacent supports with a deflection not to exceed 0.25 in. (6.35 mm) and without permanent deformation. The load-bearing surface shall be not less than 24 in. (610 mm) wide and shall be inclined upward from the horizontal toward the center of the car at an angle of approximately three degrees.

C. The luggage tower will be designed such that it can accommodate a full-size ATLAS style airline service cart. The luggage tower will have a securement method for the trolley, such that the tower and securement method are designed to resist loads, without failure, due to accelerations of 8g longitudinally,4g laterally and 4g vertically of the trolley at its maximum loaded weight. The location

used for the service cart will permit luggage to be stored in the same area, should the cart not be present.

D. A duplex style outlet will be positioned such that there is an available power source for the service cart. The amperage and configuration of this outlet shall be proposed to the Engineer.

9.04.11 Crew Storage Lockers

A. Each car shall contain a crew storage locker. These lockers will have sufficient space to store work-related items and personal belongings commonly used by the crew, such as a backpack, winter jacket, gloves, clipboards, paperwork. Each locker will contain at least two hooks for hanging these items. Consideration should be given to new items that might be implemented in the future, such as e-readers for scanning passenger tickets. Each locker will contain a duplex outlet equivalent to what is provided to each passenger seat row. Access to the lockers will be with the standard coach key.

B. The Contractor will propose location and dimensions so that space for revenue passengers is not appreciably affected. The location will also be chosen so that it does not cause a nuisance to passengers, should employees need regular access. [CDRL 09-003]

9.04.12 Bicycle Racks

Both the trailer and cab cars will contain four bicycle racks per car. Rack style will be the same as is currently used on CTDOT's existing vehicles. This allows for four bicycles to be mounted vertically and attached to the carbody sidewall. The lower portion of the rack supports the bicycle's rear wheel and, when not in use, will automatically return to its stowed position against the sidewall. The upper portion will be a fixed hook that will secure the front wheel of the bicycle. The Contractor may propose alternate locations for the bicycle racks for the Engineer's review if it would beneficial to the overall interior layout.

9.05 Toilet Rooms

9.05.01 Accessible Toilet Room (ATR)

The Accessible Toilet Room (ATR) shall be located on the right side of the B-End of each car type immediately adjacent to the side entrance door. It must be compliant with all applicable ADA requirements and shall have the following features:

A. The restroom shell shall be constructed primarily of FRP with a high gloss (80-90% on a 60° gloss meter) gel coat finish on surfaces exposed to the public. All corners of the shell shall have a minimum 2 in. (51 mm) radius to eliminate the accumulation of debris and aid in cleaning.

B. Minimum ATR dimensions shown by 49 CFR Part 38 Subtitle A, Figure 4 *Intercity Rail Car (with accessible restroom);* and as defined in 49 CFR Part 38 Subpart F, Section 38.123(a) shall be met or exceeded.

C. The toilet room shall have a clear floor area of no less than a 60" radius (1524 mm).

D. The toilet room, inclusive of the sliding pocket door and exterior wall panels (passenger compartment), shall be readily removable and capable of passing through the vestibule doors with a minimum amount of disassembly, but in no case shall there be more than four pieces.

E. The toilet shroud shall be constructed of FRP with gel coat color to match the interior toilet room interior walls. The toilet seat and cover shall be constructed of Coralink or reinforced fiberglass. See Chapter 15 for toilet details.

F. The toilet room exterior car body wall shall be fitted with an exhaust fan per the requirements of Chapter 10. The exhaust air shall be sufficient to maintain a negative pressure in the toilet room

(with respect to the vehicle interior pressure). An airflow inlet grille shall be included in the design. All grilles shall be stainless steel.

G. Supply air and floor heat shall condition the interior room to comply with the interior temperature requirements of Chapter 10.

H. Floor heater grille shall be stainless steel and located at a height that will not be exposed to cleaning products used on the toilet room floor. The grille surface temperature shall comply with the maximum limits specified in Chapter 10.

I. All drain water from restroom sink drains will be piped into the waste tank and will not be discharged from the coach (see Chapter 15).

9.05.02 Toilet Room Door

A. A transit service-proven sliding pocket door with lock shall be provided. The toilet door shall be push-button operated and be of the sliding type. The lock shall be operable from the outside with a standard coach key. The lock will be simple and easy to operate by the passengers with disabilities. The lock shall be submitted for consideration by the Engineer. [CDRL 09-004]

B. The door shall incorporate a dampened closing device that will fully close and latch the door when released. Bump stops will be provided to protect the door when fully opened.

C. The door shall be capable of resisting a 250 lb (113 kg) load at the geometric center of the door. The load shall be applied to a 3″ x 3″ area (76 mm x 76 mm). No permanent deformation shall occur.

D. The door clear opening width shall be no less than 39″ (991 mm).

E. Stainless steel kick plates shall be provided on the interior and exterior surfaces of the door. The kick plates shall be no less that 6″ (150 mm) tall. The kick plates shall be bonded in place during door fabrication.

9.05.03 Toilet Room Amenities

A. All controls, switches and amenities shall be readily accessible and operable by passengers with disabilities.

B. Stainless steel, anti-slip grab bars shall be provided in accordance with 49 CFR Part 38 Subpart F, Section 123(a)(3).

C. A transfer seat to facilitate shifting onto the toilet shall be provided.

D. Water-resistant, LED light fixture(s) shall be mounted over the toilet vanity mirror. The light shall be on at all times during revenue service. Lighting levels shall be in accordance with APTA-PR-E-RP-012-99.

E. A high velocity motion-activated hand dryer/blower shall be provided. Make and model subject to review by the Engineer.

F. A toilet stand with shroud assembly (see Chapter 15) shall be located in the toilet room.

G. An automatic electronic flush mechanism shall be incorporated into the toilet. A manual back-up flush button shall be in an obvious and convenient location to the user.

H. A sink with an electronic touch free faucet to automatically blend hot and cold water shall be located conveniently next to the toilet. The sink shall have a one-gallon capacity and a permanently mounted strainer. Water temperature shall meet the specifications contained in Chapter 15.

I. Sink and countertop shall be constructed of Corian or approved alternate material. See Chapter 19 for acrylic requirements. The sink and countertop shall be seamless. A sample of the proposed surface and a rendering/photo of the proposed finished product shall be submitted to the Engineer for review. [CDRL 09-005]

J. A storage shelf shall be included so that passengers can temporarily store small belongings (such as a purse, backpack, or briefcase). This shelf shall contain a lip or other feature to prevent items from sliding off. Additionally, it shall be located in an area that will minimize the chance of being splashed by any liquids (such as from the sink, toilet, or passengers drying hands). The storage shelf's design and material will fit with the overall aesthetic of the bathroom and be easy to clean.

K. A 120VAC Ground Fault Circuit Interrupter (GFCI) duplex receptacle shall be provided.

L. An electronic touch-free soap dispenser base shall be mounted on the countertop in compliance with ADA regulations. In addition, an electronic touch-free hand sanitizer dispenser will be mounted near the entrance to the toilet room. The dispenser will either include a drip guard or be mounted to prevent liquid from dripping onto the wall or floor.

M. A transit service-proven air freshener system shall be proposed by the Contractor for review by the Engineer. [CDRL 09-006]

N. A minimum of two heavy duty recessed coat hooks, a stainless steel toilet seat cover dispenser and an Amtrak standard facial tissue dispenser shall be provided. One of the coat hooks shall be provided in an ADA accessible location.

O. A trash bin shall be provided and sized for 10 gal (37 L) trash liners. The bin shall be easily removable by maintenance staff. The trash bin shall be equipped with a fire safety hood.

P. A toilet seat paper liner dispenser shall be provided. The dispenser shall be stainless steel with keyed access for re-fill.

Q. One common key shall be utilized for all maintenance activities in the toilet room.

R. There shall be one toilet paper roll dispenser that shall accommodate at least two full rolls. The location of the dispenser shall eliminate the possibility of toilet paper coming into contact with the floor heat. In addition, storage for additional toilet paper rolls shall be provided.

S. A polished stainless steel mirror with a minimum 20 in. wide by 30 in high (508 mm by 762 mm) viewing area shall be mounted above the sink. The mirror shall be removable or mounted on a hinged door to allow access to the equipment behind the wall for maintenance and shall be positioned for viewing by passengers in wheelchairs and standing passengers.

T. Exposed fasteners will be minimized, to the maximum extent practical. All exposed fasteners shall be stainless steel tamper-proof torx pin head screws.

U. The fittings in toilet rooms shall meet the attachment strength requirements defined in 49 CFR Part 238.233.

9.05.04 Toilet Room Indicator Lights

A. A yellow LED TOILET ROOM OCCUPIED indicator light shall be provided on the outside of the toilet room in a location visible to the seated passengers.

B. A DOOR IS LOCKED WHEN LIT LED indicator light shall be provided on the inside of the toilet room, activated when the door is locked.

C. A red OUT OF SERVICE indicator light shall be provided outside of the toilet room in a location visible to seated passengers.

D. A sample of the proposed lights shall be submitted for review by the Engineer. [CDRL 09-007]

9.05.05 Toilet Room Pan and Flooring

A. The floor pan of the toilet room modules shall be FRP with 2 in. (51 mm) minimum radii corners to eliminate the accumulation of debris and aide in cleaning. A stainless steel overflow pan shall be provided under the toilet and water connections. A waterproof rubber flooring covering which reduces noise and resists accumulation of odors shall be provided under the floor pan. The purpose is to prevent fluids from wicking beneath the toilet room flooring, both for hygiene and also to prevent degradation of the subflooring materials. (The subfloor materials are described in Chapter 4). This pan shall be watertight and have raised edges of at least 6 in. (152 mm) in height. The pan's exposed edges shall be folded for safety and to provide stiffness. The floor pan shall be installed over the subfloor of the car, and the perimeter of the pan shall be fully sealed to prevent moisture from seeping under the pan. Attachment points to secure the floor pan to the subfloor shall be in the sides, rather than the bottom surface, and be watertight. The floor pan joint at the door opening shall be waterproof to the subfloor. Floor penetrations shall be avoided when possible, but where required, sealed both to make the joint waterproof and also with an appropriate material to prevent flame propagation from underfloor flame sources.

B. A seam-free, skid-resistant rubber floor covering, solid surface material coating, or approved equivalent, shall be used in the toilet room floor area. Color and pattern selection shall be as specified in Chapter 23. The floor covering shall be coved a minimum 4 in. (102 mm) up the sidewalls to form the inside scuff/kick plate. The edges shall be sealed to form a watertight seal.

C. The floor shall be sloped to a floor drain. The drain shall be integrated with the rubber flooring mentioned above to ensure that all fluid is collected without leakage. The drain shall be stainless steel with stainless steel piping. No underfloor equipment shall be exposed to the drainage. The drain shall be capable of being opened and closed from the interior of the car.

D. The floor shall be designed to support a 600 lb (272 kg) wheelchair load and a 250 lb (113 kg) assistant.

9.06 Interior Décor

9.06.01 General

A. The Contractor shall develop and provide to the Engineer for approval, at the interior design review stage, no less than six storyboard palettes proposing a coordinated and comprehensive concept for the major elements of the décor for the interior of each car. [CDRL 09-008] The elements to be proposed on this palette shall include the colors, patterns, textures and gloss levels of the:

1. Seat material (revenue seats)
2. Flooring
3. Melamine laminates for use on wall panels and table tops
4. Fiberglass panels
5. Acrylic countertops
6. Thermoform plastic panels
7. Skid resistance composite flooring for vestibules, toilet rooms, passageways and other non-carpeted areas

8. Powder coated or anodized metal items

9. Warm and pleasing colors and patterns provided in the toilet room

B. The Contractor's selection of these items shall be based on the development of a comprehensive décor for the car interiors that utilizes commercial and industrial design to create a contemporary and pleasant car interior. The Contractor shall present to the Engineer, at the preliminary design review, the criteria that will be used to select the elements of the interior décor. The Contractor shall also provide color samples for interior materials. Six storyboards shall be based on adequate differences so that the Engineer has a wide variety of interior concepts from which to choose. Additional Engineer considerations or requirements that will guide the development of the storyboard palettes are included in chapter 23. The Engineer shall select the storyboard of its choice prior to the final design review.

C. Using the approved interior décor palette, the Contractor shall provide at the preliminary and final design review a series of computer-generated conceptual images and 3-dimensional computer-aided design (CAD) models that represent the simulated appearance of the car interiors, including, textures and patterns selected by the Engineer. [CDRL 09-009]

D. These images and models shall include (but are not limited to) several views of each of the following areas of the cars:

1. Passenger seating area

2. Toilet rooms

3. Vestibules

4. Cab area

E. These images shall be provided to the Engineer in both electronic and large-format print. The Engineer may use these images for purposes of public relations or other pre-production activities.

9.06.02 Floor Covering

A. Skid-resistant, waterproof composite floor covering, that has been tested and proven, shall be used throughout the trailer and cab cars, with the exception of the vestibule flooring (see below). Skid-resistant flooring material can either be integral to the flooring panels or subsequently bonded to those panels. The floor design must be compatible with the requirements in Chapter 4 and comply with 36 CFR Part 1192 Appendix (Advisory Guidance).

B. The floor covering shall have an integral cove, where specified, for easy cleaning, and shall extend from 2 in. (51 mm) to 6 in. (152 mm) up the wall, depending upon application.

C. Transitions between flooring types shall produce level changes in flooring surfaces less than 0.25 in. (6.35 mm).

D. The trim strip between the wall lining and the floor covering shall be sealed to prevent harborage, accumulation of debris or incursion of water and cleaning fluids.

E. Floors in vestibules shall be covered with stainless steel diamond plate with an approved non-skid surface.

F. Floors in vestibules and end passageways shall have a 3 in. (77 mm) wide high-contrast visibility strip directly adjacent to door openings to delineate the door opening for visually impaired passengers. The high-contrast strip at the side entry doors shall be made of high-performance photo-luminescent material so that it is integrated into the LLEPM system for exit pathway marking. The LLEPM material

and application shall comply with APTA-PR-PS-S-004-99 Rev. 2 and shall be embedded in the floor system.

G. All flooring shall be installed using an adhesive system that is approved by the flooring manufacturer.

9.06.03 Forbo Flotex Flooring (ADD-ON)

A. Prior to Contract execution, CTDOT will determine if this feature will be included in the Contract.

B. Floor covering shall be Forbo Flotex or approved equivalent. The floor covering will be installed throughout the coach interior with the exception of the vestibule and toilet room areas.

C. The Contractor shall propose a variety of colors that blend aesthetically with the railcar interior. Color selection will be by the Engineer.

9.06.04 Seats and Tracks

A. Seats

1. Overall Configuration and Layout

a. All passenger revenue seating locations in the trailer and cab car shall use a fixed (non-rotating nor reclining) passenger seat, which is appropriate for intercity service and arranged as paired seats. The predominant revenue seating arrangement shall be a central aisle with a 2 plus 2 seating configuration in trailer and cab cars. The Contractor will propose multiple seating configurations to the Engineer. [CDRL 09-010] See Chapter 23 for Engineer specifics regarding seats, seat pitch, seat inserts and other details.

b. The seat-mounting angle to the car floor shall optimize passenger knee room. Generally, the passenger fixed seats shall be arranged to face the center of the car, with a worktable provided at the center of each facing pair of seats. The minimum distance between the two facing seats bottom cushion faces shall be 23 in. (584 mm).

c. APTA-PR-CS-S-016-99, revision 2 or newer, Standard for Passenger Seats in Passenger Rail Cars shall be used as a design guideline

d. All colors shall be as directed by the Engineer. The overall interior appearance, including cushions, are to be proposed by the Contractor. All revenue passenger seats shall share the same common design appearance. Individual components shall be interchangeable wherever possible. Seats shall not obstruct emergency windows and have a profile that is free of sharp corners and edges.

2. General Characteristics

a. Each seat unit shall consist of a frame, pedestal, seat bottom cushion, and a seat back cushion. The aisle side of the aisle seat shall also have a retractable armrest.

b. The factors regarding ease of maintenance and interchangeability of parts are fundamental requirements. Quantity of different parts should be kept to a minimum.

c. Seat design and manufacture shall ensure snugness between seat elements, thus eliminating rattling or vibration while the train is in motion.

d. Seats shall be designed to accommodate the safety, comfort and ergonomic needs of passengers over the size range from the 5th percentile female to the 95th percentile male.

e. Seats shall be designed to provide maximum passenger comfort and safety. The seat design shall include lumbar support and maximize passenger legroom. Seat ergonomics, cushion and fabric type will provide a premium feel and look for the rider. The overall design shall fit aesthetically and blend naturally with the interior décor.

3. Structural Requirements

a. The seat shall meet all design, testing and passenger safety requirements of APTA-PR-CS-S-016-99, Rev. 2, as applicable, except as where noted otherwise within this specification.

b. The seat assembly, pedestal and mounting system shall meet the attachment strength requirements of APTA-PR-CS-S-016-99, Rev. 2, as well as the requirements of 49 CFR Part 238.233(a).

c. Health and Safety Requirements

d. The seats shall not have sharp or protruding parts or edges or any other potentially harmful elements that may cause passenger injury.

e. Combustible components of the seat shall be tested in accordance with 49 CFR 238.103 and Appendix B to 49 CFR Part 238.

f. The seat frame and all attached parts shall be designed and manufactured to eliminate locations where food particles, trash and debris may collect. The design shall facilitate easy cleaning.

g. The upper surfaces on the rear of the seat back or headrest (facing a passenger seated behind the seat unit) shall be individually padded with appropriate-density foam to minimize secondary impact velocity (SIV) injuries, in accordance with applicable APTA standards and FRA regulations.

4. Mounting and Installation

a. The seats are mounted in the rail cars using an adjustable floor and wall track, with a pedestal and wall bracket providing the required properties of durability and stability to the entire seat unit. The pedestal and wall bracket must be removable from the main seat frame.

b. The pedestal shall be as narrow as structurally feasible. The maximum allowable pedestal width is 2.25 in. (57 mm). The lower half of the pedestal shall have an integrated stainless steel surface to prevent cleaning equipment from chipping paint or powder coating off of the pedestal. The stainless steel surface shall have a #4 brushed finish in the horizontal direction. The side of the pedestal facing the wall shall have an access panel that is removable to access the mounting hardware. Clearance between the underside of the pedestal cross member or seat frame and the floor shall be not less than 5 inches (127 mm) at any point between the pedestal and wall.

c. The wall bracket must be removable from the main seat frame. The same wall bracket shall be used for all seats, regardless of the direction facing or width of seat.

d. Mounting slots shall be included on the underside of the seat frame allowing for lateral adjustability.

e. The seat shall be designed to be mounted in a fixed position and shall not include provision for rotating the seat to face the opposite direction. The seat frame shall be designed so that the same seat may be used on either side of the car, or face either direction, without requiring modification to the seat or seat frame. The seat assembly may use non-symmetrical fiberglass or plastic shrouds for appearance and access for maintenance and cleaning provided that these

shrouds are easily removable and installable so that a seat may be deployed in a different location in the car with minimal effort. Seats facing opposite directions on the same side of the car shall be able to use the same pedestal. When installed in a rail car, no part of the seat assembly shall make contact with the interior wall of the car except the wall-mount bracket.

5. Cushions

a. The seat back and bottom cushions must be easily removable from the seat frame without tools. The seat covers shall also be removable from the cushions without tools to allow for easy removal and replacement using a positive mechanical securement design. All seat parts, including seat cushions, shall be able to withstand deceleration forces in compliance with 49 CFR Part 238.233(a) without coming loose from the seat frame, regardless of direction of travel.

b. The cushions should be contoured to provide optimal occupant retention and comfort, incorporating ergonomic design as specified in APTA-PR-CS-S-016-99, Rev. 2.

c. The seat back and bottom cushions shall be symmetrical and completely interchangeable between left and right on all double seat units. Seat backs may incorporate an integrated headrest, or use a separate headrest that is mounted to the top of the seat back. If a separate headrest is used, the headrest shall be removable from the seat back without having to remove the seat back from the seat frame.

d. The seat foam shall be fully encapsulated with a fire barrier material, which shall be sewn with 100% Kevlar 69 lb. thread and should be firmly joined to the cushion foam. An approved fore barrier fabric is 6.4 oz. yd. min. quilted Nomex®/Kevlar® FRQh fabric with Nomex®scrim, DuPont, Merge #17253, Style #4311 or equal. Alternative fire barrier materials will be considered. All fire barrier materials used shall pass the following tests and those required by Chapter 18:

Test Identification	**Test Description**	**Test Pass/Fail Criteria**
ASTM D3884 (CS-10 wheel, 1000 gm wt.)	Abrasion Resistance	≥ 150 cycles @ 50% wear through
ASTM D2261	Tear Resistance	≥ 15 lbs (in both the warp and fill directions)
FTMS 191A Method 5122	Burst/Puncture Resistance	≥ 200 lbs

e. Durability of the seat cushions shall be demonstrated as specified in APTA-PR-CS-S-016-99, Rev. 2.

6. Armrests

a. The aisle side of each aisle seat shall have an armrest. The armrest shall be capable of being stowed in the vertical position. On design, care will be taken to not encroach on the minimum aisle width of the vehicle. The armrest shall be designed, and the materials chosen such that it minimizes the possibility of snagging on passenger clothes.

b. The armrests shall be durable and comfortable to the passenger. The armrests shall meet the strength requirements of APTA-PR-CS-S-016-99, Rev 2, Section 5.1.4.

c. Armrests shall be securely mounted to the seat frame, and shall be removable without requiring the disassembly of the seat in order to replace a damaged armrest.

d. The armrest structure shall be designed such that it ensures passenger comfort and is durable. All of the armrests shall have an easily replaceable armrest cover of a material and color that matches aesthetically with the seat and is approved by the Engineer. The design of the armrest shall be such that the padding and cover cannot twist relative to the armrest structure.

7. Paint and Coverings

a. Color shall be submitted to the Engineer for approval. Metallic parts that are not exposed shall have a corrosion-resistant protective coating. [CDRL 09-011]

b. Components that are made of polyester or other resin-like material should be dyed or painted to match the color of the seat frame.

c. Plastics

d. The seat structure may incorporate thermoplastic shrouding for aesthetics. Durability of all plastic components must be demonstrated to the Engineer. The shrouding shall be supported by the frame in critical areas. The shrouding should be easy to remove and install. All plastic components shall incorporate metal sleeves in fastener holes to prevent damage from fasteners.

e. All plastic parts must be tested for, and be compliant with, all applicable flammability, smoke density and toxic gas emissions standards as specified in 49 CFR Part 238.103.

8. Misc. Seat Features

a. Cup holders shall also be included. Design of the cup holder shall allow for easy cleaning and removal.

b. The top of the headrest for aisle seats shall have a means for holding seat checks. The holder will be positioned such that it will not interfere with a seated passenger and is easily visible to conductors.

c. Handholds shall be provided on the seats so as to provide a stable location for passengers walking or standing in the aisle to support themselves. If handholds are made of metal, they will be austenitic stainless steel, be of diameter 1.25 in. to 1.5 in. (32 mm to 38 mm). Handholds shall have a knuckle clearance of at least 2 in (51 mm). The design of the handhold will complement and fit with the overall interior design.

B. Seat tracks

1. Revenue seats shall be mounted in seat tracks on the floor and wall of all car types. Seat tracks will be designed to support either a two-by-two or two-by-three seating arrangement. Seat tracks shall be installed per PRIIA Drawing 305-809. Between seats, the wall and floor seat tracks shall be covered with a trim suitable for the application and as flush to the floor or wall panel as practical. Alternative floor and wall seat track installation locations shall be allowed as approved by the Engineer.

2. Seats shall be mounted to the seat tracks in accordance with the strength and crashworthiness requirements of 49 CFR Part 238.233(a) and APTA-PR-CS-S-016-99 Rev. 2. See testing requirements in Chapter 19.

C. Workstation tables

1. The Contractor will propose several different layouts that vary the amount and style of workstation tables. A minimum of 4 and a maximum of 6 workstation tables will be included in both trailer and

cab cars. One workstation table per car shall be adjacent to the wheelchair parking location to allow for access by the wheelchair passenger. [CDRL 09-012]

2. For facing seat pairs, a fixed workstation table shall be provided. The table shall be constructed using current technology that is intended to reduce injury potential through the use of energy-absorbing crushable elements within the table top or in the attachments to the car body. A review of this technology shall be part of the design review process for the tables. The top shall have dimensions that allow easy access to the seats from the aisle. The table top shall have a Corian, or approved equivalent, top surface and edges that are smooth and free of sharp edges and burrs. The top shall have a raised perimeter to retain spilled liquids.

3. The table shall meet all requirements and be tested in accordance with APTA-PR-CS-S-018-13, latest revision.

4. Workstation tables shall be attached to the carbody via the wall seat track and to the floor seat track on the aisle end, in accordance with the seat track dimensions shown on PRIIA Drawing 305-809. The table top of each workstation table shall measure 28 in. deep by 44 in. wide (711 mm deep by 1,118 mm wide). The table leg shall be round, with a minimum 2.5 in. (63.5 mm) diameter. Locations of mounting holes and tolerances shall be consistent so any leg can be used with any table with no modifications required; likewise, for the mounting to the floor seat track.

5. Where possible, workstation tables shall align with emergency windows.

9.07 Signage and Labels

A. The Contractor will equip each car with adequate signage to provide passengers and crew information about the amenities and safety-related features of the cars. The signage to be provided shall include, but is not limited to, the following:

1. Location of safety equipment

2. Hazards such as high voltage or heat sources

3. Operation of emergency exit pathway equipment

4. Operation of on-board equipment such as doors and door latches/locks

5. Amenities

6. Toilet room amenities

7. Seat numbers

8. Capacities for storage locations such as luggage racks and overhead luggage bins

9. Service-related signs for maintenance and inspection

10. Exterior signage for service points

11. Bicycle storage

12. ADA required signage

B. The interior and exterior signage shall conform to PRIIA Specification 305-909, National On-Board Signage Manual. The artwork, material, location and specifications for each sign shall be submitted to the Engineer for approval at the design review. [CDRL 09-013]

C. Whenever possible, existing Amtrak signs shall be used. Where new sign designs are required the Contractor shall develop artwork per PRIIA Specification 305-909 approval by the Engineer. The Contractor will provide a signage application drawing for Engineer approval identifying all signs and labels used on each car type, including text, as well as the mounting location. [CDRL 09-014]

D. LLEPM shall be installed in accordance with APTA-PR-PS-S-004-99 Rev. 2. The LLEPM system shall be passive and shall not utilize electric components. The LLEPM system shall be charged and maintain charge under all lighting conditions except Emergency. See Chapter 11.

9.08 Doors and Latches

A. All interior doors shall be built of robust materials to withstand repeated use without deforming or losing adjustment. Doors shall have continuous hinges and shall open outward into the interior of the car unless specified otherwise. Access panel doors shall have a stainless steel piano hinge and shall not open upward. Doors shall close securely without requiring the use of a key, and shall remain closed without rattling or becoming loose during operation. Cab compartment and utility locker doors shall have a grille located in the lower half of the door panel for air circulation. See Chapter 8.

B. Doors that shall use a standard coach key to open:

1. Electrical locker

2. Cab compartment

3. Utility locker

4. Crew locker

C. Doors that shall use a pencil lock shall also have a recessed pull handle to open. These doors are (unless specified otherwise):

1. Access panels

2. Storage cabinets

3. Emergency equipment locker

D. Electrical locker and utility locker doors shall have a release lever on the inside of the latch. Cab compartment doors are described in further detail in Chapter 16.

9.09 Noise and Vibration

9.09.01 Interior Noise Levels (Passenger Areas)

With any single vehicle moving at any speed up to 125 mph (201 km/hr) on tangent, at-grade, ballast-and-tie track with clean, smooth rail, with all auxiliaries operating simultaneously at normal conditions and with the vehicle operating in any specified mode of acceleration, deceleration, or coasting, the noise level in the car's interior (without passenger load) shall not exceed 70 Decibels (Acoustic) (dBA) in seating areas, 75 dBA in vestibules (referred to 0.0002 microbar) at any point not less than one foot (305 mm) from the ceiling, floor, end walls, or side walls. Compliance with this requirement shall be

demonstrated using a Type 2 sound level meter as defined by ANSI Standard S1.4: *American National Standard Specification for Sound Level Meters, using the slow meter scale*.

9.09.02 Vibration

A. All vehicle equipment shall be designed to operate without damage or degradation of performance when subjected to vibration and shocks encountered during normal service.

B. All newly designed equipment and auxiliaries mounted anywhere on the car, car body, or trucks shall not cause vertical or horizontal vibrations anywhere on the car floor, walls, ceiling panels, and seat frames in excess of 0.1 in. (2.5 mm) peak-to-peak amplitude, in excess of 0.01 acceleration due to gravity (g) peak acceleration for the frequency range from 5 Hertz (Hz) to 14 Hz, and in excess of 0.045 in./sec (1.140 mm/sec) peak vibration velocity for the frequency range above 14 Hz.

C. Carbody-mounted components shall be designed to withstand vibrations of not less than 0.2 g at frequencies up to 100 Hz and shock loads consistent with CFR Tier 1 Requirements in effect at NTP. Shock and vibration tests shall be conducted in accordance with IEC 61373 (2010) – Railway Application, Rolling Stock Equipment, Shock and Vibration Tests.

9.10 Mockup Requirements

A. Full-scale mockups of select portions of the interior shall be constructed by the Contractor as part of the design review process. The areas to be mocked up shall include, but are not limited to, the following:

1. Accessible toilet room, including wheelchair circulation in the adjacent vestibule;

2. Cross-section of the seating area, including side walls and windows, heater grilles and diffusers, overhead luggage racks, facing seat pairs and workstation table, and convenience outlets.;

3. Bike rack; and

4. Portions of the cab car, per Chapters 14 and 16, respectively.

5. Complete vestibule and side door area.

B. Details regarding the requirements for the construction and review of the mockups can be found in Chapter 3.

9.11 Contract Deliverable Requirements List

CDRL #	Title	Car Type
09-001	Conceptual Floor Plan	All
09-002	Windscreen, Stanchion, and Handrail Design	All
09-003	Crew Storage Lockers	All
09-004	Toilet Room Door Lock	All
09-005	Countertop Surface Rendering and Sample	All
09-006	Air Freshener System	All
09-007	Toilet Room Indicator Lights Proposal	All
09-008	Interior Décor Storyboard Palettes for Major Elements	All
09-009	3-D CAD Models of the Car Interiors	All
09-010	Seating Configurations Proposal	All
09-011	Seat Color	All
09-012	Workstation Tables Layout	All
09-013	Interior and Exterior Signage Details	All
09-014	Signage Application Drawing	All

* End of Chapter 9*

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Technical Specification

CTDOT Single-Level Passenger Rail Cars

Chapter 10

HVAC System

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10.00 HVAC System

10.01 Overview

A. Each vehicle shall be equipped with two identical roof-mounted units to provide heating, ventilation and air conditioning (HVAC) to the car. The HVAC units shall be removable and self-contained and shall utilize scroll compressors using non-ozone depleting refrigerant for cooling. A non-chemical refrigerant system may be proposed for consideration by the Engineer.

B. Temperature control shall be provided by a microprocessor based integrated HVAC control system that monitors outside, inside and supply duct temperatures and adjusts the system's cooling and heating functions to maintain a comfortable inside temperature and humidity level throughout the range of environmental and climatic conditions identified in PRIIA Specification 305-912. Supply air will be maintained above return air temperatures at all times in heating modes, never dropping below 72°F (22.2°C).

C. The intake vent shall be arranged to prevent a build-up of snow from blocking the fresh air flow. It shall also be arranged to prevent ingress of locomotive exhaust fumes. This may include fresh air intakes ducted down the end sheets. Demonstration ensuring compliance with this requirement shall be provided.

D. The air conditioning and basic ventilation for each car shall be provided by two identical interchangeable, unitized, roof-mounted air conditioning systems. Each system shall provide air conditioning to the entire car in case of failure of the other system.

E. The return air intake shall be in the passenger compartment nearest the vestibules at each end of the coach.

F. The vehicle shall have a main air distribution duct in the ceiling of the car, which shall supply the main ceiling air diffusers. Ducting shall be sized to keep velocities at or below 1200 Feet Per Minute (FPM) (2039 m^3/hr).

G. Heating shall be provided by forced air overhead heat in the HVAC units and by natural convection floor heaters along the base of the side walls in the vehicle interiors.

H. Freeze protection shall be provided at the side door thresholds/door pockets and all fresh water system components that may be exposed to freezing conditions.

I. Emergency exhaust shall be provided in the event of a failure of the HEP. Emergency airflow shall be no less than 50% of the normal supply air flow per coach. Emergency exhaust air shall be available for no less than 90 minutes. Exhaust fans shall be controlled by trainlined as well local controls.

J. A detailed functional description shall be submitted for Engineer review. The description shall include electrical concept schematics, all inputs and outputs to/from the microprocessor, general arrangement drawings, exhaust fan arrangement concept, refrigeration schematic and a list of equipment, including manufacturer names and model numbers. Major components shall require Engineer approval. [CDRL 10-001]

10.02 General Requirements

A. The HVAC system shall provide a comfortable temperature-controlled environment of the interior areas of all vehicles as follows:

1. The vehicles shall be designed to operate in all environmental and climatic conditions identified in PRIIA Specification 305-912.

2. The vehicle's interior temperature, including the Engineer's cab, shall be maintained to the specified value (68°F - 76°F) (20°C – 24°C) under all specified conditions.
3. Passenger load shall be assumed to be AW3 for cooling load calculations.
4. Heat and cooling requirements shall include the opening of both sets of side doors on alternating sides of the vehicle every 10 minutes and held open for 2 minutes with the vestibule doors also held open, to simulate passenger loading and unloading in all outside ambient temperatures identified in PRIIA Specification 305-912.
5. Ambient conditions as specified and heat losses due to train motion shall be included in HVAC system performance evaluation. [CDRL 10-002]
6. Air losses due to door and carbody leakage shall be included in the HVAC system performance evaluation.
7. A minimum of 200 Cubic Feet per Minute (CFM) of air exhaust shall be provided in the toilet room.
8. Conditioned air shall be provided in the electric locker such that locker temperatures conform to the interior temperature requirements of section 10.04.1.

B. A service proven microprocessor-based HVAC controller shall be provided. The system shall be designed to maintain the specified interior passenger area temperature and humidity and to also assure adequate interior ventilation. The Contractor shall prepare and submit for the Engineer's approval during design review, a detailed heating and cooling load analysis along with recommended heating, cooling and ventilation capacities. [CDRL 10-003]

C. The total heating and cooling capacity shall be calculated by the Contractor by performing a cooling and heating load analysis (which will include the expected margin in these calculations relative to the performance of the actual system) and shall be approved by the Engineer. The HVAC unit manufacturer shall conduct qualification testing to verify heating and cooling capacity per ASHRAE Standard 37-2009. All unit qualification testing in accordance with ASHRAE GPC-23 shall also be required. Test procedures shall be submitted for review and comment by the Engineer. The car level HVAC system demonstration of passenger comfort performance compliance (climate room test) is further discussed in Chapter 19.

D. The HVAC system shall be powered from the 480VAC, 3-phase, 60 Hz supply. The temperature controls shall operate from the 120VAC, 1-phase, 60 Hz supply, and the freeze protection circuits shall operate from the 120VAC, 3-phase, 60 Hz supply. The HVAC system shall be designed to perform at the nominal voltages and operate within the voltage and frequency tolerance ranges specified in PRIIA Specification 305-912. Alternative arrangements may be proposed for consideration by the Engineer.

E. All motors, unit covers and the unit itself shall be fitted with braided ground straps in accordance with Chapter 19 and IEEE Standard 16, latest revision.

F. To minimize the effects of motor inrush currents on the head end power system, the controls shall incorporate a method to provide staggered starting of all HVAC compressors throughout the train-set. The startup timing shall be set to stagger the startup of the A/F-end unit before the B-end unit of each car. All evaporator fans shall stagger start immediately when power is temporarily lost and at start-up. The Contractor shall propose an arrangement for consideration by the Engineer.

G. Freeze protection shall be provided and turned on when the ambient outside temperatures drop below 40°F (4°C) and shall shut off when the outside temperatures rise to 50°F (10°C).

H. The HVAC system shall be controlled by a microprocessor temperature control using fresh, return and supply air temperature sensors to properly regulate heating and cooling in response to temperature changes inside and outside the vehicle. Temperature sensors shall be located to

accurately reflect temperature changes without being unduly influenced by external heat sources, solar radiation or mixing of air streams.

I. HVAC system circuit breakers and temperature control adjustment devices shall be located in the electrical locker. Circuit breakers, controls and relays shall be inaccessible to the passengers.

J. The temperature control device in the electric locker shall allow adjustment of the setpoint ±5°F (3.1°C), in increments of 1°F (.6°C). Permanent setpoint changes may be done using a PTE. No software version changes will be required to permanently change the setpoint.

K. The HVAC unit shall be a fully hermetically sealed system, without threaded components, or other non-welded fittings, except for two service ports (for high and low pressure) equipped with high quality industrial Schrader valves.

L. The performance of the entire assembled HVAC system as installed in a completed vehicle shall be verified at the Climate Room Test specified in Chapter 19.

10.03 Design Parameters

A. The following parameters are to be assumed in the design of the cooling system:

Ambient Temperature	110°F Dry Bulb/76°F Wet Bulb (43°C Dry Bulb/24°C Wet Bulb), with 120°F (48°C) air entering the condenser
Solar Load	Equivalent to 40° North Latitude, maximum solar heat rate, in accordance with ASHRAE calculation methods
Passenger Heat Load	440 BTU/hr (464 kJ/hr) person at a heat ratio of 0.60
Number of Passengers	AW3
Carbody Heat Transmission	In accordance with the Contractor's carbody insulation design to meet the requirements of this Specification but not greater than 800 Btu/hr/°F (422 W/K) for stainless steel.
Minimum Fresh Air	15 cfm (0.42 m^3/min)/seated passenger, 9 cfm (0.25 m^3/min)/seated passenger permitted at outside temperatures above 100°F (38°C).
Other Heat Loads	Normal vehicle lighting, electrical equipment and appliance loads

B. The following parameters are to be assumed in design of the heating system:

Ambient Temperature	-30°F Dry Bulb (-34°C Dry Bulb)
Carbody Heat Transmission	In accordance with the Contractor's car body insulation design to meet the requirements of this Specification, and not greater than 800 Btu/h-°F (422 W/K) for stainless steel.
Minimum Fresh Air	15 cfm (0.42 m^3/min)/seated passenger, 9 cfm (0.25 m^3/min)/seated passenger permitted at outside temperatures below 20°F (-7°C).
Solar Load	None
Passenger Load	None
Other Heat Loads	"Quiet car" lighting only (see Chapter 11)

10.04 Comfort Requirements

10.04.01 Interior

A. The following temperatures shall be maintained within the vehicle, including toilet rooms and cab, when the associated ambient temperatures are present:

Outside Ambient	Interior Vehicle Temperature
Below -30°F (-34°C)	As system will provide
-30°F (-34°C) to +60°F (16°C)	68°F (20°C) ± 2°F (±1°C) [±4°F (±2°C) for toilet room]
60°F (16°C) to 110°F (43°C)	72°F (22°C) ± 2°F (±1°C) [±4°F (±2°C) for toilet room]
Above 110°F (43°C)	As system will provide.
Layover Cool Mode	85°F (29°C) [±4°F (±2°C) for toilet room]
Layover Heat Mode	50°F (10°C) [±4°F (±2°C) for toilet room]

B. During all modes of air conditioning, the interior relative humidity shall not exceed 60%.

C. Except within the area of the side doors and vestibules, the HVAC system shall maintain a temperature variation, of the following:

1. Vertical variation: On any vertical line, 4 in. (102 mm) above floor to 43 in. (1,092 mm) above floor, not closer than 12 in. (9,305 mm) from walls, and not closer than 20 in. (508 mm) from doors: 5°F (-3.1°C) maximum difference between end points of the vertical line.
2. Horizontal variation: On horizontal planes measured 4 in. (102 mm), 43 in. (1,092 mm) and 67 in. from floor, not closer than 12 in. (9,305 mm) from walls and not closer than 20 in. (508 mm) from doors: The temperature at any point within each plane should not exceed ± 3°F (±2°C) from the average temperature in that plane.
3. The average vehicle temperature shall recover within 2°F (±1°C) of the required interior vehicle temperature within three minutes maximum following a two-minute door opening on one side of the vehicle. It shall be demonstrated that this requirement can be met during two hours of continuous door cycling of two minutes open and 10 minutes closed at the design conditions in both heating and cooling modes.

10.04.02 Noise

A. The overall HVAC system shall be designed to minimize noise in the passenger and crew areas of the vehicle. The noise level from the HVAC system shall not exceed the values in the following table. Particular care shall be required at the return air grilles, and cab supply vents.

B. With the vehicle stationary and the HVAC unit in its noisiest cooling mode:

Interior noise level: Coach seating areas, cab, and toilet rooms	As specified in Chapter 9.
Exterior noise level	75 Decibels (Acoustic) (dBA) max (15 ft [4,572 mm] from centerline of vehicle)

10.05 Air Conditioning

A. The vehicles shall be cooled using electromechanical equipment that has been proven in rail service. Two self-contained, hermetically sealed, roof-mounted HVAC units shall be provided on each vehicle. The HVAC units shall be identical. The same unit shall be used on all vehicle types. The units shall be designed for refrigerant conforming to 40 CFR Part 82. All components within the unit, such as seals, shall be compatible with the refrigerant and its associated lubricants.

B. The roof mounted units shall be supplied with a stainless-steel frame and a stainless steel or aluminum housing (with dissimilar metal protection) and shall be mounted in water-tight recesses on the main carbody structural roof. There shall be removable or hinged hatches over each section of the unit that shall be of the same general appearance, color and contour as the main structural roof. There shall be no handles, flanges or other drag or noise inducing features on the hatch covers which project above the basic contour of the unit. The roof mounted units shall be designed such that all basic troubleshooting and running maintenance can be performed from inside the car through the return air grille in the vestibule, without removing the equipment from the vehicle and without interference from other systems.

C. The height of the unit shall not violate the clearance outlined defined in this specification under any static or dynamic conditions. Protrusion of the unit above the roof line, if required, shall be shown in renderings for the Engineer's review. In no case shall the top of the HVAC unit extend greater than 14′ 8″ (4.47 m) above TOR.

D. Each HVAC unit shall supply conditioned air to the entire vehicle. The main air ducts shall incorporate diagonal splitters so that all portions of the passenger areas receive conditioned air from both HVAC units. The control cab in the cab car shall also have its own local thermostat.

E. The air conditioning system shall be designed and adequately sized to maintain interior vehicle temperature as specified at the normal ambient conditions. For ambient temperatures at or above 110°F Dry Bulb (43°C Dry Bulb)/76°F Wet Bulb (24°C Wet Bulb), with air entering the condenser above 120°F (49°C), the air conditioning system shall be capable of maintaining cooling at a reduced capacity, but in no case shall the average interior temperature be less than 25°F (13.9°C)below the outside temperature. Application and integration of the system is to be in accordance with the recommendation of the air conditioning manufacturer who shall also specify air flow requirements.

F. Each HVAC unit shall be totally self-contained, easily removable, and shall consist of a compressor/condenser section and an evaporator section with electric heating units. Tapered guide pins or suitable method shall be provided to guide the unit into its position on the roof. Lifting eyes, or equivalent, shall be provided for removal and replacement of the unit. A lifting fixture and 4 storage/maintenance racks shall be supplied with the vehicles. [CDRL 10-004] The installation and removal process, including removing and installing all mounting hardware, and electrical connections, shall be demonstrated for Engineer approval at the design review.

G. A condensate drain pan shall be provided beneath the evaporator coil, headers, thermal expansion valves and coil U bends to collect moisture from the evaporator components subject to sweating. The condensate drain pan shall be made of stainless steel, with stainless steel or copper alloy fittings and shall discharge into the roof top drain pan. The HVAC unit shall be mounted above roof top drip pans that shall be sealed against moisture entering the carbody. The roof top drain pans shall catch the evaporator condensate as well as any water entering the compressor/condenser section. The collected moisture shall be directed to the roadbed through the vehicle sidewall, without leaking into the vehicle structure and shall not be discharged on undercar structure, wheels, brakes or electrical equipment. The exits of the drain pan lines to the undercar shall be arranged in an approved manner that shall be readily accessible for maintenance and shall be protected against clogging and rodent entry. Drain pans shall be designed to prevent water spillage as a result of any environmental conditions and any combination of carbody roll, gradient, acceleration or deceleration.

H. The refrigeration system shall include, at a minimum, the following components and features, or alternate design as approved by the Engineer:

1. Two scroll compressors per unit shall be provided, each feeding an independent refrigerant circuit. Compressors shall alternate starts to equally distribute use and wear. Compressor starts shall be kept to a minimum, so alternating shall not occur when a single compressor is required.
2. Compressors shall be manufactured by Emerson, or alternate manufacturer approved by the Engineer.
3. Refrigerant compressor shutdown control shall be by means of a pump down cycle.
4. Bump starting of the refrigerant compressors. Alternative arrangements for liquid refrigerant management, such as crankcase heaters, may be proposed for consideration by the Engineer.
5. A refrigerant control box, containing; pressure switches, service switches, etc. Access to the box shall be from the return air opening. Components shall be arranged for easy inspection and maintenance. Design shall be reviewed with the Engineer for approval. [CDRL 10-005]
6. Direct drive condenser fan equipped with stainless steel shafts and sealed for life bearings.
7. Condenser coil assemblies with 0.008 in. (0.21 mm) thick copper or coated aluminum fins on 0.38 in. (9.65 mm) diameter copper tubing at a spacing of 8 fins/in. (3 fins/cm). Condensers shall utilize an Engineer approved epoxy coating.
8. One charging and one evacuation port equipped with high quality Schrader valves and sealing metal caps.
9. A filter drier.
10. Discharge line check valves.
11. Sight glass/moisture indicators.
12. Direct drive supply air blower and motor assemblies.
13. Liquid line solenoid valves (2 per unit).
14. Thermal expansion valves (2 per unit).
15. Evaporator coil assemblies with two interlaced circuits for partial and full cooling. The assembly shall have 0.008 in. (0.21 mm) thick copper or coated aluminum fins on 0.38 in. (9.65 mm) diameter copper tubing at a spacing of 10 fins/in. (4 fins/cm).
16. High and low pressure switches.

I. For cab compartment air conditioning, refer to Chapter 16.

10.06 Heating

A. The cars shall be electrically heated using forced air overhead heaters in the roof-mounted HVAC unit and by convection heaters at the sidewalls. The convection heating system shall compensate for carbody losses. The overhead heat shall compensate for fresh air heating loads.

B. Overhead heater fans shall be stainless steel finned tubular or open coil. If an open coil heater is provided, a safety switch shall remove power to the heaters when a hinged access panel is opened in the heater area.

C. The heating system shall be designed, controlled and be adequately sized to maintain interior temperatures as specified, throughout the vehicle at normal outside ambient conditions. Overhead and floor heat shall be controlled by a Pulse Width Modulation (PWM) switching device.

D. The overhead heaters shall be protected against over temperature. Three protection devices shall be installed, an air flow sensing device and two self-resetting thermoswitches. The air flow sensing device shall be interlocked with the overhead heat switching device and the refrigerant compressor switching device and disable the respective control circuits when there is insufficient or no air flow. The first thermoswitch shall disable the overhead heat switching device whenever temperatures in the heater section reach dangerous levels. It shall reset automatically. The second thermoswitch shall have a slightly higher temperature setting than the first thermoswitch, disable the overhead heater switching device, energize the shunt trip coil of the overhead heat circuit breaker and require a manual resetting of the overhead heat circuit breaker. The first thermoswitch setting shall be selected to allow indefinite cycling without tripping the second stage device. The total over temperature protection method shall be reviewed by the Engineer at the design review. [CDRL 10-006]

E. Electric baseboard floor heaters, mounted behind stainless steel guards, shall be provided along both sidewalls. Baseboard heaters shall also be provided in the Engineer's cab in addition to the forced air heater described in Chapter 16. Baseboard heaters shall be ground fault protected.

F. Antifreeze protection, activated at an outside temperature of 40°F (4°C), shall be provided for the side door thresholds, side door pockets, water tank and water drain valves. The protective heater circuits shall be protected by an independent circuit breaker. Refer to Chapter 15 for additional Water and Waste System details.

G. Layover heat shall be provided by the sidewall floor heat and shall maintain an interior temperature of 50°F (10°C) ± 5°F (±3°C), including the cab. During layover heating, the evaporator fans shall not operate and the fresh air damper shall be closed.

H. The heating system shall include, at a minimum, the following components and features:

1. Modulated forced air electrical overhead heat.
2. Heat for temperature protective device.
3. Modulated electrical convection sidewall heaters.

For additional cab compartment heating requirements, refer to Chapter 16.

10.07 Ventilation

A. The ventilation system shall include, at a minimum, the following components and features:

1. Exterior fresh air intakes with water eliminators and frame type disposable air filters
2. Electrically motorized automatic fresh air dampers
3. Frame type disposable return air filters Air distribution ducts
4. Air diffusers and grilles
5. Exhaust ducts
6. Exhaust fans
7. Emergency fan shutoff switches

B. Ventilation of the vehicle shall be provided by blower fans supplied as part of the HVAC units. Fresh air shall enter the vehicle through stainless steel fresh air intakes and air filters and shall pass-through stainless-steel ducts which include drains for condensation and water to be diverted to the outside of the vehicle. The fresh air intake shall include water eliminators that prevent water or light snow from entering the unit. The fresh air filters shall remain dry under all environmental conditions.

C. Re-circulated air shall pass-through stainless-steel grilles into a plenum chamber where it shall mix with the fresh air and pass to the HVAC unit blower. The blower fans shall move the mixed air through the cooling and heating coils and force the conditioned air into the supply air ducts.

D. Conditioned air shall be delivered to the vehicle interior through longitudinal, diagonally split supply air ducts into longitudinal diffusers which are located along the ceiling of vehicle or alternate solution considered and approved by the Engineer. Local diffusers shall also be provided for the Engineer cab.

E. The diffusers shall be designed to deliver equalized airflow throughout the car and meet the temperature variation requirements specified. The maximum air velocity between floor level and 43 in. (1092 mm) above floor shall not exceed 50 fpm (0.25 m/s), while the maximum air velocity between 43 in. (1092 mm) and 67 in. (1072 mm) above floor shall not exceed 70 fpm (0l36 m/s). Air delivery performance shall be verified during HVAC system proof-of-design testing. Refer to Chapter 19. The diffusers shall be fixed on all vehicles, except for the vehicle designated for proof-of-design testing, where adjustable diffusers may be used. All vehicle diffusers shall be fixed in accordance with the proof-of-design vehicle.

F. The total air flow from the evaporator blower fans on both HVAC units shall be determined by the Contractor to meet the interior requirements at the specified ambient temperatures but shall not be less than 5500 cfm (156 m^3/min). The evaporator blower fans shall be sized to overcome the high external static pressure as determined by the Contractor. The blower shall be centrifugal type, directly driven from the motor shaft. The motor shall be TEFC, class H insulation, resiliently mounted, and equipped with permanently lubricated sealed bearings.

G. Intake of filtered fresh air shall be provided for each end of the vehicle at one-half of the total required fresh air volume as specified in Chapter 10, regardless of car position in a train or the vehicle speed and shall be adequate to maintain the positive pressurization requirements of this Specification.

H. Baffle plates shall be used to set the volumes of fresh and re-circulated air. The baffle plates shall be fixed on all vehicles, except for the vehicle designated for vehicle level testing, where adjustable baffle plates may be used.

I. An exhaust fan vented to the exterior of the vehicle shell shall be provided in each toilet room. Toilet room exhaust shall, at all operating speeds, maintain a negative pressure in the toilet room at all times as compared to the rest of the car interior. An exhaust fan shall be provided in the electric locker to assist in cooling the electrical equipment in the electrical locker. The electric locker fans shall draw air from the vehicle interior and exhaust it to the vehicle exterior.

J. The temperature controls shall provide for ventilation with no heating or cooling when temperature conditions fall in the ventilation range shown in the comfort requirements table above.

K. Ventilation detection and interlocking devices shall be provided and installed such that there shall be no overhead heat and/or cooling when absence of ventilation is detected.

L. The ventilation system shall provide a minimum positive carbody pressurization of 0.1 in. (2.5 mm) water gage (with full fresh air flow) above ambient exterior pressure with all exterior doors and windows closed and the toilet room and electric locker exhaust fans running, and the vehicle operating at normal speeds.

M. Fresh and re-circulated air shall be filtered at the HVAC units by disposable pleated-type filters or disposable "synthetic bulk media" type filters. The filters shall be located for ease of replacement from inside the vehicle via the return air grille and shall meet the requirements specified in PRIIA Specification 305-907 and be commercially available.

N. In addition, the fresh air exterior intakes shall be fitted with louvers or grilles that prevent ingress of water.

10.08 Fresh Air Dampers

A. The fresh air intakes shall be equipped with electrically power operated, infinitely variable, fresh air dampers that shall at a minimum provide three positions: Fully Open, Restricting and Fully Closed. Controlled by the vehicle temperature control microprocessors, the dampers shall be used to provide full fresh air into the vehicle under normal operating conditions. With temperatures outside the normal range, the dampers shall operate variably between OPEN and CLOSED to optimize fresh air quantity for the purpose of maintaining the required interior temperature while providing the maximum possible percentage of full fresh air. During layover and warm up/cool down, the dampers shall be fully closed. Operation of the Ventilation Cut-Out Switch shall also fully close the dampers.

B. The dampers will automatically close upon detection of smoke outside of the vehicle (activation of smoke detector inside the fresh air intake). Smoke detectors shall be located in the return air plenum of each HVAC unit. No less than 4 smoke detectors shall be provided per vehicle.

C. When any smoke detector is activated (or dampers are directed to close), an audible alarm shall be annunciated in the active cab.

D. A means to easily access and test each of the smoke detectors shall be provided.

E. The fault monitoring system shall report any smoke detector activation. The information provided shall include car number, location on the car, and whether the detector is external or internal.

F. The damper frame, blades and hardware shall be constructed of corrosion resistant material so they will last the life of the vehicle with no attention other than inspection and cleaning at 8-year vehicle overhauls. The drive motor shall be robust and readily available.

G. The dampers shall incorporate a spring close feature so that they self-close upon loss of power. They shall also incorporate a position sensor to provide a feedback signal to the temperature control panel. Design of the damper unit shall keep the number of adjustments required to a minimum. Once settings are made, they shall be locked so they remain fixed for the life of the damper.

10.09 Smoke Detectors

A. Smoke detectors shall be installed in the fresh air intake and return air plenum of each unit.

B. When external smoke is detected, the smoke detector circuit shall automatically close the fresh air dampers, shut down the HVAC units, shut down blower motors, and annunciate an audible alarm in the Operator's cab. If smoke is no longer detected after an Engineer-adjustable period of time, the system shall reset to its previous state.

C. Smoke detectors shall be a transit service-proven design and meet UL 217 or EN 54-7/9 requirements.

D. Smoke detectors shall be easily accessible from inside the train. Supply duct access panels with tamper proof screws shall be provided. Fresh air detectors shall be easily accessible through the return air grille. Wiring shall be through a connector on the smoke detector to allow easy removal and replacement.

10.10 Controls

Heating and cooling control shall be controlled by a microprocessor using solid state sensors for temperature data. The output of the microprocessor shall drive solid state and electromechanical relays and contactors which shall, in turn, control electrical power to the heater elements, motors and various

control devices. The changeover between heating and cooling shall be automatic and, except for the reheat stage of overhead heat (if provided), shall preclude the simultaneous operation of heating and air conditioning.

10.10.01 Sensors

At a minimum, the following temperature sensors shall be required:

A. Return air sensor at each HVAC unit return air grille.

B. Fresh air sensor at each HVAC unit fresh air inlet.

C. Duct supply air sensor in each side of the split main duct.

D. Freeze protection thermostat located in a position that accurately measures outside temperature.

E. Cab control compartment thermostat.

F. Sensors shall be transit service proven, encapsulated in stainless steel sheaths.

G. Sensor accuracy shall be ±0.1°F (.06°C).

H. Removal and replacement of the sensors shall take no longer than 10 minutes.

10.10.02 Use of Controls

A. The temperature control system shall operate automatically. When the vehicle is put into service, the mode selector switches shall be placed in the NORMAL position. The panel shall then operate without further attention until the vehicle is taken out of service.

B. The mode selector switches are crew-operated controls for the vehicle temperature control system. These switches shall determine the operating mode of each of the two HVAC systems. The mode selector shall switch from NORMAL to LAYOVER without cycling the HVAC through OFF. The mode selector switch shall be located in the electric locker.

C. Positions and functions are as follows:

Name	Function
NORMAL	Vehicle HVAC set up shall provide the normal occupied vehicle environment. All systems operate.
LAYOVER	Used for vehicle storage in winter to minimize energy consumption, yet still maintain interior temperature of 50°F (10°C). Only floor heat shall be available. Fresh air dampers will be closed in this mode. Used for vehicle storage in summer conditions. The system shall maintain the interior average temperature at 85°F (29°C). Fresh air dampers will be closed in this mode.
OFF	Used to shut off all vehicle heating and cooling when vehicle is being serviced or in storage. Does not disable the freeze protection system.

10.10.03 Status Display

A. The microprocessor controller shall be housed in a corrosion resistant, dust proof enclosure located in the electric locker. It shall include an indicator and monitor display which shall show the control logic state. Indications shall be by means of suitably labeled Light Emitting Diodes (LEDs) or by an

LCD screen, which shall display all microprocessor requests for heating or cooling from the zones controlled from that panel. Fresh air temperature, supply air temperature, return air temperature and supply duct temperature shall be displayed for each HVAC unit.

B. The controller shall include a keypad that allows the crew to raise and lower the setpoint up to ± 5.0°F (2.3°C). This temporary setpoint shall revert to the original setpoint after a period of 4 hours. The microprocessor shall permit maintenance personnel (using the PTE) to permanently modify set-points as well as various other parameters, such as timers.

C. Overload indicators and resets shall be available for use by the train crew without exposing the crew to hazardous voltages. The HVAC controller shall be capable of downloading data using a laptop computer that is loaded with the Contractor's HVAC diagnostic software. The HVAC software shall have the capability to monitor the HVAC system, test the HVAC system and override the control system. It shall log all faults and download history.

D. The control system shall include, at a minimum, the following components and features:

1. Temperature control panel
2. Temperature sensors
3. Motor starters
4. Motor protective devices
5. Heater switching devices
6. Diagnostics and test capabilities

E. The Contractor shall submit a temperature control schedule and a detailed description of operation for approval by the Engineer at the HVAC system design review.

10.10.04 Ventilation Cut-Out Switch

A. A ventilation system isolation switch shall be located at each end door passageway, and on the vestibule wall next to the electrical locker door. These switches shall turn off the HVAC system blowers on both HVAC units to prevent the circulation of smoke or fumes throughout the vehicle in the event of an emergency. The switches shall be wired in series so that any one switch shall shut the ventilation system off. These switches shall be labeled VENTILATION CUT-OUT. The switches shall be two-position with a red spring-loaded flip-up cover that must be lifted to place the switch in the CUT-OUT position. Forcing the cover into the closed position shall return the switch to the ON position. Operation of the Ventilation Cut-Out Switch shall also fully close the fresh air dampers.

B. Trainset ventilation shutdown of HVAC units and closure of the dampers shall also be provided in the cab cars.

10.10.05 Freeze Protection

The freeze protection system shall allow unrestricted vehicle operation of water, waste and door systems under all environmental and operating conditions specified in PRIIA Specification 305-912. See Chapter 15 for additional information on freeze protection.

10.11 Contract Deliverable Requirements List

CDRL #	Title	Car Type
10-001	System Functional Description	All
10-002	HVAC System Performance Evaluation	All
10-003	Heating and Cooling Load Analysis	All
10-004	HVAC Lifting Provisions	All
10-005	Refrigerant Control Box Design	All

* End of Chapter 10 *

Technical Specification

CTDOT Single-Level Passenger Rail Cars

Chapter 11

Lighting

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11.00 Lighting System

11.01 Overview

A. This chapter describes the interior and exterior lighting system that shall be provided on all car types. The lighting system as designed shall enhance the appeal of interior furnishings and create a comfortable and pleasant atmosphere while providing for maximum passenger and crewmember safety. Normal and emergency lighting shall conform to the requirements of all applicable APTA standards and FRA regulations.

B. The lighting system shall provide four modes of interior lighting: normal, quiet car, standby and emergency. Interior and exterior lighting shall be provided by Light Emitting Diodes (LEDs), with the exception of the cab car headlight which shall be incandescent.

C. LEDs are the preferred method of providing interior passenger seating area lighting. Lights in toilet rooms, stairways, vestibules, passageways, as well as indicator lights shall be LED. Ideally the normal lighting will be LED and supplied from the 74VDC system and will be available for use as the standby lighting. Incandescent lights shall not be used except as specified. Halogen lights shall not be used.

D. For lighting requirements in the cab control compartment and F-end of the cab car, see Chapter 16.

E. The Contractor shall prepare an interior and exterior lighting plan for Engineer review that describes the type of lighting to be used in all applications, including fixture type, voltage and color temperature, illumination levels at specified locations for all lighting modes, and compliance with emergency lighting and signage regulations and standards. This lighting plan shall be submitted to the Engineer during the design review. [CDRL 11-001]

11.02 General Requirements

A. Fixtures installed on the vehicle exterior, and in the interior within 2 ft (610 mm) of a doorway, shall be watertight, except for interior ceiling lights.

B. Car interior lighting shall provide adequate and convenient illumination under all ambient lighting conditions from complete darkness to bright sunlight. Lighting in all locations shall be arranged to minimize shadows, avoid glare and excessive brightness ratios. Lighting shall be appropriate for the application, easily maintainable and compliant with all regulations and standards including this specification.

C. The use of LED lighting is the preferred method for interior lighting. Halogen lamps shall not be used. Incandescent lamps shall not be used, except as headlights on cab cars.

D. Each type of lamp shall have a distinct fixture design for its specific voltage. Lamps of differing voltages shall not share the same base design and lamps shall not be interchangeable between fixtures with differing voltages.

E. Unless otherwise specified, the interior lighting shall be based on the latest guidelines of the Illuminating Engineering Society (IES) of North America, as well as the requirements of APTA-PR-E-RP-012-99, APTA-PR-PS-S-002-98 Revision 3, APTA-PR-E-S-013-99 Revision 1, and APTA-PR-PS-S-004-99 Revision 2.

F. All lighting components shall have prior experience in North American transit, commuter rail or intercity passenger rail application. The Engineer may approve other components based upon provided shock and vibration test results. The Contractor shall provide drawings of the lighting arrangement of each vehicle type, and the location and quantity of each lighting fixture, ballast, switch, control and lamp type. In any case, all lamps used in all fixtures shall be supplied by a

domestic U.S. manufacturer and available from multiple sources. All lighting lamps and fixtures shall be suitable for rough duty service found in the railroad environment throughout North America. The design and components of the lighting system shall be coordinated with and approved by the Engineer during design review. [CDRL 11-002]

G. The lighting fixture housing or socket shall not be used as a ground return for any other electrical circuits.

11.03 Lighting Plan Design Review

A. The Contractor shall submit their design plan incorporating all requirements listed for review and approval. Design drawings and calculations showing the complete lighting system including fixture design, fixture locations, lighting illumination, modes of lighting and electrical schematics shall be submitted for evaluation during design review. [CDRL 11-003]

B. The Contractor shall provide drawings of the lighting arrangement of each car type for Engineer approval during design review. The location of each lighting fixture, circuit breaker size and location, switch, control, lamp type, color, luminance value (in foot-candles) and quantity shall be clearly identified. Fixtures providing standby and emergency lighting shall be identified. Proposed charging light levels for photoluminescent emergency exit signage and Low Location Exit Pathway Markings (LLEPM) components will be identified.

C. Examples of each lighting fixture shall be provided for Engineer approval at the final design review. [CDRL 11-004]

D. Lighting fixtures shall not be a source of Electromagnetic Interference (EMI) and shall be included in the Electromagnetic Compatibility (EMC) plan required by APTA-PR-E-S-010-98. See Chapter 19.

11.04 Interior Lighting Levels

11.04.01 General

All light level measurements shall be made in accordance with the minimum standards defined by APTA-PR-E-RP-012-99.

11.04.02 Lighting Color Temperatures

A. The normal lighting color for all interior lights and lamps in the passenger rail car shall be in a range of 4,000° Kelvin (K) ± 500° Kelvin (K). LED luminaries shall have a color rendering index (CRI) of at least 80, with the same color consistency and color stability.

B. Mood lighting colors shall be proposed by the Contractor, depending on the Engineer's definition of the required mood lighting scenarios.

C. The Contractor is to provide a suggested light color plan for Engineer's review and approval during the preliminary design review. [CDRL 11-005]

11.04.03 Minimum Lighting Illumination

The minimum spatial average of illumination shall be at the points listed in Table 11-1, and shall meet the minimum value(s), measured in foot-candles, with all lights on and at the rated voltage when the equipment is new.

11.05 Interior Lighting Modes

11.05.01 Normal Lighting Mode

Normal lighting mode is that which is available when the car is operating from a 480VAC power source. All lighting fixtures and elements intended for use while the car is in revenue service shall be available during normal lighting mode. Minimum illumination levels for normal lighting mode are shown in Table 11-1.

11.05.02 Selectable Lighting Modes

A. The car shall be designed to incorporate selectable LED lighting modes. One of the lighting modes shall be for Quiet Car Mode. The Contractor shall submit to the Engineer for review and approval, various LED color temperatures for the lighting modes. [CDRL 11-006]

B. Normal lighting mode in the car shall be arranged to allow the level of lighting to be reduced for passenger comfort during early morning and late evening operation, while maintaining sufficient lighting for passenger and crew safety, and compliance with standards and regulations. This reduced light level, referred to as "Quiet Car" mode, may use any combination of lighting elements so long as minimum light levels are maintained at "Standby" illumination levels throughout the car, and all light fixtures operating during quiet car mode remain powered at all times, either through the Alternating Current (AC) system or the low-voltage power supply.

C. Car lighting during quiet car mode shall be adequate to charge the photoluminescent emergency signage and LLEPM system per the latest APTA standards, PR-E-S-013-99, PR-PS-S-002-98 and PR-PS-S-004-98.

D. Minimum illumination levels for quiet car mode are shown in Table 11-1 under the "Standby Lighting" column. The Contractor shall carefully design the lighting fixtures and their controls to permit the Quiet Car lighting mode to have a minimum of glare and annoyance to sleeping passengers.

11.05.03 Standby Lighting Mode

Standby lighting is that which is available when the car has lost Head End Power (HEP) but the battery has not yet discharged to load shed. This lighting mode is intended to keep sufficient lighting operational for a period of at least two hours so that short term loss of 480VAC power will not affect the passengers' ability to safely move throughout the train. Car lighting during standby mode shall be adequate to maintain the light charge for the photoluminescent emergency signage and LLEPM system per the aforementioned APTA standards. Minimum illumination levels for Standby mode are shown in Table 11-1.

11.05.04 Emergency Lighting Mode

A. Emergency lighting mode is that which is available after load drop has occurred. This lighting provides passenger orientation and sufficient light levels for passengers to move about safely within the car and if necessary, to find the nearest safe exit point. It is especially important in stairways, aisles, vestibules and enclosed spaces, such as toilet rooms. Once the low voltage system reaches a pre-determined low-voltage threshold, all standby lighting is extinguished and emergency lighting shall illuminate. This lighting system may use dedicated fixtures, may provide a reduced level of illumination from the normal lighting system, or may use some but not all of the normal lighting fixtures. The emergency lighting system shall be powered by capacitors, or by batteries if capacitors cannot comply with FRA requirements for emergency lighting, and shall provide emergency lighting for a minimum of 90 minutes. Emergency lighting shall comply with APTA-PR-E-S-013-99 Revision 1.

B. Energy storage components, batteries or capacitors must have all contacts and terminals covered to prevent shorting during storage or installation and shall be easily changed out using a connector. Energy storage components shall be common between all fixtures whenever possible.

C. The Contractor shall provide for Engineer approval during design review an Emergency Lighting Plan that describes and illustrates the emergency lighting system, including location, type and design of all lighting fixtures and the level of illumination that shall be provided at all points as identified in APTA-PR-E-S-013-99 Revision 1. The Contractor shall demonstrate compliance with emergency lighting requirements and shall provide to the Engineer written certification of compliance. [CDRL 11-007]

11.06 Interior Lighting Requirements

11.06.01 Passenger Area

The following describes the individual lighting fixture applications and specifications for all areas of the car. Lights must be LED unless otherwise specified. Light fixtures in toilet room ceiling, vestibule ceiling and hallway ceiling shall be identical units if possible.

A. Main ceiling

Two longitudinal rows of lights shall provide the primary lighting for the seating area in the revenue seating areas of trailer cars and cab cars and shall be located adjacent to the center ceiling panels/air diffusers. Other arrangements can be proposed but are subject to Engineer approval.

B. These LED fixtures provide the main light source to the car and provide lighting to the aisle as well as general lighting to the seating areas. The fixtures shall be trough-construction units, mounted end-to-end. They shall be equipped with connectors, as approved by Engineer, wired in parallel fixture-to-fixture, including all bus wiring for the entire fixture string for normal, quiet car and standby modes. LED units shall create an even light output and similar appearance to fluorescent lights.

11.06.02 Vestibules and other Non-Seating Areas

A. Flush-mounted overhead light fixtures

Flush-mounted overhead light fixtures with LED light elements shall be provided in the following locations for the purposes of commonality and interchangeability:

1. Vestibule ceilings
2. Toilet room ceilings
3. Hallway ceilings

B. Diaphragm/end passageway

The end passageway light shall be a weatherproof, sealed LED unit mounted overhead to the side of the passageway on the diaphragm side of the end doors on all car types. The unit shall cast adequate light throughout the diaphragm and passageway area including handholds, door panel, walkway surface, signage and handbrake.

C. Vestibule ceiling at side doors

Flush-mounted light fixtures shall provide overhead light to the areas adjacent to the side entry doors. The lights shall provide adequate illumination to charge all required emergency signage on and around door panels and emergency door releases. The same fixture shall be used at all side entrance locations, including service vestibules in the cab cars.

D. Hallway

A flush-mounted LED fixture shall provide light in the ceiling of the hallways. These lights shall be used in the following locations, at a minimum:

1. Hallway at accessible toilet
2. Hallway adjacent to utility lockers and toilet rooms at end doors

E. Bike rack area

Recessed can-type LED fixtures shall be provided in the ceiling of the bike rack area.

11.06.03 Toilet Rooms

A. Toilet ceiling and mirror

1. Light fixtures shall be mounted on the ceiling of each toilet room to provide general lighting to the toilet room.
2. The lighting fixtures shall be wired in parallel and shall be provided as part of the toilet module.

B. Toilet room occupied/out of service sign

1. A yellow LED TOILET ROOM OCCUPIED indicator light and a red OUT OF SERVICE indicator light shall be mounted on the toilet room exterior wall, adjacent to the toilet room door for all toilet rooms. This light shall consist of a two-light LED fixture with a sign containing text and/or a pictorial symbol which provides indication as to when the toilet room door is locked (occupied) and a second light that provides indication that the toilet room is "out of service" (when the toilet system is not functioning). Lights shall be on when the toilet is occupied or out of service and shall be extinguished when the toilet is available for use.. Artwork for the labels shall be submitted to the Engineer for approval during the design review. [CDRL 11-008]
2. A yellow LED indicator shall be provided inside the toilet room, adjacent to the door, that illuminates when the door is locked (parallel with the toilet occupied indicator outside the toilet room). This indicator shall be labeled DOOR LOCKED WHEN LIGHT IS ON.
3. The LEDs used for these indicators shall be no less than 0.25 in. (6.35 mm) in diameter for clear visibility to passengers.

11.06.04 Service and Utility Rooms

A. Electrical locker

The electrical locker shall be illuminated by at least two LED overhead lights, and shall be energized by means of an automatic light switch that turns the lights on when the door is opened and off when the door is closed. The light fixtures shall be protected by a clear shatterproof glass or polycarbonate lens, or other suitable protection, and shall not be vulnerable to damage during normal maintenance activities. Electric locker lights shall be operable during all lighting modes.

B. Utility locker

At least one LED light fixture shall be installed in each interior utility locker and shall be energized by means of an automatic light switch that turns the lights on when the door is opened and off when the door is closed. If necessary to illuminate the space, multiple light fixtures shall be installed and operated by the single switch. The lights shall be so located as to provide general illumination within the locker and be readily accessible for replacement.

C. Control cab

Lighting requirements for the control cab compartment in the cab cars are described in Chapter 16.

11.07 Exterior Lighting Requirements

11.07.01 Marker Lights

A. Each car shall be equipped with two red marker lights at each end.

B. The marker lights shall be LED with integral lens heaters, and shall meet the FRA requirements in 49 CFR Part 221.

C. The marker lights will be controlled by a 3-position switch located in the electric locker for trailer cars and on the Operator's console for cab cars. The switch positions shall be labeled A-END, OFF, and B-END, (the A-END position marking will be replaced by F-END on cab cars).

D. The marker lights on the F-END of the cab cars shall illuminate when the selector switch is placed in the F-END position, except when the headlights and/or crossing lights are illuminated. Placing the headlight selector switch in any position other than OFF shall extinguish the marker lights. Returning the headlight selector switch to OFF shall re-illuminate the marker lights when the cab car marker light selector switch is in the F-END position.

11.07.02 Platform Lights

A. Each side door opening shall have an LED platform light that will illuminate the platform area adjacent to that door opening when those doors are opened. This light shall be mounted flush into the carshell or the threshold area and not protrude beyond the side of the car.

B. The light shall be aimed downward so as to not shine directly into the eyes of passengers or crew standing on the platform or in the vestibule of the car and shall be mounted in an impact-resistant and waterproof housing. The platform lights shall illuminate when any door panel in the adjacent door opening is opened, either by command from the door control system, or by use of the emergency door release. The platform light shall remain off when the door panels are closed and latched or locked with a mortise lock.

C. The platform light shall remain off when the door panels are closed. Both high level and low-level station platforms shall be illuminated to at least the requirements of 49 CFR Part 38.119 or APTA recommended practice, whichever is greater. At a minimum, the Contractor shall meet the requirements of 49 CFR Part 38.101.

D. The platform lights shall also be a part of the emergency lighting system and shall conform to APTA-PR-E-S-013-99 Revision 1.

11.07.03 Exterior Indicator Lights

A. Each car shall be equipped with exterior door open indicator lights, four per car. These indicators shall be red LEDs and shall be located on the exterior of the car adjacent to each side door opening, so that their status is visible to the Operator when viewed down the side of the train. They shall display a red indication when any door in the adjacent vestibule is open (i.e., not closed and latched, or locked with the mortise lock) and shall be dark when all doors in that vestibule area are closed and latched. A small ceiling mounted indicator light, located in the side door vestibule adjacent to each door, shall also illuminate when the adjacent door is not fully closed and latched, as an aid to the train crew. See Chapter 8.6 for additional details.

B. Each car shall be equipped with two exterior brake indicator light units, one on each side of the car, on opposite diagonal corners. Brake indicators shall be green and yellow LEDs, and shall display the following indications:

Solid Yellow	Air brakes applied (handbrake released)
Flashing Yellow	Handbrake applied (air brakes applied or released)
Solid Green	Air brakes and handbrake released

C. The brake indicator unit may be combined with the door open indicator light.

D. The three-light door/brake indicator unit shall be mounted with the indicator lights oriented top to bottom: green/yellow/red.

11.07.04 Exterior Door ADA Lights

A flashing white LED fixture shall be mounted above or adjacent to each side door opening to serve as a visual beacon to ADA passengers when the adjacent door is open. This indicator shall be viewable from all angles on the exterior of the car. The light shall flash at a rate of 1 Hz when the door is open, and 2 Hz for five seconds before the door closes.

11.07.05 Headlights and Crossing Lights

Requirements for cab car headlights and crossing lights are described in Chapter 16.

11.08 Systems Indicator Panel

A. A multi-LED systems indicator panel shall be located on the vestibule wall adjacent to the electrical locker door and shall serve to provide a visual indication of the status of designated systems. The panel shall be mounted in a location that will prevent tampering or damage from routine maintenance or cleaning and will be visible from the vestibule area. The indicators shall be as follows:

System	**Indicator**
HVAC (one indicator for each unit)	White (A/F-end and B-end)
Wheel slide control system	Green
Toilet system	Yellow
Battery charger	Red
Communication/public address system	White
Door system	Yellow

B. Specific function of the indicator lights is described in the applicable chapter for each subsystem. Indicator lights shall be flashing on and off at 1 Hz when the system has developed a fault or is not functioning properly, as defined in each chapter, and shall be on continuously when the system is functioning as intended. All LEDs shall be appropriately labeled. The systems indicator panel shall have a lamp test button to verify that the LEDs illuminate when energized.

11.09 Lighting Fixture Requirements

11.09.01 Light Emitting Diode (LED) Lighting

A. LED fixtures shall conform to the requirements of the *Energy Policy Act of 2005* or more recent requirements and shall utilize white LEDs. The color temperature throughout the car shall be 4,000°

Kelvin (K) ± 500° Kelvin (K) and approved by the Engineer. Where practical, the LED lighting should be supplied from the DC system and be available in both Normal and Standby lighting modes.

B. All fixtures shall be dust and moisture resistant and shall be arranged to facilitate replacement of the LED luminary from the passenger compartment. Luminaires shall be removable without special hardware after removing only the hinged lens.

C. An LED driver designed to ensure proper operation of the LEDs shall be mounted on the LED assembly. LED assemblies shall be connected via interlocking, self-polarizing and modular connectors accessible when the light fixture is opened.

D. Fixtures equipped with lenses shall have a one-piece polycarbonate lens, either clear or translucent white, uniform in color and smooth on the exposed side, which will provide the specified intensity of illumination on the reading plane, while diffusing the light to illuminate adjacent wall and ceiling surfaces, increasing the overall brightness level in the interior of the car. The lens shall be mounted on a hinged bezel and shall be secured with captive fasteners. Power supplies shall comply with the requirements of Chapters 13 and 18.

E. LEDs used in passenger area overhead lighting shall be mounted on replaceable boards installed in the light fixture. Boards shall be connected to the fixture by screws and shall be plug-connected electrically for easy replacement. The LEDs shall be sized and spaced so that the failure of up to three LEDs on an individual board shall not create an appearance of a dark area on the fixture. This dark area may be driven by the number of LEDs in series within the array, depending on the design.

F. LED lighting shall be sized to provide the level of lighting as outlined in Table 11-1.

G. Changeable LED luminaires are preferred, and LED lighting may be dedicated to its fixture where the design is necessary.

H. Using common LED/Driver boards is preferred whenever possible.

I. LED luminaires shall have lumen maintenance of 70 percent (L70) for 75,000 hours as measured per the Illuminating Engineering Society of North America (IESNA) standard LM-79-08, Electrical and Photometric Measurements of Solid-State Lighting Products. All minimum lighting levels per APTA shall be maintained at the end of the 75,000-hour period. The Contractor shall propose designs that include automated scenarios to address the known reduced light output of LEDs in late life.

J. As the trains may have their lights on for extended periods, simply increasing the initial light output to address end of life degradation is not acceptable. LED luminaires shall be provided with sufficient heat sinks capable of keeping LED junctions and associated electronics below 125°F, regardless of summer ambient temperature and continuous operation.

11.09.02 Capacitor-Based Lighting

The required emergency lighting that has an alternate back-up to the vehicle batteries may be supplied by capacitor-based lighting. The capacitors must be rated for a minimum of 500,000 charge cycles. Capacitor terminals shall be covered to protect shorting and shall be connected to fixtures through connectors. The capacitor-based power source for emergency lighting shall have a label located on the side of the unit exposed for service that includes the following information:

A. OEM name and manufacturer's address

B. OEM part number — revision/modification level and date

C. Date of manufacture

D. Unit serial number

E. Voltage and capacity rating

11.10 Housings, Lenses and Diffusers

A. The overhead light assembly shall be designed for lamp replacement from below. The hinged light lens shall swing down allowing easy lamp replacement.

B. No material shall suffer any loss of performance when exposed to temperatures ranging from - 30°F (-34°C) to 150°F (66°C) or exhibit degradation of properties (including color) under long-term exposure to ultraviolet light.

C. Lighting fixtures shall have hinged lenses, which will aid in light distribution, prevent glare and facilitate easy lamp replacement. The design of the fixture shall permit easy cleaning and easy lamp renewal.

D. The lenses shall project light with an even brightness without patterns and shall have a smooth surface on all sides and edges that are open to the passenger seating area to avoid injury. Tamper-proof fasteners shall retain door to the housing. A neoprene foam gasket around the lens assembly shall make the joining of door and reflector dust-resistant and rattle free.

E. The hinged lens shall be removable for replacement. The lenses shall be easily replaceable without having to disassemble the light fixture and shall be made of an approved Ultraviolet (UV)-stabilized polycarbonate and meet the Flammability, Smoke Emission and Toxicity requirements specified in Chapter 18.

F. Apparent Light versus Illumination:

1. The primary function of lighting fixtures is to provide controlled illumination for the safety, convenience and comfort of the passengers and train crew. Lighting fixtures produce illuminating and apparent light. Illuminating light projects or otherwise illuminates objects and areas. The illumination levels for those areas are defined within the specification according to the activities of those areas or other specific needs.
2. Apparent light is the illumination that the passenger or crew person sees of the fixture itself. Lighting fixtures used for normal lighting (non-emergency) in continuously occupied passenger and crew spaces shall be designed so that the apparent light is unobtrusive to passengers. This is especially critical when cars are in Quiet Car Mode.
3. Fixtures shall be lensed and baffled to prevent the apparent light from being annoying or distracting to passengers and crew. High output fixtures such as those at body end doors which must be at full intensity at all times to charge HPPL and illuminate an exit are historically prone to generate complaints from passengers, particularly at night, such as from reflected glare. All fixtures in continuously occupied passenger and crew spaces must be shown during design review to not have normal direct view of the light source (LED array) or diffusor.

11.11 Controls

A. All lighting controls shall operate on an individual car basis, under the control of the train crew. The car lighting controls shall be located in the switch locker located within the electrical locker.

B. An Engineer-approved method of easily providing various levels of interior car illumination by the train crew shall be provided. This shall include at a minimum, selections for full lighting intensity (Normal), low level lighting intensity suitable for early morning or evening hours to allow passengers to doze (Quiet Car), or completely off. [CDRL 11-009]

C. The switch locker shall also contain a master control for the vestibule/restroom lights.

D. All lighting shall be circuit breaker protected. Lights identified for ON/OFF control shall have an ON/OFF switch in addition to the circuit breaker. Controls shall be labeled AC LIGHTS and DC LIGHTS and also NORMAL and QUIET CAR and housed in the electric locker, except as listed below, where local controls shall be provided:

1. Electrical lockers shall have automatic light switches located inside the equipment room adjacent to the entry door.
2. Utility lockers shall have automatic light switches located inside the locker adjacent to the entry door.
3. Selected lighting circuits in the cab control compartment of the cab car shall have ON/OFF switches. See Chapter 16 for details.

11.12 LLEPM

A low-level exit path floor marking system shall be installed in the car in compliance with APTA-PR-PS-S-004-99 Revision 2. The system shall operate in conjunction with the emergency lighting system. It shall be designed to be flush with the final flooring and shall be sealed from all liquids. Details shall be submitted to the Engineer for approval during design review. [CDRL 11-010]

11.13 Not Used

Not Used.

11.14 Testing

A. Car lighting shall be tested for compliance with this specification as well as all applicable APTA standards and FRA regulations regarding minimum illumination requirements and recommendations during normal, quiet car, standby and emergency modes. This shall include charging light levels for photoluminescent decals as part of the emergency signage system.

B. Test reports shall document lighting levels achieved during these modes, test methodology used during testing, and the standard or regulated light level for all measured locations to demonstrate compliance.

C. The Contractor shall provide certification to the Engineer that the car's lighting system meets all standards and regulations. [CDRL 11-011] All required material certifications shall be provided to the Engineer. See chapter 19 for more details.

Table 11-1: Minimum Illumination Levels

Area	APTA REF	Measured At	Normal Lighting *foot-candles (lux)*	Quiet Car Lighting *foot-candles (lux)*	Standby Lighting *foot-candles (lux)*
General Overhead	6.1	Table Top	30 (323)	15 (161)	5 (54)
Aisle way Lighting	5.5	Floor	20 (215)	10 (108)	5 (54)
Indirect Lighting		Table Top	5(54)	5 (54)	N/A
Vestibules	5.1	Floor. Threshold	30 (323)	30 (323)	5 (54)
General Seating Areas		Table Top	30 (323)	15 (161)	5 (54)
End Passageway/ Diaphragm Area	5.1/5.4	Floor	10 (108)	10 (108)	10 (108)
Bike/ Luggage Rack Area	11.3	Floor	10 (108)	10 (108)	5 (54)
Toilet Room	5.6	Mirror	30 (323)	30 (323)	10 (108)
		Area	30 (323)	30 (323)	10 (108)
Electric Locker	5.7	Floor	30 (323)	30 (323)	5 (54)
Utility Closet	5.8	Floor	15 (161)	5 (54)	5 (54)
Cab Overhead		Floor	5 (54)	5 (54)	5 (54)
		Cab Console	10 (107)	10 (107)	10 (107)
Cab Reading Light		Table Height	20 (215)	20 (215)	20 (215)

11.15 Contract Deliverable Requirements List

CDRL #	Title	Car Type
11-001	Exterior Lighting Plan	All
11-002	Lighting System Design and Components	All
11-003	Complete Lighting Plan	All
11-004	Lighting Fixture Samples	All
11-005	Light Color Plan	All
11-006	LED Color Temperatures for the Mood Lighting	All
11-007	Emergency Lighting Plan	All
11-008	Toilet Room Label Artwork	All
11-009	Lighting Level Descriptions	All
11-010	LLEPM Detail	All
11-011	Lighting Standards and Regulations	All

* End of Chapter 11 *

Technical Specification

CTDOT Single-Level Passenger Rail Cars

Chapter 12

Communication System

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12.00 Communication System

12.01 Overview

A. This chapter describes the system requirements for the on-board communication system to be provided on each car. The communication system includes:

1. a Public Address (PA) system
2. an Intercommunication (IC) system, including Passenger Emergency Intercoms
3. an Onboard Train Information System/Passenger Information System (OTIS/PIS), including:
   a. Exterior LED signs
   b. Interior LCD signs
4. a Data Communication System (DCS), including
   a. Ethernet Car Network (ECN)
   b. Ethernet Train Backbone (ETB)
   c. Train to Wayside Communication (TWC)
5. an Automatic Passenger Counting System (APC)
6. a Radio System, as described in Section 16.09

B. These systems have discrete functions that are extensively integrated to provide a comprehensive communication system within each car and between the car and other cars in the train (via dedicated Communication (COMM) trainline circuits and the Ethernet Train Backbone).

C. The PA and IC systems shall be fully compatible with existing locomotives operating in CTDOT service, including receiving and originating PA announcements and IC communications. Proper PA and IC volume shall be maintained in each car regardless of strength of trainline signal.

D. The Contractor may propose an alternative design for Engineer approval. The alternative design shall utilize up-to-date technologies, must include open architecture and still interface with systems in existing equipment operating in CTDOT service.

E. The car's DCS shall be capable of multiple functions, including providing a Gigabit Ethernet Car Network (based on EN61375-3-4) for communication within each car and Gigabit Ethernet Train Backbones (based on EN61375-2-5) for communication between cars. This capability shall provide and support public address, intercom, destination sign and announcement control, provision of wireless Internet access for passengers and crew, diagnostics and real-time health monitoring of on-board systems and components, and data transfer between the train and wayside communication systems. All networks shall be based on the 7-layer Open Systems Interconnection (OSI) model. Full documentation of each layer for each network shall be provided in a Network Interface Control Document to be submitted prior to Intermediate Design Review. [CDRL 12-001] The document shall be updated with all changes through testing and the end of the warranty period. Proprietary protocols shall not be used without approval by the Engineer.

F. The equipment shall meet the requirements of IEEE Std 1477 and all FRA, AAR and ADA applicable rules, regulations and guidelines.

G. CTDOT utilizes Clever Devices as their existing Automatic Vehicle Location technology provider to facilitate train tracking, station platform announcements, and other intelligent transportation system features. The Contractor shall supply, install, and test all equipment and software necessary to successfully integrate with the existing CTDOT Train Information System (TIS), supplied by Clever

Devices. The Contractor shall be responsible for all required integration of the Clever Devices onboard TIS hardware with the Contractor-supplied systems. The Contractor shall:

1. Supply, install, and test the Clever Devices INV-R® Controller with Operating system and TIS Application software and the IVN Transit Control Head, Zero Client (ZTCH) in each cab car.

2. Provide a dedicated power circuit, protected by an appropriate circuit-breaker and required ancillary support equipment such as dc-dc converter, to support the 24 volt IVN-R device.

3. Provide appropriate CAT5e (using M12 connectors) cabling connections between the IVN-R and ZTCH devices.

4. Provide an approved Multi-Band antenna to provide GPS signal via coaxial cable for input to the IVN-R.

5. Integrate onboard audio and video public address systems and on-board wayside communications capabilities (cellular, WiFi) with interfaces provided by the Clever Devices TIS devices to facilitate bi-direction TIS data transfers and real time communications.

6. Integrate on-board systems and components as required to support IVN-R functions, including supply to the IVN-R information including wheel tick signal, forward trainline signal, reverse trainline signal, door status indication, passenger counting information, and trainline audio interfacing.

H. A detailed functional description of the communications system shall be submitted for Engineer review. The description shall include electrical concept schematics, general arrangement drawings, and a list of equipment, including manufacturer names and model numbers. [CDRL 12-002]

12.02 General Requirements

A. This specification describes the requirements for the communication systems listed in this chapter, the equipment function and performance, the installation and the logistical support required to be provided by the Contractor.

B. The OTIS/PIS shall provide the passengers with both visual and audible information such as the train destination, present station, next station, pre-set messages, emergency messages and visual graphics, including advertising. The information shall be provided through the interior and exterior signs and the PA system. The system shall be based primarily on Ethernet technologies, with a 27-pin trainline interface to provide compatibility with existing fleets and backup in the event of Ethernet Backbone failure.

C. The OTIS/PIS shall be a fully automated system, with manual override feature. Once the system is activated, it will automatically establish train location through the Global Positioning System (GPS) as specified in section 12.5.5, and sequentially display and announce the upcoming stations at programmed locations. It shall allow for simultaneous voice, text, and graphical messages sent directly from the client software through the Wayside System Server (WSS) via cellular data communication.

D. The variety of audio and visual messaging possible through the communication system shall be prioritized. The system shall be capable of the preemption of higher priority announcements and allow, depending on the situation, the repetition or cancelation of certain announcements. The message priority and system function when conflicts occur shall be submitted to the Engineer for approval. [CDRL 12-003]

E. At a minimum, the following message types shall be considered in the prioritization structure:

1. Manual announcements by crew

2. Public address paging from the wayside
3. Announcement of PEI activation
4. Automatic announcements
5. Triggered train wide and public announcements

F. The functionality of the communication system described in this section shall be exposed for future system modifications and upgrades through a defined, verified, secure application programing interface (API). Functions to be exposed by the API include control and monitoring of all system components. Examples of future uses which the API shall support include:

1. Automatic assignment of train numbers to specific consists
2. Centralized answering of PEI calls
3. Sign control and announcements from alternative devices to one or more signs; audio zones; cars; or trains (such as remote announcements from the wayside, or announcements or control from train crew handheld devices)
4. Update of sign content and content triggers

G. These communication systems shall consist of the following equipment.

12.02.02 Public Address/Intercom (PA/IC) System Components

A. PA / IC control stations:

1. B-end vestibule of all cars
2. Cab control compartment in cab car
3. Adjacent to OTIS/PISCU

B. Handset at each PA/IC control station

C. Interior and exterior speakers

D. PA amplifiers

E. Passenger Emergency Intercoms

F. Interface to OTIS/PIS system

G. Interface to trainlines, including analog fallback of digital PA/IC communication

12.02.03 OTIS/PIS System Components

A. Destination signs (interior and exterior signs); (all cars)

B. Car Control Unit (CCU); (all cars)

C. OTIS/Passenger Information System Control Unit (OTIS/PISCU); (all cars)

D. Data Communication System (DCS) (all cars); GPS (all cars)

E. OTIS/PIS communication trainline; (all cars)

F. OTIS/PIS communication via Ethernet Car Network and Ethernet Train Backbone (all cars)

12.03 Public Address/Intercom (PA/IC) System

12.03.01 Public Address (PA) System

A. Cars shall be equipped with a PA system that provides a means for a train crewmember to communicate by voice to passengers for service updates and in an emergency situation. The PA system shall also provide a means for a train crewmember to communicate by voice in an emergency situation to persons in the immediate vicinity of his or her train. The PA system shall be compatible with the units currently in use on all equipment as specified in the compatibility provisions of this Specification.

B. The PA amplifier shall be programmable, with power supplied directly from the car low voltage battery circuit, and protected by a dedicated circuit breaker. The PA amplifier shall interface with the CCU and with the OTIS/PISCU over the Ethernet Car Network, and drive the car speakers whenever the PA system or the OTIS/PIS generate audio messages, or when controlled by other networked device. The CCU and the OTIS/PISCU shall allow automatic volume adjustment based on train number and car location for the purpose of quiet car operation.

C. The PA amplifier shall have a power output capacity sufficient to drive all the speakers on the car at the nominal speaker output power plus 25% spare capacity. The same PA amplifier unit model shall be installed on all car types.

D. The PA amplifier inputs and outputs shall be designed so that they may be open-circuited or short-circuited, without damage to the amplifier. Reverse polarity protection shall be provided.

E. The PA system (from the input to the microphone to the output of the interior speakers) shall have a STIPA rating of at least 0.50 when measured at each seat when tested according to IEC 60268 Part 16 during normal vehicle operation, and shall have the following performance characteristics for all modes of operation, including manual and automated digitized and test-to-speech announcements:

Frequency Response	± 5dB from 250 Hz to 8 kHz
Total Harmonic Distortion	Less than 1%
Hum or Buzz	Signal-to-noise ratio shall be greater than 40dB

F. The PA amplifier shall incorporate ambient noise sensing such that automatic gain control adjusts speaker volume based on the noise level of each car compartment. The PA system shall take an average of the ambient noise to calculate announcement level, which shall remain constant throughout any individual announcement.

G. The PA system shall have a quiet mode. The quiet mode will decrease audio output by a PTE configurable amount. The mode shall be triggered on a per-car and per-consist basis by the crew at a control unit on each car.

H. The PA amplifier shall incorporate a volume control adjustable only with the use of the PTE.

I. The PA amplifier volume shall be standardized fleet-wide and measured as a part of acceptance. The sound level from the car's speakers shall be uniform within ± 5dB at all passenger locations.

J. PA and intercom systems shall be backed-up by battery power for a minimum of 90 minutes of operation. See Chapter 13. Intermittent communication shall be considered equivalent to continuous communication during the last 15 minutes of the 90 minute minimum period for the purposes of Direct Current (DC) load budget calculations.

K. Handset and Holder

1. The handset shall use the standard Amtrak microphone handset and connector plugs (p/n 10623456).

2. Handsets shall be equipped with a push-to-talk switch. The handset cord shall be equipped with an adequate strain relief fitting where it is attached to the handset. A handset holder shall be provided with each handset.

L. Interior and Exterior Speakers

1. Each vehicle shall be equipped with a minimum number of speakers located throughout the interior of the car to provide a uniform audio level throughout each passenger compartment. The interior speakers shall be installed for replacement from the front, and sufficient length shall be provided in the wiring for this purpose. Each vehicle shall also be equipped with four weatherproof exterior speakers installed on the exterior of the car sides near each set of doors to enable the broadcasting of messages to passengers on the platform from the PA system from within the car.

2. The PA system shall be designed to allow the crew to make announcements for distribution through the interior speakers, the exterior speakers, or both sets of speakers by selection by the crew member. For a crew member to initiate a PA announcement, a handset must be plugged into the PA receptacle at one of the PA control stations. Once the handset has been plugged in, the audio from the handset shall be placed on the PA audio trainlines when the push-to-talk switch is depressed.

3. There shall be no feedback between car speakers and the control station handset when the public address system is in use.

M. Two-way Crew Intercommunications (intercom)

1. The IC system shall be designed to allow the crew to communicate with other personnel on the train including the Operator in the controlling cab of the train, and other train crew.

2. For IC communication between crew members within the train consist, a handset must be plugged into the IC receptacle at one of the PA control stations. Once a handset has been plugged in, and the push-to-talk is pressed, the audio from the handset shall be placed on the IC audio trainlines. To signal other crew members that an IC call has been requested, the crew member shall depress the IC CALL pushbutton located above the IC receptacle. Handset-to-handset communication shall be initiated once a crew member at an alternate lower level door control station plugs a handset into the IC receptacle.

N. Passenger Emergency Intercom (PEI)

1. Cars shall be equipped with a Passenger Emergency Intercom system which conforms to 49 CFR Part 238.121 and provides a means for passengers and crewmembers to communicate by voice with each other in an emergency. The PEI shall be equipped with an indication to the passenger that a call has been placed, as well as indication when the call has been answered by crew. The PEI shall be digital audio based and be capable of automatic diagnostics including checks that the microphone and speaker are operating. Maintenance shall be capable of commanding a self-test and circle-check of PEI units from the OTIS/PISCU. Full diagnostics of the PEI, including when a call has been placed, the time it was answered, the duration of the call, and any timeout shall be logged to the diagnostics system. The crew shall be notified of a pending PEI request through a method approved by the Engineer. [CDRL 12-004] Management of the PEI system, including answering calls, placing calls on hold, and returning to calls shall be possible through the CCU. At least one PEI station that is accessible to passengers without using a tool shall be placed in the following locations:

a. each half of the vehicle's passenger compartment;

b. at each wheelchair parking location;

c. in each toilet room.

2. The location of each PEI station intended for passenger use shall be conspicuously marked with luminescent material and legible and understandable operating instructions shall be posted at or near each intercom. The Passenger Emergency Intercom system shall be backwards compatible with existing systems in CTDOT service.

12.04 OTIS/PIS Capability

12.04.01 General

A. The OTIS/PIS shall be capable of full graphic and video display including advertising through the interior signs.

B. The equipment shall be designed and built for use in the rail transit environment. Special considerations for the high humidity and salt content in the air from the coastal marine areas, excessively fine dust, and from freezing temperatures to high temperatures exceeding 140°F (60°C) shall be incorporated into the design. All components shall be designed in accordance with PRIIA Specification 305-912.

C. It is the Contractor's responsibility to supply equipment capable of operation in the rail environment consistent with PRIIA specification 305-912. All individual components used in the fabrication of the equipment shall meet or exceed the requirements of the above standard. The Contractor shall submit documentation and calculations for all individual components for review and approval by the Engineer at the Preliminary Design Review (PDR) to validate the conformance to these standards. [CDRL 12-005]

D. The PA function of the carborne OTIS/PIS system shall utilize only digital communication signals between OTIS/PIS equipped cars, but be backwards compatible to send and receive analog audio signals from other cars and locomotives as specified.

E. All carborne OTIS/PIS equipment shall be powered from the 74VDC (nominal) low voltage car supply. See Chapter 13 for additional requirements related to on-board electronic equipment.

F. All carborne OTIS/PIS equipment shall have integral power conversion and conditioning.

G. External power supplies are not acceptable.

H. All carborne OTIS/PIS equipment shall be protected by external dedicated circuit breakers located on the car low voltage control panel. The circuit breakers shall be sized to protect the smallest size wire directly connected to the protected circuit. Fuses shall not be accepted either outside or inside the equipment. Internal circuit protection shall not be used, but if unavoidable must be a re-settable type circuit breaker approved by the Engineer.

I. All 74VDC low voltage power supply inputs shall be isolated from ground. All supply inputs shall be adequately filtered to minimize current and voltage ripple. All equipment enclosures and shock-mounted equipment shall be grounded with flexible, strap-type, grounding leads bolted between a car body grounding pad and the equipment grounding pad. Grounding connection pads shall be brazed, welded or silver soldered to the frame. Connections shall be stud or bolt mounted. Grounding through equipment mounting hardware is prohibited. All grounding connections shall meet APTA-SS-PR-E-S-005-98.

J. All carborne equipment enclosures shall be connected through quarter-turn, quick disconnect, multi-pin connectors with removable crimp contacts. The connectors shall be located in the front of the equipment or other easily accessible locations for quick connection and disconnection. All connectors of the same type and size shall be keyed to avoid insertion into the incorrect location. Connectors shall be identified in accordance with the schematic designation. All connector types shall be submitted to the Engineer for approval during design review. [CDRL 12-006]

K. Removal and installation of any component shall not require the removal of any other equipment.

L. The enclosure mounting attachments shall be accessible for easy installation and replacement of the unit. Whenever enclosures are supported by their mounting attachments, threaded studs and self-locking nuts shall be used to facilitate their installation.

M. All carborne equipment shall be housed in dust tight enclosures. Heat generating equipment shall have suitable heat sinks located on external surfaces of the enclosures and be cooled by natural airflow. Cooling fans are not acceptable.

12.04.02 Wireless/Satellite/Mobile/Ethernet Internet Connectivity

The OTIS/PIS system must accommodate wireless technology using satellite or mobile telecommunications ISP for Internet connectivity. A separate Ethernet Train Backbone trainline network between cars dedicated to passenger Internet access and provision of 802.11ax access points in each car to provide wireless Internet services to passengers shall be provided. See section 12.5.7 for additional detail.

12.04.03 System Operation

The OTIS/PIS system shall automatically identify all cars in the train by their car number and their location in the consist as soon as the train is formed. The communication trainline loop may be used for end of train detection. The OTIS/PIS system shall determine the train location with the use of the GPS receiver, as identified in section 12.5.5. A crew interface shall be provided to facilitate entry of route and/or train number.

12.05 OTIS/PIS Requirements

12.05.01 Display Signs

A. Interior Signs

1. Interior signs shall be located throughout the passenger cabin to provide each seated passenger a clear view of displayed information. Displays shall be provided in the following configurations:

    a. Wall mounted displays, Minimum of 32 in. diagonal display size with a resolution of at least 1920 by 1080 pixels and an aspect ratio of 16x9, minimum of two (2) mounted on each end of the passenger compartment

    b. Double sided displays, Minimum of 32 in. diagonal display size with a resolution of at least 1920 by 1080 pixels and an aspect ratio of 16x9, minimum of four (4) mounted throughout the passenger compartment

    c. Transverse double-sided ceiling mounted displays, Minimum of 42 in. diagonal display size with a resolution of at least 1920 by 540 pixels and an aspect ratio of 32x9 minimum of three (3) mounted throughout the passenger compartment

2. Interior sign types, quantities, and arrangements shall be adjusted based on seating layout to facilitate each seated passenger having a clear, legible view of a display sign. Interchangeability

of replacement units for the displays shall be maximized in order to minimize the inventory of replacement parts. There shall be no more than 3 unique part numbers for all interior signs.

3. All display types shall be capable of displaying:

   a. Audiovisual automatic announcements that include information such as present station and next station and arrival times.

   b. Text displays that may include time and date, train number, destination, and on-time and delay information.

   c. Special audiovisual messages received from the Wayside Server System or initiated by the onboard personnel.

   d. Animated graphic displays, including entertainment and advertising.

4. The interior signs shall be full color graphical Liquid Crystal Display (LCD) with LED backlighting. The displays shall utilize the maximum available space and maximize the sign display area. The signs shall meet all the applicable ADA regulations and requirements. The minimum viewing angle shall be 160° and readable at a distance of 30 ft (9,144 m).

5. The signs shall be housed in a dust-proof enclosure with a polycarbonate, non-glare display faceplate with graffiti-resistant film applied. Interior signs shall be clearly readable in all ambient light conditions including total darkness and direct sunlight. The signs shall be mounted in a tamper-proof anti-theft enclosure with tamper-proof fasteners.

6. All signs shall resume normal operation following supply power interruptions. No abnormal sign behavior shall follow any supply power interruption and reapplication.

7. The interior signs shall have self-diagnostic capability and provide fault condition information to the CCU, including sign location and type of fault. The sign unit, upon the insertion of the car wiring connectors, shall automatically recognize sign location through special coding in the sign unit or car-side wiring connector pins.

8. Interior displays shall have ambient light sensing and be coordinated with the car lighting system to control brightness under normal and quiet lighting modes. Display brightness shall match interior car illumination level under all lighting conditions.

9. Content creation for automatic announcements, advertisements and infotainment shall be based on a template system, with content templates capable of incorporating dynamic data from the train and wayside, including items such as train number, speed, destination, current station, passenger load, route and next stations, weather, time, date, and other pertinent information from the train and advertising server. Sign content shall be configurable to synchronize the display of content and shall facilitate content adjustments based on individual sign location.

B. Exterior Signs

1. Exterior signs shall be Ethernet/IP based and display train number, destination, and other text as programmed by the Engineer. Two exterior signs shall be placed on each side of each car, which shall be interchangeable.

2. The exterior signs shall be alphanumeric, RGB high intensity LED matrix, high resolution and high brightness, with full text, symbol, and bitmap capability. All LEDs shall be used at 50% of the maximum nominal forward current to extend LED life.

3. The signs shall be installed and supported to prevent any rattling, dust infiltration or movement of the sign itself. The sign support shall allow for sign tilting to allow cleaning of the glass behind the sign.

4. The signs shall be housed in a dust-proof enclosure with a polycarbonate, non-glare display faceplate with anti-graffiti resistant film applied. Exterior sign glazing must meet FRA type 2 projectile resistance. The exterior signs shall be designed to prevent fog and condensation. Maintenance and replacement of the exterior signs shall be from within the car interior. Maintenance personnel shall be capable of commanding a test pattern for all signs on the train via the OTIS/PISCU.

5. The minimum viewing angle shall be no greater than 30° from parallel to the side of the car and readable at a distance of at least 115 ft (35,052 mm). The display shall have a high contrast ratio and have an automatic LED luminosity control for different levels of ambient light conditions. LED dimming shall also be activated automatically by the CCU, to reduce low voltage supply consumption, in case of car battery charging failure or during train layover.

6. Exterior signs shall be clearly readable in all ambient light conditions including total darkness and direct sunlight.

7. The signs shall be capable of displaying scrolling text, paged text, or static text as configured by the Engineer. The signs shall have a default message or graphic when no communication is received, which shall be configurable by the Engineer. All signs shall resume normal operation following supply power interruptions. Self-testing or other functions shall only be activated by the CCU.

8. The exterior signs shall have a self-diagnostic testing capability and provide fault condition information to the CCU, including sign location and type of fault. The sign unit, upon the insertion of the car wiring connectors, shall automatically recognize its own location in the car, through special coding in the car-side connector pins.

12.05.02 Car Control Unit (CCU)

A. The CCU shall control all interior and exterior signs on that car for visual messages and provide digital input to the PA amplifier for audio announcements. It shall monitor the signs and PA status for fault diagnostics and shall digitally communicate with all other CCUs in a trainset over the Ethernet Train Backbone to verify their car systems status.

B. The Contractor shall supply a complete system to have the interior destination signs display information identifying the next regular stop on the selected route. This shall consist of the interior signs giving visual identification of the next stop (using several screens if necessary) with a simultaneous automatic public address announcement using the interior speakers of the next stop along with connecting transit routes and points of interest. Upon arrival at the stop, the exterior speakers shall announce the vehicle route and destination, and the interior speaker shall announce the stop. The system shall also allow the additional display of up to 200 supplementary emergency or public relations messages. The signs shall alternate between display of the supplemental message and station stop information. Selection of all automatic announcements and supplementary messages shall be under the control of the train crew. All interior and exterior voice announcements shall simultaneously announce on all cars of the train through the PA. The current local time shall be displayed on the interior signs at least once between each station stop.

C. A switch to disable exterior announcements during the trip shall be provided. In addition, the system shall be capable of being programmed by Engineer personnel to reduce volume and/or disable exterior announcements at select stations or during selected hours of the day.

D. Application software and hardware shall be supplied so that updates and changes can be made to the sign and announcement database including audio and visual announcements and graphics. The system shall allow the addition of new location triggers with the accompanying voice announcement and sign displays. Control of signs shall be individual based on location in car, the location the sign is facing relative to the car and direction of travel, the car type, the car position in consist, and any designation for quiet car or car out of service. The system for updating the database and system

software shall be user friendly and intuitive. The Contractor shall be responsible for developing the initial set of audio and graphic files for the Engineer. [CDRL 12-007]

E. The system shall include a simulator mode which shall make it possible to view and enter routes or locations and simulate the operation of the train along the route via the laptop computer or the control panel. It shall be possible to play any voice message or display any sign message.

F. The CCU shall be a microprocessor-controlled device, have an open architecture and allow expansion for communication and interface with additional other systems such as the car monitoring system, Closed Circuit TV (CCTV) surveillance system and Wireless Local Area Network (WLAN). In addition to the ports required for this expandability, at least two spare ports shall be provided. The CCU microprocessor usage shall not be greater than 60% of the available processor capacity.

G. The Contractor shall provide all the software needed to operate the CCU. The CCU software shall not utilize more than 60% of the available memory capacity when all initial control software, messages and animated graphics are loaded. Message capability shall include, but not be limited to the following:

1. Standard station stops
2. Advertising messages
3. Public service messages
4. Unique messages, including trainset specific messaging
5. Emergency messages

H. The CCU-stored data shall be divided in several files, following their specific function, and stored in non-volatile memory. Modifications to the CCU-stored data shall be achieved by changes only to the parts affected, to minimize the transmission time.

I. The CCU shall automatically identify the number of the car on which it is installed by the connecting hardware such as on the backplane of the rack in which the CCU is mounted, or through a programmable device that is permanently tethered to the car.

J. All CCU inputs and outputs shall be galvanically isolated from the external circuits. Shorting or opening of any of the inputs or outputs shall not result in any damage to the internal circuitry of the CCU.

K. The electronic circuits shall be designed as removable modules or circuit boards following the function such as power supply, microprocessor control and communications, contained in several card slots. Each card slot shall be clearly identified with the function performed by the contained electronics and suitably keyed to avoid inserting cards in the wrong slots. The electronic modules shall use LED indicators to provide quick visual status information. For example, power supplies shall be equipped with LEDs to show the presence of each output voltage.

L. The CCU shall have a specific port for connection to a PTE for diagnostic investigations, fault log downloading, system testing, troubleshooting and software upgrading and modification. The connection between the CCU and the PTE shall be through a standard Ethernet connection.

M. All CCUs shall be interchangeable and capable of performing the same functions.

N. All data communication between the train's CCUs shall be through the Ethernet Train Backbone.

O. The yellow indication shows that the system is working at a diminished performance, and that investigation, reset or repair is required.

P. The CCU shall have a self-diagnostic capability and store faults occurring in the CCU and in the other controlled systems, such as the signs and the PA amplifier. Faults shall be recorded with reference data such as car number, time, date and location. The fault memory shall store at least 10000 faults in a first-in, first-out sequence. The self-diagnostic system shall be capable of identifying the faulty electronic circuit function and indicate the electronic module, sign or PA amplifier to be replaced. This information shall be stored in non-volatile memory, together with the fault log.

Table 12-1: Trainline Pinouts

Description	COMM Wire Number
OTIS/PIS	ETB
Train Intercom	14 & 15
Train PA	20 & 21
Tape Music	ETB
Destination Sign Control	11 & 12
OTIS/PIS	ETB

12.05.03 OTIS/PISCU

A. Each car shall be equipped with an OTIS/Passenger Information System Control Unit (PISCU). The OTIS/PISCU shall interface between the operator and the CCU on each connected car. It will allow simple operations such as train number input, system start-up, message selection and initiation, and train formation display. It shall also be used as a local display for fault annunciation, system test and verification, in lieu of the PTE, but it shall not allow any reprogramming of the CCU itself.

B. The OTIS/PISCU shall be of rugged heavy-duty construction with hardened touchscreen display. The protected display shall be impervious to liquids, dust and heat. The front panel shall have no exposed fasteners. The display shall be readable in both direct sunlight and total darkness, and shall incorporate ambient light sensing.

C. The display shall be LCD with LED backlight and adjustable contrast and backlight intensity with a resolution of at least 1024x768. The display shall be suitable for the function of the OTIS/PISCU. The OTIS/PISCU shall be menu-driven for all functions. Data storage, if included in the OTIS/PISCU, shall be via non-volatile solid-state memory.

D. If the OTIS/PISCU is installed in a location accessible to passengers, the OTIS/PISCU shall default to an additional passenger information display screen, until full functionality is unlocked by the train crew through a means approved by the Engineer.

12.05.04 Train to Wayside Communications (TWC)

A. The Train to Wayside Communications System (TWC) shall incorporate all of the data communication required for the vehicle's remote communication functionality. The TWC shall utilize both cellular and WiFi systems for data transmission between the on-board systems and the remote server system. The TWC shall automatically utilize all available communication links so that the highest data transfer capability is available for any particular train location.

B. The antennas used for the TWC shall be designed and built for railway applications. The equipment shall be of robust construction. Installation shall conform to all railroad equipment clearance restrictions.

C. Train-To-Wayside communications (TWC) equipment shall be provided on all cars. The TWC equipment shall provide the following functions, as a minimum:

1. Transfer of consist monitoring and diagnostic data from the train to the wayside;

2. Transfer of train status information from the train to the wayside;

3. Transfer of Automatic Passenger Counting data, for all cars in the train, from train to the wayside;

4. Remote troubleshooting of car systems;

5. Transfer of OBIS/PIS database updates from the wayside to the train;

6. Transfer of audio, voice, and graphical system messages for broadcast from the wayside to the train;

7. Transfer the trigger of train-wide public and special message to the communication system;

8. Transfer of recorded or real time video from the video surveillance system;

9. Transfer of content, schedule, next stop informational messages, editorial content, dynamic content, and logs for the LCD graphical displays and the onboard dynamic advertisement system; and,

10. Transfer of real-time GPS system messages from each car to the wayside.

D. The TWC equipment shall be implemented using embedded Linux or an approved equivalent operating system. The TWC equipment shall provide wireless LAN as well as cellular connectivity between the train and the wayside. The wireless LAN shall conform to IEEE Standard 802.11b, g, n, ac, and ax. The cellular connection shall be implemented by utilizing the latest commercially available cellular technology suited for operating in CTDOT service at the time of the earliest design review, minimally a 4G LTE-Advanced Category 12 modem if the availability of 5G (sub 6Ghz and mm-wave) devices suited for the environment are not available. The antenna design used for the wireless LAN and cellular channels shall be such to support full capabilities of the selected modules. Both the wireless LAN channel and the cellular channel shall implement end-to-end security in all connections to the wayside installation by means of a secure VPN. The implementation of the two TWC channels and the security implementation must be approved by the Engineer to assure compatibility with its wayside installation, including the wayside installation, and of the service provider of the cellular network. The TWC system components, including cellular and WLAN modems, shall be designed in such a way to facilitate future upgrades which may occur through the life of the vehicle. The Contractor shall provide a document to the Engineer describing a standard interface which would allow the integration of a replacement or additional TWC channels. [CDRL 12-008]

E. The Contractor shall supply a turn-key secure hosted web-based wayside server solution which enables the TWC features and functionality.

1. Contractor shall arrange for required hosting services commencing no later than the commencement date of Conditional Acceptance testing of the first rail car and continuing through the Term of the Contract. Prior to expiration of the hosting period, Contractor shall cooperate and assist in the transfer of hosting services to CTDOT's designated contractor or successor provider, to ensure that there is no lapse in service.

2. The Contractor shall provide secure electronic web-based access to the Engineer and its designees.

3. The Contractor shall provide private virtual cellular network access for each car during the term.

4. The Contractor shall follow Best-Practice Methods regarding security for any connection to an external network, including connection to a third-party Internet Service Provider or Wide Area Network. A "Best-Practice Method" is defined as one that follows the recommendations of the server hardware manufacturer and network operating system vendor, in areas including but not

limited to, routers, firewalls, user permissions, virus scanning, e-mail content filtering, and protection of key network passwords.

5. The Contractor shall maintain the security methods in a current state at all times throughout the term of the Contract, which shall include applying virus and worm patches at a frequency recommended by the software vendor, applying operating system and application software patches at a frequency recommended by the software vendor, and modifying policies and procedures as necessary to prevent unwanted human access to any software and the network, as well as to prevent human-initiated events from causing harm to, or preventing the normal operation of the equipment and system.

6. The system shall be hosted in an environment certified to meet the requirements of the International Standardization Organization (ISO) 27002 or Federal Risk and Authorization Management Program (FedRAMP).

7. The Contractor shall provide complete and validated Interface Control Documents (ICDs) for all communication between the on-board components and the hosted wayside server solution.

8. At the end of the hosting period, the Contractor shall be responsible for delivering all collected data and all software programs necessary for the Engineer to operate the web-based wayside server solution on an alternative hosting platform, along with instructions and support to install and configure on-board and wayside systems for the alternative hosting arrangement.

12.05.05 Global Positioning System (GPS)

A. The OTIS/PIS shall utilize a Global Positioning System (GPS) for the determination of the train location and the triggering of automatic station announcements and station display. The GPS receiver shall be a stand-alone unit, powered by a dedicated power supply.

B. The CCU location capabilities shall be designed to function in the intended service. In addition to GPS, dead reckoning through the use of speed inputs (via a connected subsystem or dedicated input to OTIS) can be used in order to provide reliable location information throughout the service area of the vehicle. Door open signals can be used to initiate station announcements at stations that are broadcast over the exterior speakers, such as train number and destination. Whenever loss of GPS signal is experienced, the CCU shall be capable of automatically re-establishing train location once the GPS signal is again available. All CCUs shall be equipped to interface with the cars local GPS.

C. The antenna used for the GPS shall be designed and built for railway applications and shall conform to all operational and clearance requirements, including Drawing No. MNR-NO. 8, Rev. B and Drawing No. MNR-NO. 9, Rev. C. The equipment shall be of robust construction and weatherproof. The proposed antenna shall be submitted for approval to the Engineer during the design review process. [CDRL 12-009]

12.05.06 OTIS/PIS Communication Trainline

A. The OTIS/PIS system shall connect each car to the next one through an Ethernet Train Backbone wireline to support Ethernet as required by the needs of the Engineer.

B. The system shall support a consist of up to 8 cars.

C. The OTIS/PIS system shall identify and annotate all sign communication network failures through the fault diagnostic system. Sign communication trainline interruption due to the normal removal and reapplication of car jumper cables shall not result in a fault annunciation.

12.05.07 Provision for Passenger Connectivity

A. The Contractor shall furnish provisions (antenna space, bracket and wiring) to install a complete Passenger Wireless system as approved by the Engineer on each vehicle to provide on-vehicle

wireless Internet access. The passenger wireless Internet system and its installation shall be designed in a modular fashion to allow upgrades of all components throughout the anticipated service life of the vehicle. The passenger wireless LAN connectivity described in this section shall be capable of augmenting the capabilities of the train to wayside communication described in section 12.5.4. The proposed expected passenger bandwidth requirements, design, layout, and system capabilities of the passenger wireless Internet system shall be submitted by the Contractor for approval by the Engineer. These provisions shall include the following:

1. All cabling and wiring for Power, RF and Data for Passenger facing Access points

2. All cabling and wiring for Power, RF, and Data for wayside facing communication modems. Modems and antennas may be for both ground-based and satellite-based backhaul. Mounting provisions for all hardware including exterior mounted and passenger compartment antennas; access points; and control equipment.

3. Circuit breakers.

4. The Contractor shall establish six (6) antenna flat mounting locations atop each car. The antennas shall be 465mm long by 105mm wide by 160mm high spaced no less than 600mm apart from each other. Twelve (12) antenna cables shall be installed to support the six rooftop antennas as they are expected to be multiple input, multiple output (MIMO) antennas. The antenna locations on each car shall be capped with a removable plate to facilitate future antenna installation after delivery.

B. In addition to the Passenger Wireless LAN system, additional provisions shall be provided to facilitate the installation of cellular repeater systems capable of repeating and relaying cellular carrier signals to augment the in-car cellular communications capability of passenger devices. Provisions shall include conduit, access panels, cabling, and wiring for Power, RF, and data to several locations on the roof and throughout the passenger compartment to a dedicated reserved rack space which may house necessary electrical equipment to provide the required functionality. The Engineer anticipates that hardware from multiple carriers, or hardware which may aggregate multiple carrier signals will be installed during the life of the rail vehicle. The functionality may be provided by on-board distributed antenna systems for 3G, 4G LTE, and 5G (sub 6 GHz and mmWave), and/or on-board hosted small cell base station with carrier defined backhaul.

C. The Contractor shall ensure that mobile cellular telephones can operate reliably inside all cars within the trainset, under all operating conditions and at all locations along track CTDOT operates, provided that the necessary external facilities have been installed by others.

12.05.08 Dynamic Advertising System

A. The vehicle graphical interior messaging signs shall include dynamic advertising capabilities. When the train is not displaying next stop information in full screen mode, a mixture of advertising and editorial / infotainment messages will be displayed. The following provides a general overview of the system features:

1. Content Loop – the vehicle graphical message signs shall play a content loop to be provided by a wayside digital signage server, to be provided by the Contractor. When the station arrival information/system information messages need to play, playback of advertising and editorial content provided via the content loop should be paused. Ad/editorial content should playback from the beginning of the last message interrupted or continue playback with the next item if no interruption was required. The content loop shall be based on playlists with each item having start time and end time attributes. Content items shall be able to be played at specific times, time intervals, and locations. The content loop shall be able to play a playlist in order, or randomly as selected by the Engineer.

2. The onboard dynamic advertising capabilities shall be able to play a variety of content including: mpeg2, mpeg4, H.264, H.265, MKV, as well as JPG, PNG, BMP, and other standard graphics formats.

B. The onboard dynamic advertising system shall include the ability to connect to the advertising server via the train wireless networks to provide "fresh" data for population in templates. The capabilities shall include:

1. News/Sports/Other Feeds – various types of data feeds employing RSS or other sources. Data shall be able to flow into premade templates. If data is stale or unavailable, the message should not play. If the data source is inaccessible, an alert should be raised.

2. Ability to connect to and display external content such as sports scores and weather reports through RSS feeds, XML, or flat file manipulation

C. The onboard dynamic advertising system shall include the ability to track system operation and ad execution. Logs shall be recorded in flat files, CSV, or other format that is easily digestible in a database based server environment. Player will report log play activity and each screen that the content is played on. Play log will include date and time as well as asset played. Each player will log system status for the current settings, link health, uptime, transfer status and software/firmware versions of associated equipment.

D. The wayside advertising server software provided by the Contractor shall facilitate the following:

1. Moving content to players

2. Programming and adjusting advertising schedules

3. Moving data to and from the players

4. Fetch/modify player attributes

5. Transmit logs from the players to server

E. Access to the wayside advertising server shall secure, be protected by usernames and passwords managed by the Engineer, and role based.

12.05.09 Automatic Passenger Counting System (APC) (ADD-ON)

A. Prior to Contract execution, CTDOT will determine if this feature will be included in the Contract.

B. A non-contact sensor based Automatic Passenger Counting system shall be provided on each car. Sensor installation shall be such that manual adjustment, alignment, or calibration is not required throughout the life of the system. Sensors shall be installed on each passenger side door as well as each body end doors to accurately maintain the count of the number of passengers on board each train and each car at all times. The APC system shall time stamp the boarding and alighting data collected every time the doors are open, with the location (including latitude and longitude), station name, car number, time, date, train number, and train composition. The APC system shall be interfaced with other systems through the Ethernet based car network and the Ethernet Train Backbone, for receiving data such as GPS coordinates for locations, current station as tracked by the OBIS/PIS, car number, train number, speed, consist layout, operator ID as well as for transmitting data via the onboard TWC system to the Engineer's server system. The Contractor shall submit the design of the automatic passenger counting system to the Engineer for review and approval. [CDRL 12-010]

C. The APC shall be capable of continually monitoring, logging, and reporting, including, but not limited to the following list of required parameters:

1. Passengers joining and alighting at a particular station,
2. Passengers traveling between coaches at and between stations,
3. The number of passengers per car and per train,
4. Passenger counts (on and off) for each station stop,
5. Station dwell times, punctuality at departure, each station stop, and at end terminal,
6. Consist configuration,
7. Consist utilization (miles accumulated per day, passenger miles per day, etc.),
8. Unlinked passenger trips (UPT), and
9. Passenger miles traveled (PMT).

D. An event shall be identified as every time a car door (or doors) opens or closes. Events also occur at system startup and shutdown, or when train data is entered in the OBIS/PIS. Every APC event shall be recorded. Every event that has been recorded shall be uploaded when a wayside request for APC data is initiated or scheduled via the TWC and wayside server system. It shall be uploaded regardless of whether it has already been sent over a cellular network as a part of a real-time APC communication.

E. Every APC event shall be transmitted over a cellular network immediately.

F. The APC System shall have the memory capacity to store boarding and exiting data for all doors for a minimum of five hundred (500) trips. The memory shall be used to store trips during communications interruptions with the wayside server system and should be maintained in a circular buffer. Means shall be provided (via Ethernet connected PTE and USB flash memory drive) to extract the memory on-board the vehicle on a train-wide basis.

G. The system shall be designed to meet National Transit Database (NTD) reporting requirements, and shall accurately determine the number of alighting and boarding passengers per station to an accuracy +/- 5% and within 95% overall concurrence with manual observations for UPT and PMT. The contractor shall fully support initial certification of the APC system for National Transit Database reporting.

H. The system shall count accurately regardless of the size of the passenger, including small children and large adults. The system accuracy shall not be affected by variations in light and temperature, or the speed at which a person may pass by the sensor. The system shall provide the required accuracy by successfully identifying non-passenger objects including luggage and bicycles.

I. The Contractor shall supply a hosted web-based wayside reporting server, providing access to near real-time passenger counts for all cars and trains in the system, including raw data and processed data of collected reports, and facilitate export of the reports to CSV, XLS/XLSX, and text formats. The web-based portal shall be available to registered users via desktop and mobile devices utilizing browsers including Internet Explorer, Edge, Chrome, Firefox, and Safari. The system shall be capable of scheduling periodic reports to be emailed. The system shall handle scheduling multiple reports to multiple email addresses. The web-based portal shall support integration with automated ridership reporting software and other tools through an Application Programming Interface (API) supplied with the portal or other methods as approved by the Engineer. Access to the wayside reporting service for automatic passenger counting shall be managed by the Engineer. Access to web-based portal features shall be configurable based on defined roles.

J. The hosted web-based portal solution shall include access to data delineated by on/off counts for each station, each car, and each door, to include live consist and live individual car counts. The

standard reports shall include the ability to track and report all operational data required for FTA National Transit Database (NTD) reporting, including racking of passenger trips and passenger miles. At a minimum, the following reports shall be provided:

1. Passenger Load – Average and total passenger count between (2) stations, agreegated by train, by time period, by line, and for the system as a whole.
2. Train Ridership – Total number of alightings, per consist and aggregated by line and the system as a whole.
3. System Ridership – Total number of alightings per hour per day
4. Station Load – Boardings and alightings at a specific station, and aggregated by train, by line, and for the system as a whole
5. Consist / Car Load – Total passengers in each consist (or car) of the consist at the last noted location
6. Consist / Car Overload – A report of all consists (or cars, by consist), which have a passenger load over a configurable value.
7. Schedule Adherence – Number of trains that arrived at each station later than a configurable delay, and the number of total trains.
8. Running Times – Arrival and departure times at each station
9. Fault Data – All Passenger Counting System Faults
10. Blocked Sensors – All cars that have not seen a configurable number of boardings / alightings over the reporting timeframe.
11. Maximum load point by train/consist and by line

K. The hosted portal reports shall be filterable by the following:

1. Reporting start date
2. Reporting end date
3. Time of day
4. Train number
5. Weekend/Weekday/All
6. Include/exclude special events

L. The design, location, and integration of the APC System shall be submitted for review and approval by the Engineer. [CDRL 12-011]

12.05.10 Video Surveillance System (VSS)

A. An onboard crash and fire protected digital network video recording system (NVR) shall be provided to meet the requirements of the video surveillance system (VSS). The video data acquisition system shall monitor and record data acquired from multiple onboard PoE IP camera sources that shall be arranged to maximize the coverage of the vehicle and its operations. The onboard camera system shall have day and night capabilities and provide high quality color video. The VSS shall operate continuously off of the low voltage power supply system, and be backed up by car battery as a vital load. The Contractor shall submit a comprehensive Video System Architecture and Design Package to

the Engineer for review and approval. [CDRL 12-012] This submittal shall demonstrate how all requirements of this subsection will be achieved and provide technical specifications and datasheets for each system component.

B. The system in operation shall provide adjustable frame rates necessary to avoid latency and/or frame loss that would cause discontinuity of motion and loss of apparent causal circumstance. Maximum frame rate shall be at least 30 frames per second.

C. All acquired data shall be written, stored, and encrypted. All data shall reside on the rail vehicle on one or more solid state drives (SSD) device that is designed and applied for the purpose of mobile data acquisition and storage. The SSD shall be locked, and be easily removable and replaceable to facilitate use as evidence. The SSD shall be designed to be upgradable for increased storage. The date and time source for the NVR shall be synchronized to the same date and time source as other networked components. The NVR shall record and tag vehicle video with vehicle position data as reported from the vehicle's Global Positioning System.

D. The NVR shall be connected to the Ethernet Car Network to allow access to recorded or real time video from any camera through the TWC. Authorized personnel shall have the ability to access all data online and download all data to wayside PC based systems without the loss of storage and quality of data stored on the vehicle's SSD system. Provisions for an audit trail of personnel accessing the data shall be maintained within the wayside software. System access to the NVR and NVR video shall be coordinated through the diagnostic and TWC systems, with an audit trail of access to NVR functions (including video download, live view, and configuration) maintained. Data acquired in this mode shall be high quality to allow monitoring personnel to view data that equals the quality of data written on the vehicle's SSD device. The NVR shall have storage capacity for fourteen (14) days of the streams from all IP cameras at thirty (30) frames per second before overwriting. Power to the NVR shall be provided by a dedicated circuit breaker. The inward and outward facing cab cameras shall additionally be recorded to a Crashworthy Event Recorder Memory Module for a minimum of seventy-two (72) hours at thirty (30) frames per second before overwriting. The dedicated Crashworthy Event Recorder Memory Module used for recording the video and audio streams of the cab cameras shall meet the requirements of both IEEE 1482.1-1999 and 49 CFR Part 229 Appendix D.

E. The NVR speed and time data shall be synchronized with a source that can be aligned with on-board recorded data from the on-board monitoring and diagnostic and event recording systems.

F. The NVR shall commence recording data when the car is powered on, and continue recording until the car is powered off, unless otherwise directed by the Engineer.

G. The NVR shall tag per-camera memory sections to prevent overwrites, for a user configurable period of time, if a user configurable set of network events occur, including:

1. PEI request
2. Emergency brake (above zero speed)
3. Penalty brake (above zero speed).

H. Video Cameras

1. The cameras shall have adjustable resolution of at least 1920x1080 with frame rates adjustable up to thirty (30) frames per second. The cameras shall provide the latest MPEG-4 video compression commercially available, H.264 or greater. Each camera shall deliver compressed video in real time to the Network Video Recorder (NVR). All video cameras provided shall have a proven history of reliable operation on transit rail vehicles. All video cameras shall be mounted in vandal resistant enclosures. All cameras shall operate in the temperature range of -22°F (-30°C) to 140°F (60 °C).

2. The quantity and location of Power over Ethernet IP video cameras shall be as follows:

a. One (1) outward facing camera shall be installed in the cab of each cab car, providing the ability to distinguish signal aspects throughout all operating modes (including day and night operation) and in all environmental conditions. The camera mounting location shall be located in the swept area of the windshield wiper.

b. One (1) inward facing camera, having audio capability, shall be trained on the Operator's position in the cab, providing a field of view sufficient to show every person in the cab, full coverage of the Operator's controls, and include the ability to record during daytime with ambient light and include infrared illumination to provide night time recording capability in a darkened cab.

c. Two (2) rear-view cameras, which shall be mounted on the exterior of the vehicle such that they provide a view of all passenger doorways aft of the cab. These cameras shall be housed in waterproof and dustproof housings that are designed to be unobtrusive and blend in to the surface they are mounted on. The camera's video output shall be clear enough in all lighting conditions to discern whether any passengers are entering or exiting a doorway. In addition to being recorded on the NVR, the output from the rear-view cameras shall be displayed on the cab video monitor beginning when the vehicle is at zero-speed and for five seconds after the vehicle begins moving.

d. A minimum of eight (8) interior cameras, without audio capability, shall be placed throughout the passenger compartment to facilitate recognition of passengers on-board the rail vehicle.

3. Installation and location of all cameras shall be submitted for review and approval by the Engineer.

4. The Contractor shall be responsible for submitting, to the Engineer for approval, a coverage plan identifying the location, viewing angle, and details of the camera arrangement and capabilities [CDRL 12-013]

I. Video Download

The video surveillance system shall support wireless download via the TWC system, as well as local download via PTE. NVR storage devices shall be removable, locked via a secured key. The Contractor shall provide the Engineer with a means to recover footage from the removal storage device via standard PC connection. [CDRL 12-014] The TWC connection shall support live look in capabilities. TWC downloads shall support scheduled downloads of one or more cameras, based on car number, train number, event occurrence, and date and time.

12.06 Portable Test Equipment (PTE) Software

A. The PTE software shall be designed to perform the following:

1. Update software for all Communications Equipment systems

2. Download sign information/updates

3. Retrieve the fault file from the Communications Equipment Systems

4. Perform system diagnostic and troubleshooting

5. Perform equipment adjustment and calibration such as PA amplifier volume

6. Perform system testing, message annunciations, graphic display, etc.

B. The PTE software shall be menu-driven, web browser based and user friendly. The software and its functions shall be submitted to the Engineer for approval at the design review. [CDRL 12-015] All PTE software is reproducible without additional cost as needed by the Engineer to support the vehicles.

C. The PTE communication interface shall be via IP, utilizing Ethernet to communicate with car borne equipment. The Contractor shall provide two communication test cables, 10 ft (3,048 mm) in length. The cable shall connect between the PTE and an interface port conveniently located for maintainers in each half of the car, providing access to the CCU, OTIS/PISCU, and all other Communication subsystem devices. The PTE software shall work throughout the Ethernet Train Backbone, providing a capability to update equipment on all cars connected via Ethernet Train Backbone. The PTE port and subsystem PTE access shall be secure, both physically by placing the PTE port behind lock and key, as well as implementation of secure network access by a means approved by the Engineer. Network access and PTE functions shall be protected by roles, with design of the authentication, authorization, and access functions (such as certificates, usernames, passwords, and access logs) shall be manageable by the Engineer to allow network and information security through regular rotation.

D. The Contractor shall supply a schematic, identifying the pin outs of the cable connectors, as part of the running maintenance manual and integrated schematic manual. The details of the PTE system design, including network security considerations, shall be submitted for approval to the Engineer during the design review process. [CDRL 12-016]

12.07 Communicating Buzzer System

A communicating signal buzzer shall be provided in the operating compartment of each cab car, one (1) at each door control panel on each side of each end of car vestibule, and one (1) in an Engineer-approved location in the interior near the center of the car. The buzzers shall be trainlined, and all locations shall be connected through a car relay which is connected to the trainline. The signal buzzer trainline shall include surge suppression to prevent the generation of any electrical noise in the trainline. The communicating signal buzzer shall be operated by any of the communicating signal buzzer push buttons anywhere in the train consist without the use of a key.

12.08 Contract Deliverable Requirements List

CDRL #	Title	Car Type
12-001	Network Interface Control Document	All
12-002	Communications System Functional Description	All
12-003	Message Priority and Communication System Function	All
12-004	Pending PEI Request Notification Method	All
12-005	OTIS/PIS Equipment Documentation and Calculations	All
12-006	OTIS/PIS Equipment Connector Types	All
12-007	Car Control Unit (CCU) Initial Audio and Graphic Files	All
12-008	Train to Wayside Communications (TWC) Standard Interface Description	All
12-009	GPS Antenna Proposal	All
12-010	Passenger Load Determination System Design	All
12-011	APCS Design, Location, and Integration	All
12-012	Video System Architecture and Design Package	All
12-013	Camera Arrangement and Capabilities Details	All
12-014	NVR Storage Devices Removal Method	All
12-015	PTE Software	All
12-016	PTE System Design and Schematic	All

* End of Chapter 12 *

Technical Specification

CTDOT Single-Level Passenger Rail Cars

Chapter 13

Electrical System

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13.00 Electrical System

13.01 Overview

This chapter describes the major electrical power distribution and control systems required for each car, and for car-to-car power and signal trainline circuits. The systems include 480 Volt Alternating Current (VAC) Head End Power (HEP) trainline and power distribution, 120VAC power distribution, 74 VDC Low Voltage Power Supply (LVPS) power distribution, battery, 27-pin trainlines for car-to-car multiple unit (MU) and communications (COMM), an Ethernet Train Backbone (ETB) along with Ethernet Car Network (ECN) in accordance with EN61375-2-5 and EN61375-3-4 for diagnostic messaging and communications, and electrical locker circuit breaker panels.

13.02 General Requirements

A. Hotel power to the train shall be provided through trainline cables from a separate 480VAC, 3-phase, 60 Hertz (Hz) source not located on the vehicle. The system shall be designed for normal operation using power supplied by a locomotive HEP source, or from a wayside 480VAC power source.

B. All cars shall be equipped with 27-point locomotive control (MU) and communication (COMM) 27-wire trainlines, and an Ethernet Train Backbone (ETB) along with Ethernet Car Network (ECN). All trainline wires shall run the entire length of the car and be connected from end-to-end.

C. Receptacles for MU, COMM and HEP shall be located in accordance with APTA-PR-E-RP-017-99. Receptacles for ETB shall be located in accordance with this specification.

D. All electrical systems and components utilized on all cars shall be electromagnetically compatible with other electrical systems and components, including the crew radio, cab signal/ATC/PTC, digital trainline, the passenger information system, passenger cellular telephones and laptop computers. All electronic equipment shall conform to IEEE Std 16-2004 and EN 50155 unless otherwise approved by the Engineer. All type tests shall be performed. Supply voltage ranges for electronic equipment, including nominal voltage, setpoints for automatic shutdown and restart of equipment, and load shedding arrangement shall be coordinated by the Contractor with design details submitted for approval to the Engineer. [CDRL 13-001]

E. The electrical power distribution, lighting and communication systems shall be in accordance with all applicable FRA regulations, APTA standards and recommended practices and industry standards.

13.03 27-Pin Trainline Systems

13.03.01 General

A. Car-to-car communication for MU and COMM shall be provided by 27-pin jumper cables and receptacles. Connection between cars shall be provided by jumper cables. LVPS power shall not be trainlined. The 27-pin trainline system shall be similar to APTA-PR-E-RP-017-99.

B. The car's 27-point COMM, 27-point MU, DTL, and 480VAC HEP trainline control circuits shall be run in separate dedicated conduits or wire trays with dividers. All wiring within wire trays shall be separated by signal type, in accordance with IEEE 16. All spare COMM, MU, and DTL trainline wires shall be identified in the junction boxes.

C. MU and COMM jumpers and receptacles shall be provided by Clement National or another Engineer-approved supplier.

13.03.02 Communication Trainline

A. This trainline provides car-to-car connections for systems such as door control, door closed summary circuit, public address, passenger information and brake status lights. In normal operation, a single 60 in. (1,524 mm) COMM jumper cable shall be connected between adjacent cars or a single COMM jumper, with the length determined by the Contractor, shall be connected between the locomotive and the car adjacent to the locomotive.

B. For COMM trainline pin assignments, see Table 13-1.

C. End of Train Functions

1. On each end of each car, a two-position rotary drum switch (End of Train/EOT Set-up), labeled END OF TRAIN and OFF, shall be provided to realize the "end-of-train" detection for on-board systems, including but not limited to the door closed summary circuit.

2. The drum switch shall be provided for each end of the car to establish "end of train" for four communication trainline circuits (#19C, 20C, 23C, and #26C) by connecting car battery negative to the aforementioned circuits, providing a negative return path for the brake applied light, brake released light, conductor signal light, and the engineer door closed light.

3. Following cab activation of a cab car (CMR), a hardwired connection between COMM trainlines pins #23C and #26C will be closed to complete the door closed summary loop from the front of the train. If the cab car is placed anywhere other than lead/push or trail/pull (the cab car is buried in a consist), the connection between COMM trainline pins #23 and #26 will be open (EOT set-up is in off).

4. The functionality shall be duplicated on each end of a car in the event that the car is turned 180° in the consist.

13.03.03 Multiple Unit (MU) Trainline

A. In push-pull operation with a cab car leading and the locomotive trailing, locomotive control functions shall be transmitted through the train from the cab car to the locomotive by means of a standard multiple unit (MU) trainline.

B. A single 60 in. (1,524 mm) MU jumper cable is connected between adjacent cars, and a single MU jumper, with the length determined by the Contractor, is connected between the locomotive and adjacent car.

C. For MU trainline pin assignments, see Table 13-2.

13.03.04 Trainline System Application to Vehicles

A. The following receptacles and jumper cables shall be similar to APTA-PR-E-RP-019-99 and be provided at each end of the car:

1. 27-pin communication receptacle, painted blue, complete with contact insert and wiring.

2. 27-pin communication jumper cable, 60 in. (1,524 mm) car-to-car with blue heads.

3. 27-pin MU receptacles, painted black, complete with contact insert and wiring.

4. 27-pin MU jumper cable, 60 in. (1,524 mm) car-to-car with black heads.

B. Receptacles and fixed jumper flanges shall be mounted to the carbody with stainless steel bolts and self-locking nuts. Trainline receptacles shall be electrically insulated from the end sheet.

C. Two sets of COMM and MU receptacles shall be installed on each end of all cars, one on each side of coupler pocket, in accordance with Figure 4A of APTA-PR-E-RP-017-99. One MU and one COMM 27-point jumper cable shall be connected between adjacent cars as well as to the locomotive. Jumpers and receptacles shall be color-coded as well as mechanically keyed to prevent cross-connection.

D. The plate to which receptacles and jumper flanges are mounted shall be designed to resist a 500-pound force (2225 N), without deforming, produced by pulling the locked jumper (with the receptacle cover locked down utilizing a rubber-O ring type retainer) out of the receptacle.

E. There shall be no interference that restricts the receptacle cover from being fully opened to allow insertion or withdrawal of jumpers.

F. Under all operating conditions, a minimum of 2 in. (51 mm) clearance for the trainline cables shall be provided between trainline jumpers and the carbody and all appliances including air hoses, couplers, uncoupling levers and other equipment.

G. No portion of the MU, COMM, or DTL cables shall hang down to within 5 in. (127 mm) of the top of rail (vertically) when connected to an adjacent car on straight, level track. No portion of the cable shall pass below top of rail when navigating a 250′ radius turn.

H. Each car shall be delivered with one loose jumper cable of each type.

13.03.05 Trainline Junction Boxes

A. Separate stainless-steel weatherproof junction or switch boxes shall be provided at each end of each car within the trainset for the communication (both DTL and COMM) and MU trainline systems. The trainline junction boxes for all cars shall be located at the transition bulkhead or if there is no transition bulkhead, to beyond the adjacent truck. Trainline junction boxes at the F-end of cab cars shall be located behind the F-end truck or other Engineer approved protected location.

B. The wiring for the MU, COMM and DTL trainline receptacles shall be of adequate length to reach from the end sheet to the trainline junction box. This shall be accomplished without requiring connectors, splices or intermediate terminals.

C. The inside of the box shall be painted with a white insulating epoxy paint. All wires shall be terminated using AMP PIDG ring tongue terminal lugs, mounted onto terminal blocks in the junction boxes. Trainline junction boxes shall be located where they are shielded from roadbed debris and car system liquid drains. All trainline junction boxes shall be weatherproof to NEMA4 requirements if located undercar and have provisions for a drain hole with a cotter "jiggle" pin.

13.04 Ethernet Train Backbone (ETB) and Ethernet Car Network (ECN) System

13.04.01 General

A. A Gigabit-Ethernet based Ethernet Train Backbone shall be constructed and installed on the cars in accordance with the requirements of this specification. All cars shall also be wired to be capable of handling all existing COMM trainline functions with vehicles used in CTDOT service. The Ethernet Train Backbone shall be comprised of managed train switches installed in each end of each vehicle. The switches shall route Ethernet communication from adjacent vehicles and shall be configured with bypass relays to pass Ethernet communication through them when failed or without power. The ETB shall be configured with redundant links to adjacent cars.

B. Each Train Switch shall connect to the Ethernet Car Network such that redundancy is provided. The Ethernet Car Network shall be comprised of managed Vehicle Switches connected in a fault tolerant ring topology. The speed of the Ethernet Car Network ring shall be one Gigabit per second. Each managed switch on the Ethernet Car Network shall be provisioned with one additional Gigabit port reserved for diagnostics, troubleshooting, servicing, and/or expansion. Devices capable of communication over 100 Mbps shall be connected to the Ethernet Car Network via Gigabit ports using four-pair Category 7 cables terminated at X-coded M12 connectors. Devices which are not capable of saturating a 100 Mbps link may be connected using two-pair Category 5E cable terminated at D-coded M12 connectors.

C. The primary method of communication between vehicles for communications, diagnostics, and non-vital controls shall be the ETB and ECN. Legacy communication through 27-pin COMM communication shall be supported when coupled with legacy equipment, or in instances of failure of the ETB system. Safety related functions, including throttle, braking, and door control shall remain controlled by 27-pin and pneumatic control, with monitoring and diagnostics via the ETB and ECN.

D. The Contractor shall designate a single supplier as having system integration responsibility for the onboard networks. The selected supplier shall have successful prior rail industry experience in performing such integration. The Contractor shall submit the selected integrator to the Engineer for review and approval. [CDRL 13-002]

E. The Contractor shall ensure that all trainline components and networks are designed to provide proper operation of trainlined functions for train lengths up to 10 cars.

F. The Contractor shall provide fault tolerant networks that have the ability to maintain communications between connected nodes without loss of data in the event of a single open or short circuit.

G. The Contractor shall provide a description of the Ethernet Train Backbone and Ethernet Consist Network control and architecture for Engineer review and approval. The description shall include detail on the data network protocols, fault tolerance, degraded operating modes, redundancy arbitration, error detection, list of IP devices on each network, IP addressing scheme, and a description of network initialization and configuration. [CDRL 13-003]

H. The Contractor shall perform and maintain throughout design a Cyber Security Risk Assessment and develop the onboard and wayside networks using the NIST Cybersecurity Framework, IEC/ISO 27000 series standards, and ISA/IEC 62443 series of standards. The security analysis documents shall be submitted for Engineer review and approval. [CDRL 13-004]

13.04.02 Trainline System Application to Vehicles

A. Two digital trainline receptacles shall be installed and wired on each end of each car. The locations for these receptacles shall be proposed to the Engineer for approval. Each receptacle shall meet the following requirements:

1. Each fixed receptacle shall be pre-wired with two four-pair Category 6A (or Category 7) cables (one as a spare). Each of the cables shall be terminated with an eight-way X-coded bulkhead M12 connector.

2. The system configuration shall be wired to ensure that the network takes advantage of both sets of ETB cables to provide redundancy and to protect against individual device or car failure.

3. The receptacle shall have alignment markers to ensure correct orientation of the jumper. The covers of the receptacle shall be designed to automatically hinge shut, providing IP67 water resistant seal to prevent ingress into the electrical contacts.

4. The plate to which receptacles and jumper flanges are mounted shall be designed to resist a 500-pound force, without deforming, produced by pulling the locked jumper (with the receptacle cover locked down utilizing a rubber-O ring type retainer) out of the receptacle.

5. There shall be no interference that restricts the receptacle cover from being fully opened to allow insertion or withdrawal of jumpers.

B. Under all operating conditions, a minimum of 2 in. (50.8 mm) clearance for the trainline cables shall be provided between trainline jumpers and the carbody and all appliances including air hoses, couplers, uncoupling levers and other equipment.

C. Each car shall be delivered with two (2) loose ETB jumper cables meeting the following requirements:

1. The jumper shall be composed of two four-pair Category 6A (or Category 7) cables, populating position one and three of a four position receptacle. Positions two and four shall be plugged.

2. The connectors shall be four position twist lock bayonet style with visual and tactile indexing.

3. The jumpers shall be designed with keyways to ensure that there is only one way to fit the jumper.

4. The jumper is to be designed to allow removal from the fixed receptacle without causing strain to the internal cables or damage to any part of the jumper or connector face.

5. Each end of the jumper shall allow free movement, with a horizontal 270 degree arc of the mating face, in relation to the cable jumper to prevent excessive force on the jumper either when being mated to the vehicle or during normal vehicle movement. The jumper pulling failure force shall be no greater than 110 kg-ft which shall be less than the strength of the attachment of the receptacle housing to the carbody. The jumper plug shall be designed to break away before any damage to the fixed junction box of vehicle body in instances where the jumper has not been disconnected between two vehicles that are separating.

6. Each cable shall be protected externally with an industrial woven, close fitting sleeve that ensures mechanical protection from abrasion along the length of the cable's jacket. The sleeving selected shall meet NFPA 130 requirements for fire performance. The cables shall incorporate an internal EMI screen over the length of the cables, with the screen continuous over the connector. The screen arrangement shall be coordinated by the Contractor such that EMI protection is offered, while preventing common earth connection between adjacent vehicles. The screen of each cable shall be connected to any vehicle body at one point only.

13.05 480 VAC Head End Power (HEP) Trainline System

13.05.01 General

A. HEP shall be provided to the car through receptacles at standard locations on each end of the car and on both sides of the coupler, in accordance with APTA-PR-E-RP-016-99, for a single bus configuration.

B. In addition to the three main power conductors, the jumpers also include three control pins, which provide locomotive trainline complete (TLC) signal (indicating all jumpers throughout the train are in place), and a car-to-car carbody ground bond. All car types shall utilize HEP control Pin #1 as the HEP Trainline Complete (TLC) circuit; Control Pins #2 and #3 shall be run end-to-end, not grounded to carbody.

C. The loads between phases shall be balanced so that the load on one phase will not exceed more than 5% of the load on either of the other two phases. To that end, the HEP 480VAC cabling shall rotate one phase at each HEP receptacle and trainline jumper installation at the A-end of each car. This is to provide HEP phase current balance on the trainset.

13.05.02 Receptacles and Jumpers

A. Each end of each car will be equipped with two fixed jumper cables and two receptacles with housings per APTA-PR-E-RP-017-99 (Figure 4A) and APTA-PR-E-RP-018-99. The HEP receptacles and jumpers shall be provided by Clement National, or another Engineer approved supplier. Components shall include:

   1. 480VAC fixed jumper (length to run from end sheet to transition bulkhead)

   2. 480VAC receptacle

   3. 480VAC receptacle housing

B. The receptacles shall be mounted with a downward slope of approximately 15° to provide drainage. Receptacles and fixed jumper flanges shall be mounted to the carbody with stainless steel bolts and ESNA type locknuts.

C. Receptacle mounting shall provide adequate clearance from all car apparatuses such as jumpers, receptacles, uncoupling rods, diaphragms, buffers, couplers, safety appliances and air hoses. It shall allow for such variables as coupler motion horizontally and vertically, motion relative to the adjacent coupled car under conditions of curving, passing through a crossover, and in buff and draft, and whether the jumper is inserted into a receptacle or not. There shall be no interference that restricts the full opening of the receptacle cover to allow insertion or withdrawal of jumpers.

D. All HEP receptacles shall be labeled with appropriate DANGER 480V warnings, in accordance with PRIIA Specification 305-909.

E. The 480V receptacle housings shall be of the breakaway style as on existing Amtrak *Amfleet* cars. The plate to which the receptacles and fixed jumper flanges are mounted shall be reinforced to resist, without bending, a 500-pound force (2225 N) produced from pulling the locked jumper out of the receptacle, such as by an unintended uncoupling. The jumper cable shall be sacrificial relative to the carbody components.

F. The holsters shall be mounted on the car end frame convenient to the adjacent fixed jumper, to provide storage for the jumpers during car switching. They shall consist of a short length of stainless-steel tubing with a stainless-steel crossbar at the bottom, of a diameter to accept the 480V plug body, yet prevent it from sliding through. The holster shall be sloped steeply downward to allow any moisture which has accumulated in the plug to drain.

G. The HEP jumpers shall be of adequate length to reach from the end sheet to the trainline junction box at the transition bulkhead without requiring connectors, splices or intermediate terminals. No portion of the HEP cables shall hang down to within 3 in. (76 mm) of the top of rail (vertically) when connected to an adjacent car on straight, level track.

13.05.03 Wiring and Connections

A. The 3-phase HEP trainline power cables per APTA-PR-E-RP-002-98 and APTA-PR-E-RP-009-98, with 1600-amp capacity, shall be routed along the length of the car. Line drop shall not exceed 3.5V, at capacity load, between receptacles at opposite ends of the car.

B. The wire used in the trainline power cables and jumpers shall be 4/0 as specified in APTA-PR-E-RP-016-99. The voltage drop due to the impedance of the power trainline at the extreme end of the 12-car consist shall be minimized under the train's heaviest load. The Contractor shall supply a line voltage analysis showing the voltage loss from one end of a 12-car train to the opposite end under the heaviest load case.

C. All HEP cables routed over the wheels and trucks shall be enclosed in rigid galvanized steel conduits or Engineer approved wire trays, and shall be supported by heavy-duty stainless-steel straps equipped with vibration resistant material at intervals not to exceed 36 in.

D. The HEP cables may be run between junction boxes on the underside of the lower level of the car in a protected wire race depending on the design of the car. If routed in open air, all cables and conduits shall be supported by suitable cleats at appropriate intervals not exceeding 24 in. (610 mm). Spare trainline wires shall be identified in the end-of-car junction boxes.

13.05.04 Power Junction Boxes

A. A HEP trainline junction box shall be located at each transition bulkhead where the jumpers and leads from the receptacles on the end sheet shall be terminated and connected to the cables running the length of the underside of the car. The B-end junction box shall provide connection to the 480VAC power distribution circuit for the car.

B. A central HEP trainline junction box shall be provided as a 480VAC distribution point to all the car AC voltage auxiliary loads and systems.

C. All connections between end of car HEP cabling and HEP trainline cabling shall be accomplished using bus bars. In-line splices shall not be permitted.

D. The F-end, cab control car HEP junction box(es), shall have provisions to disconnect the 480VAC power from the F-end receptacles and jumpers when that end of the car is in a lead position. Controls for the disconnect shall be located inside of the cab car's electrical control locker adjacent to the Operator's cab.

13.06 480 VAC Power Distribution

13.06.01 General

The 480VAC power is distributed within the car utilizing power transformers, switch and circuit breaker panels located in the electrical and/or equipment lockers. Power is controlled and fed to all loads through this distribution system.

13.06.02 Main Circuit Breaker

A main circuit breaker shall be provided in the electrical locker to allow isolation of the car from the 480VAC trainline systems.

13.06.03 Power Transformers

A. All transformers shall be of a dry type, and convection cooled, in accordance with PRIIA Drawing 305-806. Calculations shall be provided to demonstrate that the transformers provided have sufficient capacity to supply their intended loads. All inputs and outputs shall be circuit breaker protected. [CDRL 13-005]

B. At a minimum, the following types of transformers shall be provided:

1. All car types: Set of three single-phase 480/120VAC transformers connected delta-delta, ungrounded, to provide 120VAC service.

2. All transformers may be located on the undercar, inside the electrical lockers or inside equipment rooms. The Contractor shall demonstrate by calculation that there is sufficient ventilation to prevent transformer failure and/or damage resulting from excessive heat buildup, during all operating conditions.

3. Transformers shall be de-rated at least 10% for current, or other appropriate approved factor, based upon duty cycle.

13.07 120 VAC Power Distribution

13.07.01 General

A. The 120VAC power shall be distributed within the car utilizing three 480/120VAC step down transformers, and switch and circuit breaker panels located in the electrical equipment lockers. Power is controlled and fed to all 120VAC loads through this system.

B. A main circuit breaker shall control power distribution to all 120VAC circuit breakers.

13.07.02 Passenger Convenience Outlets

A. A flush-style 120VAC duplex convenience outlet with dual USB ports shall be installed in the wall panel at each seat pair location using the GFCI circuits. Outlets shall be located on the sidewall 24 in. (610 mm) forward from the front of the seat back. The outlets are intended to provide power for passenger electronic equipment, such as laptop computers.

B. Two duplex outlets with dual USB ports shall be installed at each table, located such that the table or seat does not interfere with access to the outlet. Power strip conduit and cover are to be powder-coated in a color approved by the Engineer [CDRL 13-006]. An Engineer approved 120V decal, per PRIIA Specification 305-909, shall be installed on the power strip conduit cover at each outlet location, 0.5 in. (12.7 mm) from outlet, between the outlet and the seat facing the outlet. [CDRL 13-007]

C. The passenger convenience outlets in each car shall be protected by four separate power circuits, each of which shall be equipped with a 20-amp GFCI breaker with test and reset buttons. The convenience outlets on each car shall be evenly divided into the four power circuits.

13.07.03 Interior Service Outlets

A. Duplex service outlets shall be located by the sink in each toilet room, outside each toilet room, near the luggage tower, in each electrical locker and in each utility locker in all car types. The cab area of the cab car shall also be equipped with service outlets as specified in Chapter 16. These 120VAC outlets shall be the type with a visible trip indication pilot light.

B. The duplex outlets inside the toilet room, outside the toilet room and in the operating cab shall be equipped with a spring-loaded water-proof cover over each outlet.

C. The car's 120VAC service outlet circuit shall be protected by a single 20-amp GFCI type circuit breaker rated for 120VAC, single phase, 60 Hz.

13.08 Battery Charger

13.08.01 General

A. A solid-state 74VDC, battery charger shall be provided. The battery charger shall be mounted under the car in an equipment box, near the battery box, oriented so that the indicator lights can be seen from outside the car with the equipment box open. The battery charger shall be rated appropriately for the DC load it will be supplying.

B. The battery charger provides DC power to support all 74VDC loads while the car is operating with HEP on. With the loss of HEP or the failure of the battery charger, the battery charger automatically transfers the 74VDC load to the battery system. The battery charger provides for charging of the battery system whenever HEP is available.

C. The 64/74VDC battery and battery charger system shall be responsible for feeding car loads and systems which must be available for operation independent of the availability of the 480VAC HEP, such as public address, side and end door systems, standby lighting, cab functions, and others, as specified in Table 13-3.

D. The battery and charger system is comprised of:

1. Battery charger with temperature sensor
2. Battery (multiple cells)
3. Load drop device

E. The same battery type and battery charger shall be used on all car types.

13.08.02 Operation

A. The battery charger shall be connected in parallel to simultaneously charge the battery while supplying power to the car DC bus. The charger shall incorporate two modes of operation, current limit and float, the latter when the output voltage is regulated at a battery temperature-compensated value.

B. The charger shall be sized with sufficient capacity to simultaneously recharge the battery from a fully discharged state and to support the maximum possible DC bus loads plus a 25% reserve beyond the worst-case continuous load condition. Recharge time of a fully discharged battery shall not exceed five hours to reach at least 80% of capacity at 77°F (25°C), with all normal car DC loads on. On the cab car, this includes radio, headlights and crossing lights, cab signal/ATC/PTC, event recorder and all cab loads from an active cab.

C. The Contractor shall provide at design review a load budget assessment that includes calculations to demonstrate that the charger provided has sufficient capacity to meet these needs. [CDRL 13-008]

13.08.03 Basic Charger Characteristics

Basic charger characteristics shall include the following:

Input Voltage	480VAC nominal (tolerance range +10%/-15%), 3-phase, 3-wire
Input Frequency	60 Hz nominal (tolerance range 56-64 Hz)
Input Protection	3-pole circuit breaker (external reset)
Output Voltage Temperature Compensated	73.6VDC at 68°F (20°C) ambient; 80VDC maximum
Temperature Compensation	In accordance with the battery manufacturers recommendation.
Ripple	Maximum of 2 volts peak-to-peak any load within rating
Audible Noise	62 dBa maximum for components mounted inside the car
Ability to automatically recharge the battery from any state of discharge, including 0 volts on battery terminals.	
Charging voltage ambient temperature compensated as sensed at the battery.	
Following a HEP power outage, the charger shall restart with a reduced current load for a period of	

time after restoration of HEP in order to minimize the short-term startup HEP load.
Only a single circuit board, containing all charger control functions

13.08.04 Circuit Breakers

The charger shall be equipped with two circuit breakers on the front face, one for the battery charger output and one for the battery protection and isolation.

13.08.05 Indicators

A. The charger shall include individual status indication LEDs that are displayed from the front face. These shall include:

Supply 480VAC On	Green
Current Limit (in current limit mode)	Amber
Load Dump Relayed Energized	Amber
Supply 480VAC off/out of tolerance	Red
Rectifier Failure	Red
Temperature Sensor Failure	Red

B. A lamp test pushbutton shall be provided, which when pressed will cause all lamps to light.

C. The charger shall include three meters on the front face:

DC Amps (total charger output)	0-100 amps
Battery Amps (current into/ out of battery)	100-0-100 amps (zero center)
DC volts (charger output voltage)	0-100 volts

D. The charger shall include a local battery charger fault indicator. The single red LED fault light shall be illuminated under any of the following conditions: 480VAC failure, rectifier failure or temperature sensor failure.

E. All metered information, diagnostics, and fault information shall be recorded and available remotely through the CCU and the ETB network.

13.08.06 Self-Protection

At a minimum, the charger shall be self-protected against the following fault conditions:

A. Open circuited battery or wiring

B. Short circuited battery or wiring

C. Battery ground fault

D. Temperature sensor fault

E. Low input voltage

F. Input phase loss

G. Reversed phase rotation

H. Reversed battery connections

I. System overload

J. Voltage or current over limit

13.08.07 Temperature Sensor

The temperature sensor shall be sealed and mounted onto one of the intercell plates of the battery.

13.08.08 Operation of Battery Charger

Operation of the battery charger is as follows:

A. **Normal:** 480VAC HEP "ON"; DC system "ON"

1. All AC and DC loads available
2. All DC loads fed by battery charger

B. **Standby:** 480VAC HEP "OFF"; DC system "ON"

1. Battery voltage above 58 VDC
2. All DC loads fed by battery
3. Immediately after loss of HEP, the car shall go into standby mode, where most of the car lighting, all doors and the communications system remain in operation. All cab equipment and exterior lighting shall also remain operational. See Load Shed in Table 13-3.

C. **Emergency:** 480VAC HEP "OFF"; DC system "OFF"

1. Battery voltage below 45VDC
2. All DC loads are without power because the load shed device has disconnected the battery system, or the battery system is disabled due to equipment failure.
3. In emergency mode only independently powered emergency lights remain on. See Chapter 11 for details.
4. Upon restoration of HEP, all DC loads shall be available immediately, including those that were disconnected as part of standby, emergency or load shed. DC load transfer by the battery charger shall be independent of the state of the battery when HEP is available.

13.08.09 Load Shed Device

The battery charger shall be equipped with a switching device, which shall shed load from the battery as follows:

Load Drop Device: Opens as the battery voltage falls below approximately 45VDC (the battery is essentially discharged.); except for essential load on a cab car, such as radio, and other safety related systems, as defined by CTDOT. This device disconnects DC loads, so the battery is not damaged by running cell voltage to zero (0). Independently powered emergency light fixtures turn on automatically upon Load Drop. This condition is called Emergency.

13.09 Battery System

13.09.01 General

A. The battery shall provide power for necessary systems when the HEP system is not available.

B. The battery system shall be compliant with APTA-PR-E-RP-007-98.

13.09.02 Batteries

A. The Contractor shall submit a battery design that:

1. Meets the load requirements found in Table 13-3 with at least 25% extra capacity;
2. Provides the longest life-cycle cost effective system; and
3. Provides the latest technology that is available in passenger rail battery design.

B. All car types shall utilize the same type of battery cell. The batteries shall be recharged by the battery charger as specified above.

C. Batteries shall be nickel-cadmium (Ni-CAD), lithium ion or nickel-metal hydride, whichever provides the most optimum performance as specified.

D. The batteries shall be housed in cases of a fire-retardant design. The batteries shall be a low-maintenance type and shall not require the frequent addition of electrolyte. The battery system may utilize a centralized electrolyte fill apparatus.

E. The battery shall be designed to minimize hazards to operating personnel during service, operation, line maintenance and shop maintenance.

13.09.03 Battery Performance

A. Nominal battery voltage of 64VDC shall be provided to the DC power distribution system in each car when HEP is not present and the batteries are fully charged.

B. The batteries shall have a design service life of no less than four years and shall be capable of withstanding a minimum of 1000 deep cycles without failure. A deep cycle shall be defined as discharging the battery to 0.8V/cell and recharging it to 80% of its rated capacity at 77°F (25°C) in no more than five hours.

C. The battery system shall be sized to carry the full DC load after loss of HEP, as defined in Table 13-3 (standby mode) for no less than two hours. After load shed, battery shall be disconnected from the DC load and the car shall go into emergency mode for 90 minutes. The battery system shall provide a 25% power safety margin above the calculated load. On cab cars, the DC load shall include all cab loads plus headlights and auxiliary lights.

D. A DC load budget shall be developed by the Contractor and submitted to the Engineer for approval during the design review process, demonstrating that the battery system as proposed meets all requirements and provides adequate capacity for the required loads for the required duration. [CDRL 13-009]

13.09.04 Battery Markings

A. Each battery cell or battery unit shall be permanently marked with the following information:

1. Manufacturer's name

2. Battery type
3. Catalog or part number
4. Nominal rated capacity at five- and eight-hour discharge rates
5. Serial number
6. Date manufacture
7. Customer name
8. Customer part number
9. Warning and safety precautions (i.e. USE NO ACID, etc.)
10. Blank space where installation date can be written

B. Markings shall be resistant to the chemical and mechanical environment encountered in service for the design life of the cell.

C. Polarity of the positive cell terminal shall be identified by a red post insulator or bushing and/or a plainly marked P, POS or + symbol. Polarity or the negative post shall be identified with a black post insulator or bushing and/or a plainly marked N, NEG or - symbol.

13.09.05 Battery Enclosure

The batteries shall be housed in an approved rattle-proof stainless-steel battery box located under the car floor, adjacent to the car side in an approved convenient location. The battery box shall be of adequate size to accommodate a crated battery from at least two suppliers. Ventilation holes shall be provided. The battery shall be mounted for ease of replacement and maintenance. All cells shall be fully and easily accessible for servicing. The cover shall be hinged and be reasonably watertight. Means should be provided within the box to prevent lateral and longitudinal movements of the battery using approved fire-resistant material. The box floor shall have a drain inboard of the running rail. No combustible material shall be used for the trays or cell blocking. The cells shall be installed such that the plates are parallel to the sides of the car. The battery trays shall be mounted on a robust locking slide-out tray for ease of servicing. The rearmost cells shall have vertical line of sight visibility to the filler caps well clear of the side of the carbody when the tray is extended. Sufficient slack shall be provided in the battery cables to permit tray movement, and anti-chafing materials shall be applied to prevent damage to the cables. Use of cable disconnect plugs for tray movement is prohibited. The tray shall lock in the fully extended and fully retracted positions, with a safety latch. Fiberglass or other approved fire resistant easily replaceable filtering media shall be applied to ventilation openings to prevent dust ingress due to car motion. The battery box shall be completely self-draining to allow flushing of the battery with water. Wire terminations shall be both labeled and color coded red (for positive) or black (for negative).

13.10 DC Power Distribution System

13.10.01 General

Power for all DC loads shall be distributed throughout the car through switch and circuit breaker panels located in the electrical equipment lockers.

13.10.02 74VDC Power System

Systems and components that are operated on 74VDC shall be powered from the battery charger through a power distribution system that includes control switches, circuit breakers and load shed, and load drop relays

located in the electrical locker. Circuit breakers shall be sized and labeled according to their circuit and function. A master circuit breaker shall control power distribution to all 74VDC circuit breakers.

13.10.03 24VDC Power System

Passenger reading lights shall be powered from 24VDC. A DC-to-DC converter shall be used to convert DC power as supplied from the battery charger or batteries (74VDC to 58VDC) to 24VDC for the reading lights. Power shall be provided to the reading lights when the car is in standby mode. The reading lights shall be protected by a dedicated 24VDC circuit breaker.

13.11 Electrical Panels

13.11.01 General

A. An electrical locker shall be provided in all car types. All control switches, circuit breakers and indicators shall be located in this locker unless specified otherwise.

B. All circuit breaker and switch panels shall meet all recommendations of APTA-PR-E-RP-002-98.

C. The circuit breaker panels shall be dead front type, with removable front covers, of a design such that all components are front serviceable. Bus bars shall be arranged to have tapped holes along their entire length and be of a design such that all phase combinations are available at each circuit breaker site. Circuit breakers shall be arranged so that the handles move vertically, with the ON position up.

D. The panels shall be conveniently located, in the electrical locker, for ease of access by service personnel. Reduced wiring and ease of maintenance shall be of prime consideration. If it is impractical to house all circuit breakers in the electrical locker, additional circuit breaker panels may be proposed for Engineer approval.

E. A wiring gutter or tie bar rail shall be provided along the top, sides and bottom, for the routing of high-voltage leads to their designated circuit breakers.

F. The circuit breaker panel shall be configured for easy removal so that maintenance and repair action are not impeded.

13.11.02 Switch and Circuit Breaker Panel Arrangement

A. Each circuit breaker panel shall carry apparatus arranged to be easily accessible to connections and designed to prevent an operator from coming in contact with live voltage when operating switches or circuit breakers.

B. All switches and circuit breakers shall be provided with a nameplate clearly identifying the electrical circuit it controls. The ampere rating for each circuit breaker shall be indicated on the toggle lever. All circuit breakers and switches shall indicate ON with toggle up and OFF with toggle down.

C. Circuit breakers for the 74VDC, 120VAC and 480VAC power distribution systems shall each be grouped with their respective voltage and be labeled according to the appropriate voltage. A master circuit breaker shall be provided for each voltage level.

13.12 Vehicle Monitoring System (VMS)

13.12.01 General

A. The Vehicle Monitoring System (VMS) shall collect status and failure data from vehicle subsystems and components, display train configuration and status information on the Drive Display Unit (DDU) in each cab console and on the OTIS/PISCU touchscreen as a Maintenance Display Unit (MDU), and store, filter, and display acquired data for crew and maintenance use. This system shall monitor and report the health of the various systems on the car as specified. An event log shall be stored inside the Vehicle Monitoring System on a Solid-State Drive (SSD) of at least 120GB in size. The DDU and MDU shall implement displays through a Web-based User Interface (WUI) for viewing the data stored and accessing system functions. The VMS shall communicate to periphery devices through the Ethernet-based Ethernet Car Network. The VMS shall be connected to the Systems Indicator Panel (SIP) and have it give a visual indication and status of designated systems as described in section 11.8. The following systems shall be connected to the Ethernet Car Network and monitored for real-time status, fault data, and diagnostic information for all processor-based systems including at least:

1. Side Doors
2. End Doors
3. HVAC
4. Brakes
5. Cab and Train Controls, including Positive Train Control
6. Trainlines
7. Wheel-slide
8. Water/Waste
9. Battery Charger/LVPS
10. PA/IC/Comm
11. Train to Wayside Communication
12. Passenger WiFi
13. Closed Circuit Television System
14. Automatic Passenger Counting
15. Lighting
16. Event Recorder
17. Train Control Systems

B. The Contractor shall submit a detailed functional system description of the Vehicle Monitoring System to the Engineer for review and approval. [CDRL 13-010]

C. The Vehicle Monitoring System shall operate as the central processing and storage unit for each vehicle. The VMS shall facilitate presentation of safety-critical and operation-critical information to the train crew, including specific presentations that are appropriate for the operator (accessing information via the DDU), and for other train crew (accessing information via OTIS/PISCU as the MDU). The VMS shall also present

maintenance specific information to dedicated maintenances screens to facilitate preventative and corrective repair of the vehicle and train.

D. The VMS shall:

1. Collect status and failure data from vehicle subsystems and components.
2. Exchange data between connected VMS in the same train
3. Display train configuration and status information on the DDU and MDU
4. Permit personnel to request self-tests and data logs from the VMS and the vehicle/train subsystems
5. Store, filter, and display acquired data for operator, train crew, and maintenance use.
6. Provide appropriate system faults to facilitate identification of failures to the LRU level, and where possible, to specific parts within the LRU.

E. The VMS shall not degrade the reliability and safety of other vehicle systems. Operating systems used in the VMS system shall be design for real-time embedded applications and approved by the Engineer. [CDRL 13-011]

13.12.02 System Clock

The VMS shall provide a system clock. The VMS time and date shall be used by all sub-systems within a vehicle The VMS internal clock shall continue to keep time and date while the system is powered off. The backup capabilities of the clock shall last the anticipated service life of the vehicle, or shall be a replaceable item with a minimum lifespan of 8 years. The event recorder shall, in addition to recording VMS time, maintain its own free-running clock not influenced by VMS network time commands. One VMU on each train shall be elected to provide the master clock for the train. The time displayed shall be Eastern Time and shall be automatically adjusted for daylight savings time. The VMS shall have the ability to synchronize to a wayside time server or shall connect to a GPS receiver to obtain an accurate time on a periodic basis. Time zone configuration (including start and end for daylight savings time) shall be configurable by the Engineer.

13.12.03 Fault Management Plan

A. The Contractor shall submit for Engineer review and approval a VMS Fault Management Plan. [CDRL 13-012] The first submittal shall be prior to the Preliminary Design Review and shall be updated and re-submitted prior to the Final Design Review, with updates throughout the warranty period. Events which are not related to any fault but may be useful in isolating a failure shall also be logged and identified in the Fault Management Plan. The Fault Management Plan shall include:

1. Fault/Event listing.
2. Detailed description of each fault.
3. Detail description of the triggering conditions for each fault, including time delays and event counts.
4. Conditions required for a reset of the fault.
5. Detailed description of triggering conditions for subsystem lockout, including time delays and event counts.
6. Conditions required for a lockout reset.
7. Recommended attributes for each fault.

B. The VMS shall differentiate failures of systems from a failure to communicate with a system. The VMS shall include capabilities to limit, interrupt, or otherwise mark fault data logging while the vehicle or train is in the shop. The capability shall allow the shop to see and use fault data in response to tests but shall not include the data in normal data logs. Shop mode shall be manually triggered, with options to automatically re-enter normal mode when the car enters service through means approved by the Engineer.

13.12.04 Fault Attributes

A. Each fault shall be assigned appropriate attributes that define how the subsystem and VMS responds to the fault. Attributes shall permit a fault to be:

1. Logged or not by the subsystem
2. Logged or not by the VMS
3. Trigger a snapshot
4. Transmit associated snapshot to local VMU
5. Transmitted train-wide
6. Transmitted immediately to the wayside
7. Displayed on the DDU
8. Displayed for crew on the MDU
9. Trigger an operator alarm
10. Require operator acknowledgement

B. A minimum of sixteen additional spare attributes, to be named and configured by the Authority, shall be available for future purposes.

13.12.05 Fault Storage

The VMU storage capacity shall be sized such that all recorded failure data including 200 snapshots that occur within a one-hundred-day time interval are saved in non-volatile flash memory in circular buffers without data overwrites. The flash memory shall be designed to last an estimated thirty-year service life. Provision shall be made within the VMS and other data storage devices to take advantage of higher capacity media as it becomes available to prevent obsolescence. The Contractor shall submit worst case memory usage calculations to the Engineer for review and approval. [CDRL 13-013]

13.12.06 Fault Log

A. The VMS shall record status and failure data received from all subsystem through the Ethernet Car Network and Ethernet Train Backbone. All faults and events recorded by the VMS shall include the following associated information:

1. Train make up (car numbers of each of the cars in the train).
2. Subsystem.
3. Fault code.
4. Fault description.

5. Vehicle number.
6. Date and time the fault first occurred.
7. Date and time at which the fault cleared.
8. Car mileage at time of failure.
9. Snap shot file name.
10. Location information, such as GPS

B. Faults which are activate should be tagged as such. The complete dataset recorded for each fault shall be approved by the Engineer. [CDRL 13-014]

13.12.07 Snap Shots

Each microprocessor-based subsystem shall have the ability to record fault or event triggered snapshots of system parameters. The snapshot shall be stamped with time, date, vehicle number, subsystem name, and the associated fault or event. The Contractor shall implement a de-bouncing scheme for snapshot triggering to prevent multiple snapshots from being generated by the same event. The snapshot data from any subsystem shall be retrievable by using a PTE service port. The parameters recorded by each snapshot shall be configurable by the Engineer. The software used to retrieve snapshots shall support the display of recorded data in chart recorder mode, as well as support the export of snapshot data into a format approved by the Engineer. The VMS system shall be capable of recording snapshots which include system parameters from multiple subsystems. The Contractor shall submit the snapshot capabilities of each subsystem, and of the VMS, for Engineer review and approval. [CDRL 13-015]

13.12.08 Equations

The VMS shall provide the capability of user configurable logic equations to provide further capability of isolating and identifying faults. The functionality shall be programmed by using a user-friendly equation editing tool. The Contractor shall submit, for Engineer review and approval, the equation capabilities of the system. The Contractor shall also submit the design of the software utilized for creating and managing equations. [CDRL 13-016]

13.12.09 VMS Displays

A. The Driver Display Unit (DDU) in each cab, and the OTIS/PISCU (defined in Section 12, which shall operate additionally as the Maintenance Display Unit (MDU)) in each car shall be of rugged heavy-duty construction with hardened touchscreen display. The protected display shall be impervious to liquids, dust, and heat. The displays shall be readable in both direct sunlight and total darkness and shall be LCD with LED backlight and adjustable (automatic and manual) contrast and backlight intensity with a resolution of at least 1024x768. The DDU and MDU communication with the vehicle network, Communication System, and Vehicle Monitoring System shall be via IP/Ethernet. The VMS, DDU, and MDU shall be powered from the DC Power Distribution System.

B. The information provided on the DDU and MDU shall include train status and failure information in an organized manner based on the needs of operating and maintenance personnel who will use the information, including the train operator, the train conductor, maintenance shop workers, and engineering. The design and layout of the operations, maintenance, and engineering level screens shall be submitted for approval be the Engineer. [CDRL 13-017]

13.12.10 Networks

A. Each intelligent device shall communicate with and report faults, status, and parameter data to the VMS over the Ethernet Car Network.

B. The VMS system shall be configurable such that the design is extensible, with the understanding that additions and subtractions of systems on the vehicle, as well as the types of vehicles the train will interface with, will occur throughout the life of the vehicle. Each vehicle shall have a Universal Service Port (USP) which provides access for authorized maintenance personnel to connect a laptop to any end station or switch on the vehicle or in the train consist through an X coded M12 connector providing a Gigabit connection.

C. All networks shall be based on the 7-layer Open Systems Interconnection (OSI) model. Full documentation of each layer for each network shall be provided in a non-proprietary Network Interface Control Document to be submitted prior to Preliminary Design Review. The document shall be updated with all changes through testing and through the end of the warranty period. [CDRL 13-018]

13.12.11 Network Coupling

The VMS shall utilize the Ethernet Train Backbone for train initiation and sequencing, obtaining the car numbers of each vehicle in the train. The train makeup function shall be capable of identifying the number, sequence, and orientation of each car in a train of up to twelve cars. The Ethernet Train Backbone shall detect and report any dead cars and their location in the train. When vehicles are coupled or uncoupled, the Ethernet Train Backbone shall automatically reconfigure itself for the new train configuration. Fault and event messages pertaining to the disconnected vehicles shall be removed from display on the DDU and MDU.

13.12.12 Protocol Analyzer

A. The Contractor shall provide a laptop based Protocol Analyzer for Engineer use to perform real-time monitoring of network activity on all networks provided under this contract, including networks between subsystem components. The Protocol Analyzer shall:

1. Displaying all network data in engineering units.
2. Setting of capture filters to limit the recording of telegrams to only the ones that are targeted.
3. Providing a visualization of the protocol stack in adjustable levels of detail.
4. Developing and displaying statistical reports on traffic, errors, protocol types, etc.

B. The Contractor shall submit for Engineer review and approval the capabilities of the Protocol Analyzer for each Network. [CDRL 13-019]

13.12.13 Node Replacement

Each device on the vehicle shall implement a unique device ID using external static ID scheme that shall identify the device and its location, such that no configuration is required when devices are replaced. When nodes on the network are replaced, the network system shall automatically identify the replacement equipment and its communications links (e.g. network settings). Replacement of intelligent networked devices shall not require any configuration of the device or of vehicle/train switches. The use of a port-bound device ID shall be limited to CCTV Cameras of the same type.

13.12.14 Network Cables

The Contractor shall provide shielded two-pair Category 6 cables for 100Mbps connections and shielded four-pair Category 6A cables for all 1Gbps connections. All cable connections to subsystems and switches shall be made using crimped M12 connectors, 4-pin D-coded for 100Mbps devices, and 8-pin X-coded for 1Gbps devices. A common crimp contact cable-end connector manufacturer and part number for each Ethernet network connector type shall be submitted for approval by the Engineer and used throughout the vehicle on all subsystem and network switch connections. [CDRL 13-020] During production of each railcar, the network path from the network switch to each end device shall be tested and certified to meet TIA/EIA-568 category

standards at Category 6 for 100Mbps connections, and Category 6A for 1Gbps connections. The test results shall be included in each car history book.

13.12.15 VMS / ETB Extensibility

The VMS and Ethernet Train Backbone shall be designed to be extensible, with the understanding that additions and subtractions of systems on the vehicle, and of vehicle fleets which connect to the vehicle, will occur throughout the life of the vehicle. The VMS shall be configurable to add and remove systems without requiring modifications to system source code. Through a defined interface, systems added to the Ethernet Consist Network shall be capable of full integration with the VMS system. Similarly, the VMS shall be designed to enable future fleets to add displays to the DDU and MDU to facilitate, as well as allow access to the monitoring, diagnostic, and status information of the vehicle to the displays integrated on future fleets.

13.13 Integrated Schematics

The Contractor shall prepare and submit, for acceptance by the Engineer, an integrated schematic and wiring diagram package showing all electrical systems and including all components, wiring and circuit breaker (nominal and peak) on the car. See Chapter 22. [CDRL 13-021]

Table 13-1: Communication (COMM) Trainline Pin Assignments

Pin	Description	Code	Comment	Wire Size
1	Shield (PA)	SHLD	All shields from TW-SH-PR are terminated at the B-end of the cars, only.	#12
2	BATT NEGATIVE (car)	TB-		#10
3	PA-Tape 1	PA1	(*) cross with 4C	#14
4	PA-Tape 2	PA2	(*) cross with 3C	#14
5	Intercom	PA3	(*) cross with 6C	#14
6	Intercom	PA4	(*) cross with 5C	#14
7	PA Control	PA5	(*) cross with 8C	#14
8	PA Control	PA6	(*) cross with 7C	#14
9	Radio-Music 3	PA7	(*) cross with 10C	#14
10	Radio-Music 3	PA8	(*) cross with 9C	#14
11	Brake APPLY	EP1	(Spare-Future Use)	#12
12	Brake RELEASE	EP2	(Spare-Future Use)	#12
13	Brake NEGATIVE	EP3	(Spare-Future Use)	#12
14	Door Open-RIGHT	D1	(**) Cross with 15C	#12
15	Door Open-LEFT	D2	(**) Cross with 14C	#12
16	Door Close-RIGHT	D3	(**) Cross with 17C	#12
17	Door Close-LEFT	D4	(**) Cross with 16C	#12
18	DOORS CLOSED light (Engineman)	DC1	(**) Cross with 23C	#12
19	Brake RELEASED light	BRA		#12
20	Brake APPLIED light	BAA		#12
21	Hot Journal	HJ		#12
22	Conductor Signal Buzzer	CS		#12
23	Door Closed Light	DC2	(**) cross with 18C	#12
24	Tape-Music 2	PA7	(*) cross with 25C	#14
25	Tape-Music 2	PA8	(*) cross with 24C	#14
26	Conductor DOOR Light Feed	BLS		#12
27	Spare (Car Attendant Call Button)	AN	NOT USED	#12
(*) Twisted, Shielded Pairs (2-cond., AWG14): 3C&4C, 5C&6C, 7C&8C, 9C&10C, 24C&25C (in jumper and within car)				
(**) Crossed Trainlines: 14C&15C, 16C&17C, 18C&23C, (in jumper and within car)				
Table is derived from APTA-PR-E-RP 017-99, Table #8.				

Table 13-2: Multiple Unit (MU) Trainline Pin Assignments

Pin	Description	Code	Comment	Wire Size
1	PAN UP	PU	Pantograph UP when in consist with an ACS64 locomotive (Electric Mode)	#12
2	Alarm	SG		#12
3	Governor Solenoid DV	DV		#12
4	Negative Control	N		#10
5	Spare (Emergency Sand)	SP		#12
6	Generator Field Control	GF		#12
7	Governor Solenoid CV	CV		#12
8	Forward (*)	FO	(*) Pins 8 and 9 cross at the F/B-end of all cars	#12
9	Reverse (*)	RE	(*) Pins 8 and 9 cross at the F/B-end of all cars	#12
10	Wheel Slip	WS		#12
11	Spare	SP		#12
12	Governor Solenoid BV	BV		#12
13	Positive Control	PC		#10
14	PAN Down	PD/ PBA	Pantograph DOWN when in consist with an ACS64 Electric loco (Electric Mode)	#12
15	Governor Solenoid AV	AV		#12
16	Engine Run	ER		#12
17	Spare (Dynamic Brake Set Up)	SP/B		#12
18	Spare (**)	RLC	Reserved for Remote Load Meter	#12
19	Spare (**)	RLD	Reserved for Remote Load Meter	#12
20	Spare (Dynamic Brake Warning light)	SP/BW		#12
21	Spare (Dynamic Brake Start)	SP/BG		#12
22	Spare (Compressor Synchronization)	SP/CC	NOT USED	#12
23	Sanding Control	SA		#12
24	Spare (Dynamic Brake Excitation)	SP/BC		#12
25	MU Headlight	HLS		#12
26	Remote Reset	SV		#12
27	MCB Open	SP	Main Circuit Breaker OPEN when in consist with an ACS64 locomotive (Electric Mode)	#12
	(*) Pins 8T and 9T cross at the F/B-end of all cars and within the jumpers (**) Pins 18T and 19T, twisted, shield pair (in jumper and within car)			
	Table is dereived from APTA-PR-E-RP-017-99, Table #2.			

Table 13-3: Power Phase Matrix

Condition:	Normal	Standby	Emergency
Description of Condition	**HEP Power. Normal operation. All systems on and functioning.**	**After loss of HEP. Systems powered by main car batteries. ALL DC loads on.**	**No Battery Power. Lights are independently powered per FRA requirement.**
Timeline	normal	2 hours	90 minutes
Threshold	normal	after HEP loss	after load drop
Battery voltage	normal	64-58V DC	below 45V DC
AC Lights:			
Seating Area	yes	no	no
DC Lights:			
Seating Area	yes	yes	yes
Vestibules	yes	yes	yes
Toilet Rooms	yes	yes	yes
Reading	yes	yes	no
Electrical Locker	yes	yes	no
Exterior Platform	yes	yes	yes
Passageway	yes	yes	yes
Marker	yes	yes	no
Capacitor Lights	no	no	yes
Doors:			
Side Door control	yes	yes 40 sec every 20 min	no
Side Door operators	yes	yes 40 sec every 20 min	no
End Door Controls and Operators	yes	yes 30 sec every 5 min	no
Door Closed Summary Circuit	yes	yes	no
PA	yes	yes 20 sec every 5 min	no
HVAC	yes	no	no

Condition:	**Normal**	**Standby**	**Emergency**
Description of Condition	**HEP Power. Normal operation. All systems on and functioning.**	**After loss of HEP. Systems powered by main car batteries. ALL DC loads on.**	**No Battery Power. Lights are independently powered per FRA requirement.**
Timeline	normal	2 hours	90 minutes
Threshold	normal	after HEP loss	after load drop
Battery voltage	normal	64-58V DC	below 45V DC
HVAC Exhaust Fans	yes	yes	no
Toilet Systems	yes	no	no
Toilet Room Exhaust Fans	yes	yes	no
Destination Signs/PIS	yes	yes	no
Wheel slide	yes	yes	no
Convenience Outlets	yes	no	no
Cab:			
Headlights and Crossing lights (cab only)	yes	yes	No
Cab Radio	yes	yes 20 sec every 5 min	no
Locomotive Control	yes	yes	no
Event Recorder	yes	yes	no
Alerter	yes	yes	no
PTC	yes	yes	no
Lights (Cab only)			
Cab Radio	yes	Yes 20 sec every 5 min	no
Locomotive Control	yes	yes	no

13.14 Contract Deliverable Requirements List

CDRL #	Title	Car Type
13-001	Electrical System Design Details	All
13-002	Network Integrator	All
13-003	Network Architecture	All
13-004	Network Security Analysis	All
13-005	Transformer Calculations	All
13-006	Power strip Conduit and Cover Powder Coat	All
13-007	Power Strip 120V decal	All
13-008	Battery Charger Load Budget Assessment	All
13-009	DC Load Budget	All
13-010	VMS Functional System Description	All
13-011	VMS Operating System	All
13-012	VMS Fault Management Plan	All
13-013	Memory Usage Calculations	All
13-014	Fault Log Dataset	All
13-015	Snapshot Capabilities	All
13-016	Equation Capabilities	All
13-017	VMS Display Layout	All
13-018	Network Interface Control Document	All
13-019	Protocol Analyzer Capabilities	All
13-020	Ethernet Network Connector Details	All
13-021	Integrated Schematic and Wiring Diagram Package	All

* End of Chapter 13 *

Technical Specification

CTDOT Single-Level Passenger Rail Cars

Chapter 14

Food Service [Not Used]

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Technical Specification

CTDOT Single-Level Passenger Rail Cars

Chapter 15

Waste and Water System

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15.00 Water and Waste System

15.01 Overview

A. Each car shall be equipped with a pressurized water supply system, along with a toilet and a constant vacuum type waste retention system. An alternative service-proven water and waste system may be proposed for review and approval by the Engineer. Ease of servicing and maintenance, rapid repair, reliability, resistance to winter freezing conditions, and safety shall be major design considerations. The car shall be successfully able to operate without damage under all specified environmental temperatures and elevations. Significant attention must be given by the Contractor to the design of all water and waste systems for freeze protection using components with long-term durability and protection from debris damage, along with complete and automatic draining of all water from the car in the event of freezing temperatures being encountered with a minimum of specialized hardware being required. The entire car piping system shall be designed and installed from the onset for complete gravity drainage of all water and waste with a minimum of drain valves being required. Inadequate performance of this system will result in significant operational problems, as well as costly equipment freeze damage, which must be avoided by intelligent design of the car systems. All undercar water and waste piping and systems shall be housed within undercar protective enclosures and shall not be exposed. The water and waste systems shall comply with all requirements of this Specification. All details of the entire water and waste system shall be submitted to the Engineer for approval. [CDRL 15-001]

B. All water, waste and sanitation systems on the car shall comply with all Federal regulations, such as the most recent edition of the Federal Regulations for the FDA and Environmental Protection Agency (EPA) concerning general sanitation, water, the toilet and interstate conveyance sanitation, including 21 CFR Part 1250. The Contractor shall arrange for an FDA inspection of the design and completed installation of the water and waste system of each car type to ensure it meets all requirements, in accordance with 21 CFR Section 1250.41. Documentation of compliance is required to be submitted to the Engineer. An approved replaceable cartridge water filter system shall be used to filter all potable water used in the cars, arranged for ease of servicing and replacement. The design of the water system on all car types shall incorporate means to easily permit the introduction of Contractor proposed liquid sanitation compounds to sanitize and flush the entire water system, as periodically required by the FDA. All passenger amenities described in the chapter shall meet the requirements of 49 CFR Part 38 for accessibility.

C. The highest level of winterization protection in the design of the water and waste systems is of great importance. It shall be a mandatory requirement that the cars must be designed to be immune from all aspects of winter operations, with or without Head End Power (HEP) being present. Previous experience has demonstrated the infeasibility in high-speed intercity service conditions of routing water and waste piping under the car in the truck area. The undercar routing of water and waste lines anywhere in the truck area, or outboard from the truck to the end of the car, is prohibited. All water and waste lines for the restroom must be routed through the base of the sidewall in the car interior, from the vestibule restroom to a location well inboard of the A-end truck, at which point the lines shall pass through the floor to the underside of the car, where they shall be protected by the underfloor protective enclosures.

D. Special attention shall be given by the Contractor to the routing of all piping systems to completely facilitate gravity drainage of all water and waste piping. Piping layout shall be performed as part of the first aspects of design work. It is required that the piping systems be designed from the start to provide complete gravity drainage with an absolute minimum of automatic freeze protection valves, manual drain valves and vacuum breakers being required for complete drainage in freezing conditions. It is preferred that only one valve of each type be necessary in the design of the car piping. The routing of all piping above the floor, including sidewall enclosures, shall be lined with stainless steel and sealed watertight against any leakage to the side wall. All water and waste piping above the floor, unless otherwise approved by the Engineer, shall be stainless steel including

connections. Servicing and shutoff valves shall be stainless steel quarter-turn ball valves unless otherwise specified. All piping shall have complete gravity drainage slope from the restroom to the undercar tanks and be securely mounted to sidewall using vibration resistant mountings. All parts of the restroom and its associated water and waste piping shall have complete maintenance access provided to all components. Each component within the car interior of the water and waste system, including the toilet, sinks, drains, all piping and all fittings, shall be designed and installed to be replaceable in a terminal yard within 30 minutes. All piping and tanks shall be installed with attachments which prevent vibration while in service while allowing for thermal expansion and contraction.

E. The complete system shall be fully inspected for leaks before any section is covered with sidewall liners or interior components.

F. Operating conditions occasionally require that a car must be electrically shut down while in train service. When this occurs in freezing temperatures, all heating is disabled and the train crew must verify that all water and waste systems have been successfully drained and are completely protected from freeze damage. This must include all drain lines for all systems where water traps are used. Previous designs have used auxiliary compressed air to blow out all lines after initial draining. The Contractor shall investigate and incorporate into its water and waste system designs the methods to easily permit drainage of all fluid systems on a car while in service. This may require the addition of additional piping connections into the systems. the drainage design shall be verified in the climate room tests to ensure that no damage occurs under these conditions.

G. Each water consuming device inside the car, such as each sink, shall have an individual stainless steel quarter-turn shutoff valve located adjacent to the device that can easily and logically accessed by the train crew without the use of tools, to deal with in-service failures during train operation. Each shutoff valve shall have an exterior locker identification label and shall have complete identification and operating instructions on the valve itself.

H. Complete details of the water and waste systems on all car types shall be presented to the Engineer for approval during design review, and they shall be included in the interior mockups. This shall include maintainability analysis and access provisions, and winterization details. Prior to car delivery, the Contractor shall completely clean and sanitize the entire water and waste system on the car, then completely drain all systems to permit the car to safely be exposed to subfreezing shipping and storage conditions without damage.

15.02 Water System

15.02.01 General

A. Each car shall be provided with a pressurized water system which will supply hot and cold potable running water for various crew and passenger needs. The water supply system shall supply water for hand washing and waste disposal. The design and materials shall be approved by the Engineer. Particular emphasis shall be placed on meeting the winterization and maintainability requirements of Chapter 15. [CDRL 15-002]

B. The water system shall be pressurized using filtered air derived from the air brake main reservoir system. Water system pressures shall be 20.0 pounds per square inch (gauge) (psig) (1.4 bar) (nominal) for potable water and 30.0 psig (2.1 bar) (nominal) for toilet flushing, or other levels as approved by the Engineer. Backflow and back siphon protection shall be provided in accordance with Chapter 15. The entire water system shall conform to FDA and USPHS regulations. Plans for construction of the water system shall be submitted to the FDA for review for conformity with FDA requirements. The water system shall include water tanks, fill system, drain system with freeze protection valves, protective heaters, water pressurization equipment, filter, water distribution piping

with service valves, water cooler, water heater and thermal insulation. Means for complete freeze protection, system drainage, maintainability and periodic sanitation shall be included. Both the water storage tank system and the hot water tank shall have a manual drain valve, a manual shutoff valve, an American Society of Mechanical Engineers (ASME) pressure relief valve and a freeze protection automatic drain valve. The water raising system shall have an ASME pressure relief valve, a check valve and pressure reduction valves.

C. A fill status indicator shall be provided. The approach shall be reviewed and approved by the Engineer.

D. A water hose connection shall be provided under the sink. The spigot shall be equipped with a ball valve and shall be located behind a locked cabinet. The hose connection shall allow water to flow from the water tank or fill location at the exterior of the coach. A suitable valve shall be provided to select the water source.

E. Sink water supply shall be disabled when the waste tank level sensor indicates 2/3 full or the water level falls to 1/3 full.

15.02.02 Capacity

The water storage capacity shall be a minimum of 112 gal (424 L). The required storage capacity may be provided in one or more tanks.

15.02.03 Storage Tanks

Storage tanks shall be stainless steel and include internal baffle plates. They shall be located under the floor in the equipment enclosure, fully covered with water resistant fiberglass insulation, supplied with protective heating for winter operating conditions, and be enclosed in protective shrouding. All storage tanks shall be constructed in accordance with the latest revision of Section VIII of the ASME Boiler and Pressure Vessel Code for Unfired Pressure Vessels at a setting pressure of 75.0 psig (5.2 bar). The tanks shall include an inspection cover that may be removed to inspect the tank interior. Complete gravity drainage provisions shall be incorporated into the design. All tanks shall be refillable from a single fill location on both sides of the car exterior. Each storage tank shall have a manual drain valve, a manual shutoff valve, an ASME pressure relief valve and a freeze protection automatic drain valve. All valves must be accessible by a train crew member standing alongside the car.

15.02.04 Freeze Protection

A. The freeze protection system shall consist of insulation, protective heaters, valves, self-draining pipes and similar devices configured to provide the required protection. The system shall have sufficient capacity to permit train operation without damage or failure to -40°F (-40°C) exterior ambient. There shall be 25% excess capacity of insulation to allow for time-related deterioration. The freeze protection system shall be designed to permit pipes and fittings to be disassembled for maintenance and repairs without removing the entire protective system. The freeze protection system shall be fully automatic in operation, and not require any train crew or maintenance personnel action to activate or reset.

B. The water storage tanks and all water supply components exposed to ambient temperatures shall be protected against freezing by electrically powered self-regulating heat tape and thermal insulation. To prevent unnecessary electrical consumption, all heat tapes shall be supplied electrical power only when the exterior ambient temperature is below 45°F (7.2°C). Light Emitting Diode (LED) indicator lights shall be provided in the electrical locker inside the car to indicate the operating status of the heat tape systems.

C. The water system in each car type shall be freeze protected to enable the car to be shut down from Head End Power (HEP) and heating discontinued indefinitely in subfreezing temperatures, with no

damage resulting to any component of the water system under any condition. Complete manual means shall also be provided to permit a car to be fully drained when desired. The entire car water system, including its piping and all appliances, shall be free-draining and shall avoid arrangements where water may become trapped upon activation of the drain valve. Automatic vacuum breaker valves shall be installed at all elevated points and other locations as necessary to permit complete venting of the system when draining. The system shall be designed and geometrically arranged so as to only require the absolute minimum of drain valves. It is desired that only one manual drain valve and one automatic drain valve be required in the design of the car. All pipe insulation shall be water resistant.

D. The freeze protection system shall use an automatic, self-contained drain valve which will automatically open when sensing an adjacent ambient air temperature of approximately 38°F (3.3°C) (temperature falling) and close at 40°F (4.4°C) (temperature rising) when there is no electrical power on the car. The drain valve shall be equipped with a quick warm-up heater to close the drain valve when HEP is available, to allow a car in freezing temperatures to be immediately watered when placed on electrical power. The automatic drain valve shall be a heated Ogontz valve, or equivalent.

E. All electrical heat tape shall be of an automatic self-limiting 120 VAC design which can be cut to length from bulk rolls for replacement. All connections shall be made using the manufacturer's watertight splicing kit, and each individual length shall be terminated with the manufacturer's LED power indicator light, consistently orientated on all cars so as to be easily inspected from the side or interior of the car.

F. All details of the freeze protection system shall be submitted to the Engineer for approval during design review. [CDRL 15-003] Maintainability aspects of the system shall be demonstrated on the interior mockups.

15.02.05 Water System Fill Locations

A. Maintaining high-levels of sanitation of the water system fill points is of great concern to the Engineer. All water fill stations shall be easily cleanable, and so located and protected as to minimize the hazard of contamination of the water supply. The water fill controls shall operate in a similar fashion as existing CTDOT rolling stock.

B. A water fill point shall be provided on each side of the car at an approved location, recessed into the underfloor equipment shroud at approximately the midpoint of the car. Each fill station shall be mounted in a recessed stainless steel enclosure and covered with a spring loaded top hinged weather-tight stainless steel gasketed cover. The cover shall be labeled and equipped with over-center springs to securely keep the cover either open or closed. The bottom surface of the enclosure shall be sloped to the outside of the box and have a smooth curved outer joint to the faceplate to allow drainage. The fill points shall be located and self-protected to minimize contamination hazards arising from wastewater system discharge, dust, dirt and debris. The design of the water fill point shall be adequately dimensioned for ease of use by maintenance personnel wearing heavy winter gloves.

C. The water fill point itself shall be a barbed male nozzle, which shall be enclosed in a blue painted metal housing with a self-closing cover. Adjacent shall be a three-way water system pressurization valve, in compliance with the requirements of Amtrak AAMPS catalog number 22 946 70710. This valve must have the enlarged vent port design to permit rapid venting of the water tank within seconds. The valve shall have two positions, FILL and WATER. In the FILL position, the valve shall cut off tank pressurization air, rapidly vent the water tank and permit filling the tank. This will allow the tank to be filled via a check valve located immediately behind the fill nozzle. The system shall permit complete filling from one side of the car, without requiring access to the other side of the car. When the water tanks are completely filled, the excess water shall be directed to the bottom of the undercar enclosure and easily visible from the side of the car. When the valve is placed in the WATER position, the vent will be closed, and air pressure applied to the water in the tank. The air valve and check

valve shall be enclosed behind sheet metal, easily serviceable from the front, with only the valve operating handle exposed.

D. The water fill point shall be compatible with existing CTDOT filling equipment and shall be designed for a maximum fill time of 10 minutes. The system shall permit existing CTDOT wayside water fill lines to be used without modification. A manual drain valve shall be provided to permit the water tanks to be flushed and drained. Complete identification signage and refill instructions shall be provided. All potable water lines shall be isolated from flush water lines through appropriate valving.

15.02.06 Hot Water

A. The hot water system shall provide hot water for the restroom. The water heating system shall be capable of providing one gal (4 L) of water heated to 110°F (43.3°C) at every faucet. The hot water storage tank shall be stainless steel or other corrosion resistant approved material, be suitably insulated and include internal baffle plates. It shall be constructed in accordance with the latest revision of Section VIII of the ASME *Boiler and Pressure Vessel Code for Unfired Pressure Vessels* at a setting pressure of 75.0 psig (5.2 bar). Complete gravity drainage provisions shall be incorporated into the design. The storage tank shall have a manual drain valve, a manual shutoff valve and a freeze protection automatic drain valve. The manual valve controls shall be easily reached by a train crew member standing alongside the car. An accessible thermostat shall be provided, and the tank shall be equipped with low water protection. The hot water heater elements shall operate from 120VAC power supply and shall be easily replaceable with the tank installed in the car. No damage shall result to the hot water heater if the water supply is cut off, it runs dry or if electrical power is disconnected in freezing conditions. The heater shall be equipped with an ASME temperature and pressure sensitive relief valve, along with a separate caged fusible plug safety relief device. Both devices shall be piped to drain under the car between the rails clear of other equipment and shall be arranged for ease of replacement in less than one hour as installed on the car.

B. Alternatively, a tankless water heater may also be proposed for consideration by the Engineer. Details, benefits and detractions, service proven history, and a conceptual arrangement shall be provided for design review.

15.02.07 Not Used

Not Used.

15.02.08 Undercar Shroud

All undercar components of the water system, including piping, shall be enclosed in a corrosion resistant shroud to protect against impact and debris damage and to aid the freeze protection system. It shall comply with the undercar enclosure requirements of Chapter 4. The shroud shall be configured to allow for condensation drainage and must allow easy access to the water system for all maintenance. The shroud shall be sealed to keep all insulation dry. The design of the shroud system shall be approved by the Engineer. [CDRL 15-004]

15.02.09 Piping

All water system piping and fittings, unless otherwise approved by the Engineer, shall be seamless stainless steel tubing in the longest possible continuous length without joints. Anti-water hammer air chambers shall be provided as required. Waterproof plastic identification labels shall be applied to all piping where connections are made to valves or devices. All water supply piping shall comply with the requirements of Chapter 18.

15.02.10 Water Backflow Checks

The water system shall be configured to prevent water backflow into the water raising system under all conditions, in compliance with Federal regulations. Engineer approved backflow and back siphon protection devices meeting American Society of Sanitary Engineers (ASSE) standards shall be installed at all points of connection between potable and non-potable water systems, and at all points where potential backflow or back siphon conditions may occur.

15.02.11 Water Raising

A. The water system shall use auxiliary compressed air supplied by the car's main air reservoir through an approved governor and regulator valve to pressurize the water system, per Chapter 07. A desiccant type air filter with automatic drain and oil removal filter shall be provided to remove all contaminates and moisture from the air supply to the system. The arrangement shall easily allow replacement of the filter from the side of the car. Air pressure for the water raising system shall be set for 45.0 psig (3.1 bar) (nominal). All air regulation valves shall be mounted above the top of the water level in the storage tanks. An ASME pressure relief valve shall be provided.

B. The potable water supply to the sinks shall be provided through a check valve and pressure reduction valve set at 20.0 psig (1.4 bar) (nominal). The potable water supply used for toilet rinse water shall be separately taken from the water supply tanks through a check valve and pressure reduction valve set at 30.0 psig (2.1 bar) (nominal). The potable water supply used for toilet retention waste tank rinse water shall be separately taken from the water supply tanks through a check valve, and the pressure shall be unregulated. All settings shall be easily accessible for inspection with pressure test ports being provided, and backflow protection shall be provided.

15.02.12 Restroom Sink Supply

Hot and cold water shall be piped to the sink faucet in each restroom, which shall incorporate a mixing valve to provide warm water only. The faucet, operable with one hand, shall provide warm water to the sink. All exposed parts shall be stainless steel. All fixtures, dispensers and appliances shall be constructed in accordance with the requirements of USPHS. The faucet design shall be approved by the Engineer. [CDRL 15-005] See Chapter 9 for additional details.

15.03 Waste Retention System

15.03.01 General

A. A Waste Collection and Retention System (WCRS) shall be provided on each car for the handling of human wastes. It shall vacuum collect into an undercar waste holding tank system all toilet system waste from the restroom. All waste collection fixtures and components shall be constructed in accordance with the requirements of 21 CFR Part 1250 and USPHS.

B. The drain water from all restroom sink drains shall be piped to the waste retention tank Freeze protection heat tape per Chapter 15 shall be applied.

C. Waste incineration is not permitted. All toilet system piping, the waste tank and all associated fittings, drain piping and serving valves shall be manufactured from a stainless steel type suitable for sewage service. All servicing valves shall be quarter-turn stainless steel ball valves with full diameter port openings.

D. The WCRS shall be a vacuum system with sufficient capacity to collect and retain all waste water generated on the car during a 48-hour period in a single tank, for discharge at a wayside dumping facility. Minimum waste capacity shall be 120 gal (454 L), and shall be verified during design review. Electrical and plumbing connections shall be designed so that components can readily be installed,

removed and exchanged. Modular construction shall be utilized in the design of all components and subassemblies. No special tools, other than those normally available to service mechanics, shall be required for maintenance or replacement of system components. The waste collection system shall meet the noise requirements and shall not generate rattles or excessive vibration. As there are frequent foreign object blockages of the toilet system encountered in CTDOT service, numerous easily accessible leak-tight access caps and cleanout ports shall be provided in all waste system piping to easily permit the removal of clogs by maintenance staff during servicing stops.

E. The tank and all piping shall be designed to prevent damage from freezing. The waste system shall be designed to operate over all operating and environmental conditions specified by PRIIA Specification 305-912. The design and materials shall comply with the requirements of this Specification. Particular emphasis shall be placed on meeting the winterization and maintainability requirements of Chapter 15. Plans for the toilet and waste retention system shall be submitted to the FDA for review for conformity with FDA requirements. Complete details on the system design shall be presented to the Engineer for approval during design review. [CDRL 15-006]

15.03.02 System Requirements

A. The WCRS shall be designed with a minimum service life of 30 years, a minimum overhaul cycle of 8 years and a minimum maintenance cycle of 1 year. The system shall be mounted under the car, and all its components shall be designed for failsafe operation and protection of passengers, crew, service personnel and equipment. Ease of servicing and maintenance, reliability and safety shall be major design considerations. The WCRS shall be designed to operate from sea level to 5,000 ft (1,524 m) elevation.

B. The vacuum pump motor shall operate from 480VAC, 3-phase, 60 Hz. All motor controls, solenoid valves, relays, contactors and antifreeze protection shall operate from 120VAC, single-phase, 60 Hz. All indicator devices and tank rinse controls shall operate from 72VDC with or without the presence of the HEP supply.

C. Fresh water shall be provided for toilet flushing in the amount of 8 oz (237 ml) per flush at 30.0 psig (2.1 bar) (nominal), and shall be supplied per Chapter 15 through an independent line with regulator isolation valve. An FDA approved cross connection device shall be provided to prevent contamination of the potable water system. Gray water shall not be used as flush water.

D. All gray water shall be retained in the waste tank. All requirements for stainless steel piping, freeze protection and gravity drainage of the water and waste system shall apply to the gray water piping.

E. The WCRS shall use auxiliary compressed air supplied by the car's main air reservoir per Chapter 7 through an approved governor and regulator valve to pressurize the toilet system. This shall be separate from that used for the water supply system previously specified in this chapter. An identical desiccant type air filter with automatic drain and oil removal filter shall be provided in the undercar enclosure to remove all contaminates and moisture from the air supply to the system. The arrangement shall easily allow replacement of the filter from the side of the car. Air pressure for the system shall be set for 100.0 psig (6.9 bar) (nominal). The toilet system shall be operable over the pressure range of 60.0 -100.0 psig (4.1-6.9 bar). All air regulation valves shall be mounted above the top of the water level in the waste tank. The air lines and valves shall be sized for air pressures up to 150 psig (10.3 bar). The air line shall be designed and configured to allow future conversion to a vacuum line, for use with a vacuum controlled toilet, for vacuum operation up to 12 in. Hg (40.6 kPa). Toilet flushing shall be inhibited due to lack of either air pressure, vacuum or electric power.

F. The toilet system shall have no adjustments and shall automatically recover from loss of power (including interruptions of HEP) or compressed air without nuisance alarms. The system shall have a manual reset switch located on an electrical locker WCRS status panel to reset the system en-route after isolating a toilet with a failed open vacuum flush valve. Cycling the 72VDC control power circuit

breaker shall also reset the system, except that no reset shall be permitted for additional toilet flushes if the waste tank is full.

G. Vacuum loss for the entire system at 10 in. Hg (33.8 kPa) shall not exceed 1 in. Hg (3.4 kPa) per hour with new equipment. There shall be no loss of greater than 2 in. Hg (6.8 kPa) per hour after six years of service. Vacuum loss for the installed waste tank assembly, including all pipes, valve stations and fittings, at 10 in. Hg (33.8 kPa) shall not exceed 0.5 in. Hg (1.7 kPa) per hour with new equipment. This shall be verified on each car during production testing.

15.03.03 Toilet Operation

A. A toilet flush cycle shall be initiated by the passenger by operating an ADA compliant, photoelectric sensor-operated universal flush actuator, which shall be mounted on the wall above the height of the raised toilet lid and easily apparent to the passenger. The actuator shall also have a manual control push button. The photoelectric sensor system shall be recessed to prevent tampering, have adjustable sensitivity and be powered by the 74VDC power system. Pressurized rinse water shall be sprayed into the toilet bowl before and during waste evacuation. The toilet waste shall be drawn by vacuum from each toilet and transported through a minimum 2 in. (51 mm) diameter pipe to the undercar waste tank, for later discharge at a collection facility. The waste tank shall be continuously under vacuum, regulated by vacuum pump blower operation and maintained by an airtight check valve between the tank and each toilet.

B. The electronic flush control unit shall control all toilet operations and activate the air ejector when the flush cycle is initiated. The electronic module shall plug into a card socket and shall be constructed in accordance with the applicable requirements of Chapter 18. The control unit shall provide the following timing functions, which shall be easily adjustable by the Engineer:

   1. AIR EJECTOR ON signal from flush initiation, not to exceed 5 seconds;
   2. to 1.5 second RINSE, activated 0.5 to 0.7 second from flush initiation; and
   3. 3.0 to 3.5 second DRAIN, activated 1.0 to 1.5 second from flush initiation.

C. The toilet shall not flush if the waste tank is full, or if system logic determines that a complete flush cycle is not possible. The electronic flush control unit shall be a unit in current Amtrak use.

15.03.04 Toilet

A. Each restroom described in Chapter 9 shall be equipped with an identical complete toilet system, of a type currently in use at Amtrak. The toilet assembly shall be designed as a self-contained, interchangeable, universal, free-standing unit consisting of a bowl with spray ring, rinse valve, drain valve, electronic flush control, isolation valves, flush intensifier IR K79013 or approved equivalent, stainless steel drain, clam shell flange, supporting frame, shroud, seat, lid, and swivel elbow or straight pipe, as approved by the Engineer. The unit shall be structurally adequate to handle all loads it will be subject to during a 30-year service life. All components except seals, rinse water solenoid valve, air solenoid valve and bushings shall be stainless steel. Plastic valves, elbows and fittings shall not be used. The shroud shall be easily removable and coordinated with the car interior design.

B. The toilet shall be securely mounted to the floor of the restroom. The assembly shall be mounted on a stainless steel pan, to contain flooding should the outlet become blocked. The pan shall be equipped with an overflow tube which shall drain under the car clear of the truck or other enclosures. A stainless steel floor plate and riser shall be provided for installation under the toilet stand. The reinforcement plate shall be pre-drilled for permanent mounting to the toilet room floor with toggle anchors. The riser shall be factory welded to the floor plate. Four stainless steel 1/4-20 UNC bolts shall be part of riser assembly along with wing nuts and lock washers for toilet installation. Production installation hardware, fixtures and mounting shall be standard design materials from qualified sources. All mounting hardware shall be stainless steel.

C. The toilet bowl shall be easy to maintain and clean. It shall be stainless steel and coated with gray color 3M Fusecote Fusion Bond model 135 or approved equivalent epoxy powder to prevent waste matter and mineral deposits from adhering. It shall not rust or corrode. A Teflon coating shall be applied to the interior surface of the bowl. Bowl surfaces shall curve in a continuous fashion and shall be free of recesses and inaccessible areas. The sides of the bowl shall be steep and sloped toward the vacuum vent inlet to allow waste to accumulate for evacuation. To prevent downstream blockage of waste system piping, the bowl outlet shall be a maximum of 1.7 in. (43.2 mm) in diameter to serve as the most restrictive point in the piping system. An overflow tube shall be provided to prevent the bowl from flooding should the outlet be plugged. Dismounting of the toilet bowl shall not be necessary for maintenance of the piping, valves or fittings.

D. Rinse water shall be injected into the bowl through a spray ring with sufficient force and distribution to push all waste matter toward the bowl outlet and clean the bowl. During the flush cycle, the entire bowl surface shall be wetted and cleaned with water. The bowl shall be free of water after flushing. The bowl and spray ring shall be easily and completely cleaned with ordinary cleansing agents and tools. An approved 120VAC solenoid valve shall be used to control rinse water injection.

E. The stainless steel flush-drain valve shall be a pneumatically operated, self-contained unit which provides a leak free seal at the bowl outlet after operation. The toilet system shall be designed to retain a hermetic seal over the opening of the waste pipe. There shall be a positive seal at all times to prevent odors from entering the restroom. Operation shall be initiated through a qualified 120VAC air solenoid valve. The flush valve shall go from full closed to full open in less than 0.1 second. The flush valve shall seal within 0.1 second from a full open position. The leak free seal shall be maintained under 15 in. Hg (50.8 kPa) of vacuum and a 3 ft (915 mm) head of water. At 6 -10 in. Hg (20.3 -33.8 kPa) there shall be no more than 0.01 oz (0.3 ml) of water leakage across the flush valve in a 24-hour period with toilet bowl full of water. At 6-10 in. Hg (20.3-33.8 kPa) there shall be no more than 0.02 in.^{3} (327.74 mm^3) of free air leakage across the closed flush valve in a 24-hour period. The valve and drain fittings shall be constructed entirely of stainless steel with the exception of seals. All surfaces subject to wear shall be designed to be self-lubricating with no maintenance required for a six-year period. The valve design shall be self-cleaning and prevent waste material from being trapped in it. The design shall be robust and survive severe torture tests including closing on solid objects without damage. Seals shall be easily replaced without special tools.

F. A rinse valve shall control rinse water flow into the bowl. The 120VAC solenoid valve shall be designed to maximize water pressure for water flow and orifice size when activated and provide a positive zero leak seal when closed. A rinse water and air cutout valve shall be provided for each toilet assembly. Cutout valves shall be easily accessible, without tools, for operation en route from inside the car. A stainless steel vacuum isolation valve shall be provided on the toilet assembly with locking actuator handle accessible en route from the right front of the toilet at floor level.

G. The toilet assembly and its components shall be mounted to be easily accessible and removable for service and maintenance, and removable access covers shall be provided. Special attention shall be given for ease of clearing foreign object clogs from the piping system, and additional piping cleanout ports with suitable maintenance access shall be provided throughout the toilet to waste tank piping to facilitate rapid cleanout during train station servicing stops. A clamshell assembly to connect the toilet drain to the car waste piping shall be provided along with all associated hardware and fittings. The waste line connection shall be equipped with a 90-degree stainless steel swivel or straight pipe as approved by the Engineer with a clamshell compatible O-ring flange and O-ring. All piping and mechanical connections which require access for toilet servicing, overhaul and replacement shall be completely accessible by the removal of access covers. The shroud shall be secured with captive fasteners. Special attention shall be given for complete ease of system maintenance, troubleshooting, cleaning and repair as installed on the car.

15.03.05 Waste Tank Assembly

A. The waste tank assembly shall be designed as a self-contained unit suitable for safe and efficient installation and removal from under the car. The assembly shall consist of the waste tank, vacuum pump blower, level measuring system, drain valve, freeze protection, electronic controls and debris shields. All valves, piping, underfloor sheet metal and related hardware shall be AISI type 304 stainless steel to inhibit corrosion. The waste tank assembly shall be constructed to withstand debris damage, cleaning chemicals and waste water. It shall be contained in a separate section of the undercar shroud.

B. The waste tank shall be constructed of AISI type 316 stainless steel. The tank design shall prevent sloshing during normal train operations yet shall not impede normal tank gravity drainage nor flushing operations and shall not cause excessive sludge deposits during operation. It shall be designed to prevent freezing of waste water during normal operation and shall prevent damage whenever the temperature of the contents falls below 40°F (4.4°C). The tank design shall allow all internal portions of the tank to be cleaned by maintenance personnel.

C. LED displays powered by solid state level sensors shall indicate the FULL, 2/3 and EMPTY levels Self-cleaning sight glasses shall also be provided as a visual check of the waste level. A removable cleanout cover large enough to permit the interior of the tank to be cleaned and inspected from the side of the car shall be provided on the side of tank. A removable inspection and pump out cover shall be provided on top of tank large enough to permit emergency tank pump out [6 in. (152 mm) minimum diameter]. A water separator shall positively prevent any water or waste from being ingested into the vacuum pump blower. Rinse water will be supplied by the servicing facilities at a normal pressure of 30.0 to 40.0 psig (2.1 to 2.8 bar) [maximum allowable of 75 psig (5.2 bar)] and shall apply a minimum of 5.0 gallons per minute (gpm) (18.9 L/min) of fresh rinse water to the sides of the tank during the drain cycle. The rinse water flush shall be controlled by two 72VDC 0.75 in. (19.1 mm) diameter solenoid valves piped in series, which shall be activated whenever the waste tank drain valve is open and the waste is below the full level. In addition, a 72VDC 1 in. (25.4 mm) diameter solenoid valve shall vent the tank when the tank drain valve is open. The rinse and vent solenoid valves shall be electrically connected in series and operate from 72VDC power supply. A 2 in. (50.8 mm) diameter ball valve with bolt lock open shall be provided on the tank waste inlet to isolate the tank from the car waste piping and the toilet. A manual vent valve with hand release lock and a limit switch shall be provided for emergency draining. The limit switch shall disable the system whenever the valve is not fully closed.

D. A tank level measuring system shall be provided for the control system to monitor the retention tank status. The system shall identify when the tank is FULL, 2/3 FULL and EMPTY. A WASTE TANK EMPTY indicator light (black dead front with green letters) shall be located on both sides of the car near the drain hose connection. The sensors, measurement system and indicator panels shall operate from the car 72VDC power source and shall draw no more than 3 amps current at nominal voltage. During tank draining, the monitoring system shall indicate WASTE TANK EMPTY when its level is under 6 gal (23 L). The level measuring system shall be nonadjustable and factory set to coincide with the FULL and 2/3 FULL sight glasses or LED displays. The level measuring system shall be maintenance free. Waste tank assembly installation and replacement of any system circuit boards shall not alter the settings.

E. Waste tank drainage shall be readily possible from either side of the car, through a 4 in. (101.6 mm) diameter full port qualified stainless steel ball valve equipped with an Amtrak standard Andrews 400A style quick-disconnect adapter in compliance with Amtrak AAMPS catalog number 24 422 08502. A hose connection to the adapter shall interface with the wayside servicing facility. Waste system servicing must be possible using existing Amtrak toilet system service trucks and carts under all environmental conditions, using either vacuum or gravity drainage. Only one person shall be required to drain and service the waste tank from a single point outside of the car. Tank drainage shall be controlled on each side of the car by a manually operated drain valve station. Actuating torque shall not exceed 300 in.-lb (34 Nm), and the valve station shall withstand a 3,500 in.-lb (395 Nm) torque

without damage. No adjustments or field drilling shall be permitted, and the valve station shall be easily removed and replaced as an assembly in less than 30 minutes. When opened 7.5 to 12.5 degrees, the valve station shall vent the tank, open the tank rinse valves when waste is below full level, deactivate the vacuum system and drain the tank. The tank drain time using a vacuum service truck shall not exceed 2 minutes from completely full to less than 6 gal (23 L) of remaining waste. The drain connection arrangement shall minimize the amount of possible waste spillage when the drain hose is disconnected. All waste tank assembly exposed surfaces which are liable to waste spillage during servicing shall be sealed as water resistant and as nonporous as practical and shall be easily sanitized by CTDOT maintenance forces without damage. The wayside rinse water source to the waste tank shall be via a suitable backflow preventer mounted on the car. The car rinse hose fitting shall be equivalent to that used on the Amtrak *Viewliner* car. Electrical power or compressed air from the car shall not be used for tank draining.

F. Accumulated deposits shall not exceed 1% of the usable tank volume. Level sensors shall operate for eight years without attention from mechanical personnel. The bottom of the tank shall be sloped 15° or a greater slope to a center drain. Drain lines, fittings and valves shall be 4 in. (101.6 mm) full port stainless steel. The installed waste tank assembly, including all pipes, valve stations and fittings, shall not have a loss of vacuum greater than 0.5 in. Hg (1.8 kPa) per hour.

15.03.06 Vacuum Source

The waste collection system shall be a constant vacuum type, with the vacuum obtained through an electrically operated vacuum pump blower which shall be compliant with the requirements of Amtrak AAMPS catalog number 42 726 00085. The blower shall operate on 480VAC, 3-Phase, 60 Hz power, be rated for continuous duty and have self-resetting thermal overload protection. It shall be connected to the waste tank by an air tight check valve. An approved water separator shall positively prevent any water or waste from being ingested into the vacuum pump blower.

15.03.07 Vent

Exhaust from the vacuum pump blower and the waste tank system vent shall be vented to the top of the car and designed to prevent passengers, both inside and outside the car, from being exposed to objectionable odors from waste gases or from being ingested by the car fresh air intakes. The Contractor shall investigate and propose replaceable filters or other such methods for approval by the Engineer. [CDRL 15-007] All vent piping shall be sloped for gravity drainage of moisture, and all horizontal piping of the vent line shall incorporate antifreeze heat tape and thermal insulation. A moisture drain shall be provided at the base of any vertical piping of the vent to prevent accumulation of condensation. The design shall be approved by the Engineer. [CDRL 15-008]

15.03.08 Piping

All waste system and gray water piping shall be seamless stainless steel suitable for sewage service, in compliance with Chapter 18. The use of copper piping is expressly prohibited, as it extensively corrodes in service. All piping shall be installed with positive gravity drainage slope to avoid traps, and have generous radius sweep bends and elbows to avoid blockages. Cleanout access ports shall be provided throughout the waste piping. The line from the toilet outlet to the waste tank shall be a minimum 2 in. (50.8 mm) diameter, installed in the sidewall of the car interior per Chapter 9. The sidewall piping shall be one piece without joints. The pipe between the restroom and the point of exit from the car interior shall also be a single piece without joints. Piping shall be designed to minimize the chance of blockage, with all fittings chosen with this goal in mind. The system shall be designed to facilitate the clearing of any line blockage. Any flexible tubing shall be reinforced to avoid collapse under a continuous 29 in. Hg (98.2 kPa) vacuum and it shall be easily removable for cleaning. All piping and tubing shall have a smooth interior finish. Flexible tubing shall be avoided in the design and shall only be used after approval by the Engineer. Vacuum and pressure test ports shall be provided for system troubleshooting. Pneumatic system piping shall comply with Chapter 18.

15.04 Status Indicators

A. The status of the water and waste systems, including the volume of waste collected in the waste tank, shall be monitored continuously and displayed on a set of LED indicator panels. The power source for these indicators shall be the car battery system, so that system status is indicated during servicing when the car may not be on 480VAC HEP. A separate system shall provide the diagnostic status of the antifreeze protection heat tapes on the car when HEP is present. The design of all status indicators shall be approved by the Engineer. [CDRL 15-009]

B. A water and waste system status indicator panel shall be installed in the car electrical locker, and behind a viewing window on either side of the undercar waste tank assembly, to display the current status of the system to train crew and servicing personnel. A system reset pushbutton shall be provided only at the undercar locations. The following indications shall be provided:

1. Power Off (red): Electrical power off
2. Low Air (red): Less than 60.0 psig (4.1 bar) of air pressure at the toilet
3. Low Water (amber): Car water tanks less than 1/3 full
4. No Vacuum (red): Less than 3 in. of Hg (10.2 kPa) available (vacuum leak)
5. Tank Valve Open (red): Tank drain valve or manual vent valve open
6. Tank Full (red): Waste tank full
7. Tank 2/3 Full (amber): Waste tank 2/3 full
8. Tank Empty (green): Waste tank empty

C. The low vacuum indicator shall be disabled for the normal flush cycle and shall only display actual fault conditions.

D. The sink water supply shall be disabled when the water tank falls to 1/3 full.

E. A WASTE TANK EMPTY indicator (black dead front with green letters) easily seen in bright sunlight shall be installed at the top of the waste tank assembly adjacent to each of the drain valves. It must be visible by maintenance personnel to indicate when the tank is empty during tank servicing.

F. An OUT OF SERVICE red LED indicator shall be located on the outside of each restroom per Chapter 9, which shall indicate if the control system has determined the toilet to be out of service due to a full waste tank or other malfunction, or if the train crew has locked the restroom.

G. To verify the proper operation of all antifreeze protective heat tapes for the water and waste system, the Contractor shall arrange a monitoring system to verify that electrical power is present at the far end of every heat tape segment when power is being supplied to the system. A set of LED indicators shall be located on a display panel in the electrical locker to display the status of each heat tape. A logical, organized system layout shall be provided, with each indicator labeled for ease of maintenance personnel quickly identifying an individual defective heat tape. A POWER ON test pushbutton shall be located on the panel to allow electrical power to be supplied to all of the heat tapes on the car when ambient temperature is above the setting when the system would be energized. The design shall be approved by the Engineer. [CDRL 15-010]

15.05 Waste System Controls

15.05.01 General

A. An Engineer approved control system shall be supplied to provide proper control and maintenance diagnostics for the WCRS. Design and materials shall comply with the requirements of Chapter 18.

The control system logic shall be located in the car electrical locker. All motor controls, solenoid valves, relays, contactors and freeze protection, unless otherwise specified, shall operate from 120VAC. All transducers and indicator devices shall operate from the car battery system. The system shall be designed for the passenger railcar environment and shall not be affected nor need to recycle itself due to interruptions of the HEP or trainline air pressure, en-route waste tank system servicing, or other normal aspects of intercity train operation per this Specification. All controls, switches and sensors shall be unaffected by the environment, and be maintenance free for a six-year period.

B. The vacuum pump blower shall operate at the beginning of the flush cycle, and as needed to maintain the required vacuum. Toilet flushing shall be inhibited due to HEP outage, the waste tank being full or its drain valve is open, or by inadequate auxiliary air pressure or vacuum. The vacuum pump blower shall be capable of continuously producing a differential pressure of 12 in. Hg (40.7 kPa) nominal. The combination of the blower and the waste tank volume shall provide an initial flow rate of 200 Standard Cubic Feet per Minute (SCFM) (5.6 Sm^3/min) in the waste line when a toilet flush is actuated. Tank vacuum shall be maintained at 6-10 in. Hg (20.3-33.8 kPa) through flush operation. The vacuum pump blower shall cycle on when the system differential pressure falls below 6 in. Hg (20.3 kPa) and cycle off when the differential pressure rises above 10 in. Hg (33.8 kPa). An approximately 20 second timeout function shall prevent continuous vacuum blower operation at high altitudes, but any flush signal shall restart the timeout function. The vacuum blower shall remain off whenever the waste tank if filled, or during tank drain servicing.

C. The Contractor during design review shall present for Engineer approval a matrix of all normal, abnormal and fault conditions, and the water and waste system response to each condition. All logic parameters shall be designed for ease of future adjustments and reprogramming by the Engineer, with complete software provided to the Engineer to make such adjustments. [CDRL 15-011]

15.05.02 Control Panel

An electronic central control panel shall be an interface between the toilet and the waste tank assembly, operate all system indicators and contain any auxiliary power supplies required for system operation. Low voltage electrical connections between the car wiring and the control panel shall be made using quick disconnects. The control system shall inhibit the operation of the toilet by disconnecting both legs of the 120VAC input power. It shall prevent flushing whenever 3 in. Hg (10.2 kPa) of vacuum cannot be achieved at the toilet or when air pressure falls below 60.0 psig (4.1 bar). Major components shall include the system control board, level control board, 120VAC disconnect switch, and manual closure feature. The electronic control modules shall plug into a card socket and shall be constructed in accordance with Chapter 18. Removal and replacement of any control printed circuit boards shall not require field adjustments.

15.05.03 Fresh Water Sensor

A nonadjustable solid-state fresh water sensor switch shall be provided to provide a low water signal to the control system when the water tanks are less than 1/3 full. The switch shall open when water is present. The fresh water sensor shall be unaffected by water deposits.

15.05.04 Air Pressure Switch

A nonadjustable air pressure switch shall be provided to prevent flushing of the toilet when the supplied air pressure drops below 60.0 psig (4.1 bar), and to provide a low air pressure signal to the control system. The switch shall open when pressure rises above 60.0 psig (4.1 bar).

15.05.05 Vacuum Switches

Three nonadjustable vacuum switches, color coded and labeled with their vacuum setting, shall be provided to provide 3 in. Hg (10.2 kPa) (coded red), 6 in. Hg (20.3 kPa) (coded amber), and 10 in. Hg

(33.8 kPa) (coded green) control and status panel signals. The switches shall close above the vacuum specified and be accurate within 5% of their nominal setting.

15.05.06 Limit Switches

Three valve handle position detector switches shall be supplied to provide control signals for the waste tank drain valve and the manual vent valve. All limit switches shall be environmentally sealed, nonadjustable, keyed to ensure proper installation and permanent setting, provided with one wiring configuration, color coded and labeled.

15.06 Contract Deliverable Requirements List

CDRL #	Title	Car Type
15-001	Waste and Water System Details	All
15-002	Water Supply System Design and Materials	All
15-003	Freeze Protection System Details	All
15-004	Undercar Shroud System Design	All
15-005	Restroom Faucet Design	All
15-006	Waste Retention System Details	All
15-007	Replaceable Vent Filters or Equivalent Proposal	All
15-008	Moisture Drain for Vertical Vent Piping Design	All
15-009	Status Indicators Design	All
15-010	Water and Water Electrical System Design	All
15-011	Logic Parameters and Software	All

* End of Chapter 15 *

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Technical Specification

CTDOT Single-Level Passenger Rail Cars

Chapter 16

Cab and Train Controls

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16.00 Cab and Train Controls

16.01 Overview

This chapter describes the design and functionality of the cab area of the cab car, including locomotive control equipment, instruments and gauges for systems necessary for the safe and efficient operation of the train from the Operator's cab and ancillary equipment for crew comfort and safety.

16.02 Cab Car Arrangement

16.02.01 General

A. The cars procured through this Specification are intended to be used in push-pull service. The propelling locomotive will be kept at one end of the consist. Movement in the opposite direction will be controlled by a cab car at that end of the train, which contains an operating compartment for the Operator and Observer seat. This section provides details regarding the cab car type of vehicle, such as its operating compartment. The cab car will require a specific configuration of carbody shell design, suitable for front of train use as described in Chapter 4.

B. An Operator's control compartment shall be located at the F-end of the cab car. The Operator's compartment shall be separated from passenger seating areas by a full-width bulkhead.

C. The compartment shall be a full-width arrangement.

   1. The front face of the compartment shall have one body end door in the center, with an electrically-heated windshield on both the right (Operator's) and left (Observer's) sides.
   2. The Operator's control station, and its associated control panels, shall be located on the right side of the compartment.
   3. Drop sash windows conforming to the requirements of Section 16.2.1. shall be provided on the right and left sides of the compartment.

D. It is of great importance that the cab compartment be designed to provide maximum comfort and alertness for the Operator and Observer for long periods of duty, as well as have the highest level of durability, reliability and maintainability. The cab area shall be laid out so as to be neat and orderly in appearance, with all apparatus designed and arranged in a manner that will not cause confusion to the Operator. The layout shall maximize the use of available space and shall employ sound ergonomic and industrial design principles in its development, yet be designed to be rugged and easily maintained. The more critical displays as identified herein shall be located adjacent to the windshield, in the Operator's plane of normal forward vision, for ease of viewing. Utility shall not be sacrificed to aesthetics, although a pleasing and comfortable environment for the Operator shall be a design objective.

E. Adequate space shall be provided on the cab console for maintenance personnel to place a standard laptop computer for operation during vehicle tests. The Operator's cab shall be isolated from passenger access while in use, and shall be configured, including its door and locking provisions, to be in compliance with all applicable security guidelines. The cab shall be configured so that it may be closed off and locked when not in use.

F. Controls shall be arranged so that those which are most often used, or are of critical importance, are the most convenient to the Operator, and others shall be located such that the hazard of misuse is minimized. The cab flooring shall be installed to permit its removal (including the floor panel) without the need to disturb or remove the cab partitions or electrical lockers, per Chapter 4. It is desired that the cab arrangement be in compliance with the Tier II cab requirements of 49 CFR Part 238.447. All cab designs, materials and workmanship shall comply with the requirements of the appropriate

sections of this specification and shall be submitted to the Operator for approval during the design review process. [CDRL 16-001] A cab mockup shall be constructed as detailed in Chapter 3.

G. The cab compartment shall be constructed of minimum 5/8-inch thick honeycomb. The linings shall be highly durable, scuff and scratch resistant materials, such as fiberglass reinforced plastic or melamine covered with Tedlar composite laminate or other approved materials. Modular console construction shall be used, with quick-opening captive black-finished stainless steel fasteners used for attachment of console panels. All interior panels shall be designed with large radius corners [0.5 in. (12.7 mm) minimum] and smooth transitions to facilitate cleaning and prevent injuries. The number of exposed fasteners, seams and moldings shall be minimized. The control panels facing a seated Operator shall be provided with a dull black finish to eliminate glare. Exposed fasteners used to retain components shall be captive and have a black anodized finish to match the surrounding area. The cab shall be arranged and finished to minimize injury to the Operator and Observer in the event of an accident or collision, and shall be free of sharp edges, protruding objects, safety hazards and floor obstructions as required by Military Standard MIL-STD-1472, latest revision. Areas in which newspapers and other debris can accumulate are not permitted. Cab equipment and controls shall be mounted in modules and/or panels to be easily replaceable from the front or top of the installed position. Electrical control panels shall have all wiring for the panel electrical devices terminate in an approved keyed quick-disconnect interface to the carbody wiring, so as to permit ease of panel removal. All pressure switches and sensors, and all pneumatic cutout cocks, shall be arranged for ease of complete crew and/or maintenance access; a diagram identifying all the cut-out cocks and their locations in the cab shall be provided at a location as approved by the Engineer. [CDRL 16-002] Innovative methods to facilitate cab equipment servicing and troubleshooting shall be proposed, such as mounting equipment panels using hinges and hold-open prop rods for access to electrical terminations. All modules and panels, however, shall be designed for rapid complete removal from the car. Pneumatic devices shall be fed from a non-kinking hose to permit ready panel removal and have in-line connections for removal, arranged to prevent incorrect connections of adjacent hoses. As it is expected over the life of the cars that future regulations will mandate additional controls and indicators be added to the cab consoles, as an aspect of its design the Contractor must provide adequate spare room on all panels for future additions. Ergonomic control layout, maintainability access and provisions for future additions shall be key aspects of the cab design review and the cab mockup.

H. All annunciator lights shall use Light Emitting Diodes (LEDs), and shall have a self-test feature or separate test switch to verify operation. All indicator lights and controls shall be either permanently engraved white paint filled identification signs on a flat epoxy powder coat black background, switch label inserts protected by a clear durable plastic cover, panels protected by a clear Tedlar overlay, or other approved techniques with equal permanence. Insert labels for any rocker switches shall have black lettering on a gold background for proper viewing under red cab lighting conditions.

I. The Operator's minimum clear viewing distance from the seated position shall be no more than 20 ft (6,096 mm) to the top of rail. The cab layout shall also be arranged so as to provide the Operator with an effective field of view to the right and left of the direction of travel. Obstructions to the field of view caused by required collision and corner post structural members shall be minimized.

J. The arrangement of the cab shall be under the direction of the Contractor's industrial designer, who shall verify all human factors data. The Contractor shall submit for design review and Operator approval a series of general arrangement diagrams of the interior of the Operator's cab compartment. [CDRL 16-003] They shall include the location of all features and appointments, as well as general arrangement diagrams of the Operator's control consoles, Observer’s work station, and seat, illustrating the location of all features, appointments, controls, switches, gauges, meters and indicators. Fields of view, legroom provisions and ranges of arm movement for a seated Operator and Observer of the specified percentile range shall be included. The review period for these initial cab and controls arrangement drawings shall permit internal review by Operator-approved personnel. The final console arrangement shall be submitted for approval during drawing and design review and at cab mockup reviews called for in Chapter 3. The entire cab area shall be properly heated, ventilated

and cooled, be draft-free, and insulated against noise and thermal loss. The cab compartment arrangement and all controls shall be approved in detail by the Engineer during design review.

16.02.02 Emergency Egress/Ingress

A. A means for emergency egress or ingress of the cab shall be incorporated into the design of the cab. The Contractor shall design the layout incorporating provisions for the cab occupants to exit in an emergency. Exit pathways must be considered in the design by not locating other cab equipment in the exit pathway(s). Emergency lighting shall comply with AAR Standard S-580. The provisions shall also incorporate a means for outside emergency personnel to enter the cab area.

B. A means shall be incorporated in the design of the cab area for emergency exit or ingress by means of framed cab windshields (see Chapter 4) and an emergency evacuation ladder from the cab to the track level at the end of the trainset on the Observer's side, for situations when there is no side access to the trainset.

16.02.03 Cab Enclosure

A. The cab shall contain an Operator's control console located below the windshield, a right and left side vertical panel on either side of the windshield, an overhead panel located above the windshield and a circuit breaker panel in an approved location. To the Operator's and Observer's rear shall be a transverse partition extending across the full carbody width, incorporating a door, centered transversely, and exiting to the passenger area. This partition wall will completely separate the passenger area from the cab enclosure and the door shall allow the cab to be configured as a full width or quarter width cab, as specified in TS 16.2.2. The cab will be arranged as to allow the Operator visibility to observe the far left side of the track such as at grade crossings.

B. The carbody adjacent roof, end and sidewalls shall be fully sound insulated. Air ducts shall be baffled as required to control windage noises and to attenuate exterior noises. Use of components that cause noise, vibration or oil canning will not be acceptable. Under all normal conditions of operation, vibration of interior components such as partitions, walls, doors, ceiling panels, light fixtures, etc., shall not be visible nor audible.

C. All cab components shall be evaluated individually for their noise contribution such as windows, cab seats, doors, lighting fixtures and hardware. If noise from vibration is caused by any part of the vehicle equipment, the Contractor shall modify and revise the design to eliminate this condition. These partitions shall be constructed of 5/8 in. (15.875 mm) honeycomb or thick plymetal faced with integrally colored melamine covered with Tedlar composite laminate or other approved materials. The exterior face shall match the styling of the car interior, and the interior face shall match the Operator compartment styling.

D. An operable window shall be provided on the Operator's right and Observer's left side, and shall incorporate an exterior rain deflection gutter. The sliding portion of the window shall be equipped with a lever type latch that locks the window in the closed position. The lever, latch, and lock shall be subject to Engineer approval. A sample of the complete window assembly shall be provided during design review. [CDRL 16-004]

E. The cab partitions shall be securely mounted to run from floor to ceiling and be of adequate structural integrity to withstand all normal or extraordinary loading from passenger contact, such as from vandalism. Each partition, when mounted, shall withstand a horizontal load of 330 lbf (1,468 N) applied at any location without permanent deformation.

F. Incorporated into the rear wall of the cab in an approved, easily accessed location shall be a locker for the Operator's and Observer's personal effects. This locker shall be solidly constructed and lined with stainless steel, and have a hinged door secured by a slam lock. The door lock shall be locked when

desired by the standard coach key. The door shall be mounted with a stainless steel piano hinge, and have an external face treatment matching the cab decorative effect. The locker shall be sized to be large enough to fit a full-size backpack. An open door stop shall be provided. A second, smaller storage locker shall also be located on the rear wall, and shall be locked when desired by a standard coach key. It shall contain an intermediate shelf, and be used for storage of crew individual portion water bottles, crew kit, paper towels, etc.

16.02.04 Cab Door

A. The bulkhead shall have a center-mounted door with a window and shall be capable of completely segregating the Operator's compartment from the rest of the car. The door design, hardware and location shall facilitate rapid Operator evacuation in the event of an emergency. The cab door shall contain a fixed window and a fixed louvered grille.

B. Any pending FRA or APTA regulatory action regarding the implementation of a "kickout panel" shall be considered for implementation. The window from the passenger compartment to the Operator's compartment shall be tinted neutral gray with a visible light transmission of 12 percent.

C. The cab door and cab door latch shall automatically lock and shall only be unlocked with the use of a cab or coach key from the passenger side of the cab door. The design of the lock case on the aisle side shall have a security cover plate to preclude any unauthorized entry into the cab by forcing the latch head back.

D. The cab door shall be provided with a large, low-profile, push type panic bar with tapered ends located on the cab side of the door to facilitate rapid unlatching and exit from the cab compartment without the use of a key and without the need to manually unlock the cab door latch. The cab door shall have a center aisle ceiling mounted recessed metallic latch, which will hold the door in the open position when desired. An elastomer bumper shall cushion the door when fully opened. The operating functionality of the cab door from the cab side and passenger side shall be submitted to the Engineer for review. [CDRL 16-005]

E. The door shall be of hollow stainless steel construction with a phenolic foam core and brushed exterior finish. Minimum thickness of exterior sheathing shall be 0.050 in. (1.27 mm). Each door shall be provided with adequate stainless steel reinforcements for the attachment of all hardware. The door shall be bound on all four edges by welding, rolled seams, or a combination. The cab door shall be hung on a continuous, full length, stainless steel piano hinge having a stainless steel hinge pin, located at the outboard edge of the door. When closed, the door shall bear against a neoprene elastomer cushioned door stop across the top and both sides. The cab door shall be of sufficiently rigid and strong construction to withstand, when mounted and closed, a horizontal load of 330 lbf (1,468 N) applied at any point without permanent deformation. The door shall not rattle or squeak in any position and shall be sealed when closed to provide a highly soundproof barrier.

F. The cab door shall have a window in its upper portion. The clear viewing area shall be approximately 6 in. (152 mm) vertically by 8 in. (203 mm) horizontally and located on the centerline of the door, approximately 3 ft 6 in. (1,067 mm) above the bottom edge of the door. The window material shall be 0.25 in. (6.35 mm) thick mar-resistant polycarbonate, tinted the same color as the side windows. The window shall be glazed in a neoprene rubber section and mounted to the door using a two-piece frame (inner and outer) aluminum extrusion, which shall be satin finished and anodized. The exterior face shall either have no exposed fasteners or fasteners with tamperproof heads.

G. A sight-tight, louvered, heavy-duty, nonadjustable stainless steel or anodized aluminum air grille shall be located in the lower part of the cab door for ventilation. The louvers shall be a minimum of 0.125 in. (3.175 mm) thick, and shall be reinforced with two 0.125 in. (3.175 mm) thick vertical stiffeners. The size of the grille shall be approximately 7 in. (178 mm) vertically by 9 in. (229 mm) horizontally and located on the centerline of the door, at least 12 in. (305 mm) above the floor.

16.02.05 Windshield Wiper

A. An Engineer approved, heavy-duty, automatic electric windshield wiper powered by the low voltage power system shall be installed at the top of the Operator's and Observer's windshield at each cab. The wiper motor shall be brushless, be thermally protected against stall conditions, have Radio Frequency Interference (RFI) suppression, and shall be easily accessed and removable from inside the end of the car, using quick disconnect fittings. A super heavy-duty transit quality tubular low wind lift pantograph wiper arm shall be used, with all visible parts having a black finish. A curved-glass type black finished heavy-duty wiper blade with a replaceable rubber element sufficiently long to wipe 80% of the glass shall be used, mounted with a saddle type connector. The system shall operate successfully in rain or snow at all vehicle speeds. Windshield wiper control knobs shall be provided in the cab arranged for ease of Operator/Observer's use. They shall have an OFF position, a variable delay of approximately 10 to 0.5 seconds between each cycle, and either a variable speed of approximately 30 to 90 cycles per minute or two fixed speeds. The wipers shall automatically move to a park position to the edge of the windshield when turned off. The wiper mechanisms shall operate smoothly without hesitation throughout its cycle under all conditions. Wiper operating mechanisms and drive units shall be accessible for repair and replacement. The operating mechanisms shall be enclosed.

B. An Engineer-approved, service proven electrically or pneumatically operated windshield washer, with fan-type pattern spraying nozzles mounted on the windshield wiper arm, shall be provided. The washer system shall effectively cover the entire portion of the windshield within the sweep range of the wiper. A windshield washer reservoir using corrosion-resistant materials and fittings, of minimum 5 gal (19 L) capacity shall be mounted under the car. It shall be easily accessible and refillable from inside the car, incorporate a drain valve and require no special hardware for filling.

C. The windshield wiper and washer shall be operational when the vehicle is in both leading and trailing modes.

16.02.06 Sun Visor and Sun Shade

An Engineer-approved, adjustable sun visor and sun shade shall be installed in each cab which meet the flammability and smoke emission requirements. The visor shall be mounted on the left side of the Operator's windshield as the Operator faces forward. It shall consist of a vertically adjustable, black anodized aluminum padded visor, using a spring-loaded pistol grip locating handle, which shall ride on a stainless steel tubular rail and permit the Operator to locate the visor at any point on the rail. All exposed parts of the assembly shall be low glare black finish, and all corners shall be rounded. The sun shade shall be provided at the Operator's window. The shade shall be fully adjustable over the range of the windshield and designed to rotate and cover the side window. The shade shall be fabricated from polycarbonate with a thickness no less than 1/4" (6.4 mm). Vibration and normal vehicle motions shall not cause the sun visor or sun shade to change position. A similar sun visor and sun shade shall be provided for the Observer. The design and placement shall be approved by the Engineer. [CDRL 16-006]

16.02.07 Not Used

Not Used.

16.02.08 Operator's and Observer's Seats

A. Each cab shall be equipped with heavy-duty, synthetic-leather upholstered Operator's and Observer's seats supported on a center pedestal designed to provide satisfactory comfort and proper access to cab controls with good visibility. The cab seats shall be mounted in line with the transverse centerline of the windshield (on both sides) and the seats shall provide a minimum of 0.5 in. (12.7 mm) clearance from the back wall when in the rearmost position. The seat design shall take into account the limited amount of space available in the cab, and also the possible standing of the

Operator/Observer to look out of the side cab window. The seat assembly shall incorporate failsafe operating features and adjustment methodology to prevent sudden seat failures during the life of the car to avoid Operator/Observer injuries. All mounting hardware to the cab floor shall be stainless steel. The seat frame shall be of tubular steel construction designed for hard usage. The seat bottom and back cushions shall be properly contoured to provide adequate lumbar, back, side and thigh support, and shall be constructed from foam material meeting the requirements of Chapter 18. The Contractor shall make every reasonable effort to minimize the number of unique parts (especially adjustment mechanisms and knobs) used in its construction and installation. No seat component shall be removable without tools.

B. All strength, performance, and other criteria defined within this chapter shall be considered minimums. The seat and its attachment shall comply with the requirements of 49 CFR Part 238.233. In addition, the seats shall comply with the requirements of APTA-PR-CS-S-011-99. Where conflicts exist, the most restrictive shall apply. The seat assembly shall meet the smoke and flammability requirements of Chapters 2 and 18.

C. Heavy-duty transportation grade leather upholstery having an approved color and weave pattern meeting the requirements of Chapter 18 shall be used on the seats. All upholstery seams shall have high mechanical strength, and bottom cushion transverse seams in the area of the top front corner are to be avoided. The details and colors of the seat design shall be reviewed and approved by the Engineer. [CDRL 16-007] The Contractor shall consider utilizing darker colors in areas that tend to accumulate dirt and stains, such as the head rests and the armrest caps. As part of the design review efforts, the Contractor shall present an ergonomic analysis and report of the seating system. [CDRL 16-008] One sample seat of each type shall be submitted by the Contractor for approval by the Engineer following completion of testing. [CDRL 16-009]

D. The seat's suspension shall have a scissor mechanism with a pendulum design to eliminate lateral wobble, and shall use service-proven bearings at all moving points. A protective bellows shall encase the suspension system mechanism. The seat back height shall be coordinated with the cab arrangement. The seat back shall have an infinitely adjustable mechanical lumbar support and a back shell to protect the rear cab wall from damage. There shall be no sharp edges or surfaces which could cause injury.

E. The seats shall contain mechanical components only and shall provide simple, smooth adjustments while an Operator is seated. The seats shall have a minimum of 6 in. (152 mm) fore/aft adjustment [9 in. (229 mm) being desirable if the cab arrangement permits] with roller bearing slides each having locking mechanisms. The seat height adjustment range shall be a minimum of 6 in. and shall not allow the seat to free fall. The seat bottom cushion shall have a range of 8° of tilt, and the back cushion shall have a range of 20° of tilt past the vertical, if cab arrangement permits. Recliner mechanisms shall be double gear with a tooth and sprocket on both sides of the seat. Adjustment devices using simple notched cam plates with flat sides for setting heights or pitch are prohibited.

16.02.09 Horn

A. A roof mounted horn shall be supplied which shall be a Nathan/Airchime from Micro Precision Group LLC, model K5LA, with an integrated heating element, or approved equivalent, pneumatic horn with bell frequencies of 311, 370, 415, 494 and 622 Hz, with all bells facing forward and shall be installed on the roof at the cab end of every cab car. Each horn bell shall be provided with the manufacturer's stainless steel conical debris/snow filter to prevent accumulation and packing of debris and snow in the bell mouth. The method of debris and snow deflection shall be subject to the approval of the Engineer. To reduce vibrations transmitted into the carbody, the horn shall be mounted on a 0.5 in. (12.7 mm) thick elastomer mounting pad. The horn mounting location on the car roof shall take into account airflow patterns and snow accumulations, in both the leading and trailing modes, to minimize snow and ice accumulation.

B. The horn shall be operated by a modulating horn valve with cushioned lever located on the right side of the center cab console. The valve shall be a Graham-White Manufacturing Company model 353 series, or approved equivalent, metering horn valve with a vertical padded handle orientation, prior successful use in this application, and a high cycle life. In addition, a guarded momentary contact switch shall be located on the center cab console which, when activated, shall automatically produce a standard grade crossing warning signal sequence (long - long - short - long), with CTDOT-adjustable timing settings. The switch function shall be inoperative below 1 mph. Pressing the switch during the automatic horn sequence shall instantly cancel the remainder of the sequence and silence the horn.

C. The air supply to the valves shall be through vented cutout cocks recess mounted in the lower cab console. All control valves and supply piping shall be sized to handle the required air flow, so that there is no delay in the buildup to full horn volume when activated. The horn as installed shall comply with the requirements of 49 CFR Part 229.129. A restriction choke shall be installed in the base of the horn as required to prevent excessive sound level. Activation of the horn as sensed by an appropriately located pressure switch shall cause the auxiliary light control in Chapter 11 to operate as approved by the Engineer. All valves, switches and controls shall be completely accessible for maintenance. Details of the horn installation shall be approved by the Engineer. [CDRL 16-010]

16.02.10 Bell

A 12 in. (305 mm) bell shall be located under the car near the F-end of the car. It shall be shock-mount isolated from the carbody and be equipped with a Salem model 506 bell ringer or approved equivalent pneumatic or electronic bell. Its mounting location shall minimize the accumulation of snow and ice in either travel direction. A two-position pull type locomotive style bell ringer pneumatic control valve or electronic switch shall be located on the left side of the center cab console. If a pneumatic bell is used, the air supply to the valve shall be through a vented cutout cock recess-mounted in the lower cab console. Activation of the bell as sensed by an appropriately located pressure switch if pneumatic, shall cause the auxiliary light control in Chapter 11 to operate as approved by the Engineer. All valves, switches and controls shall be completely accessible for maintenance. Details of the bell installation shall be approved by the Engineer. [CDRL 16-011]

16.02.11 Miscellaneous Cab Items

The following shall be provided in each cab and each item will be approved by the Engineer:

A. A PTC/cab signal/Automatic Train Control system fully compatible with Amtrak's ACSES II, latest version

B. White reading lights and red night time illumination

C. Alerter system

D. A ceiling air diffuser, a floor heater element and a forced air heater.

E. A Conductor communications signal system pushbutton and buzzer shall be located in the cab, along with a crew intercom speaker with integral volume control which cannot be muted.

F. The cab windshield shall be heated.

G. A permanent car number identification plate shall be applied to the console in a prominent location near the speedometer.

H. Four flush, heavy-duty, spring loaded coat hooks with integral rubber bumper shall be located on the rear partition. The coat hook locations shall be staggered such that two hooks are positioned to be easily reachable from a standing position and two are reachable from a seated position for the Operator.

I. One 8.5 in. by 11 in. (216 mm by 279 mm) "blue form" inspection card frame with transparent cover, conforming to FRA document size requirements, shall be located on the inside face of the rear partition electric circuit breaker locker door, as directed by the Engineer and in accordance with 49 CFR Part 229.23(d).

J. An "air slip" inspection form clip holder for a 3 in. by 5 in. (76 mm by 127 mm) daily inspection form shall be located on the rear partition wall near the cab door

K. A footrest for the Operator shall be provided as directed by the Engineer.

L. Clipboard-type spring loaded holders shall be installed with clear areas sufficient to hold 8.5 in. by 11 in. (216 mm by 279 mm) bulletin orders shall be located within easy reach of the Operator and Observer

M. A cup holder to retain a large coffee cup or soft drink container shall be mounted forward of the Operator's seat. It shall be a rugged design with a bottom drain hole, designed for ease of cleaning. A similar cup holder will be provided for the Observer

N. One 120VAC grounded duplex GFCI-protected receptacle, protected for 15 amps service, and a 74VDC receptacle, shall be located in the lower cab wall

O. A blue flag light on both the interior and both sides of the car. This light shall be activated either with a key or an on-board switch, as approved by the Engineer.

P. Flat writing surfaces sufficiently large to hold 8.5 in. by 11 in. (216 mm by 279 mm) paper shall be located directly in front of the Operator and Observer, at the base of the windshield, in order to permit the Operator or Observer to write train orders. These surfaces shall also be sufficiently large to allow a laptop computer to be used by maintenance personnel

Q. For train crew use during backing movements, a two-position key switch operated by the standard coach key shall be included in the cab console in an approved location, for use by the Conductor and train crew in a trailing cab of the train. When this switch is turned 90 degrees to the right, it shall activate the controls for the headlights, cab ceiling lights and cab gauges and the communications system (radio, public address and crew intercom). The key shall be captive in the ON position

R. For train crew use during backing movements, a conductor's emergency brake valve shall be provided in an approved location. It may be located immediately outside the cab door

S. A flag holder and a fireproof closed metal container for fuses shall be provided in accordance with 49 CFR Part 229.119(f), and as directed by the Engineer.

T. A small trash container shall be provided that uses a standard trash liner

U. Exterior FRA marker lights at each end of the car, with the lights at the cab end controlled by a switch on the cab console

V. One female USB Type A charging outlet shall be provided in an Engineer approved location. The USB outlet shall be provided with a spring-loaded cover or similar device to prevent liquid or other objects from damaging the port.

16.03 Cab Controls

16.03.01 Arrangement of Controls

A. The Operator's cab shall feature a desk-type, primary control console centered below the Operator's windshield, with an additional vertical instrument and control panel located to the Operator's right by the cab corner. Consoles and panels shall be neat in appearance, with all equipment, indicators, devices and controls arranged in an orderly manner. The console and panels shall be constructed of a stain, burn and corrosion-resistant, integrally colored, non-glare material as approved by the Engineer. The console cabinet color and design shall match the adjacent cab lining scheme. Indicator and annunciator lights shall be positioned centrally to the Operator's forward line of sight, arranged so they do not cause reflections in the Operator's windshield, shaded against direct sunlight and readily visible under all ambient light conditions, and provided with intensity adjustment capability. The cab console shall be illuminated for day and night operation without causing reflections on the windshield. The console lighting shall be located so as to properly illuminate all switches and gauges necessary for train operation, and shall be controlled by a rheostatic dimmer switch. The consoles shall be designed and shaped in such a manner to permit the Operator or Observer to open and lean out of the cab side windows to inspect the train. The center console shall extend to the bottom of the windshield (no dead areas in cab to collect debris and dirt).

B. The arrangement of controls to satisfy the ergonomics of a wide range of Operator physical sizes shall be given particular attention by the Contractor. All controls shall be positioned for ease of access for Operators of the size percentiles identified in Chapter 1. In particular, the speedometer and cab signal aspect display unit, car number sign and air pressure gauges shall be positioned from the horizontal to 15 degree downward range of a 50th percentile adult male Operator's eye position. The layout of the cab shall be coordinated with the Engineer, shall be incorporated into the car mockup per Chapter 3 and shall be subject to review and final approval by the Engineer. All aspects of the cab design shall be approved by the Engineer.

C. Locomotive traction power shall be controlled by the Operator by means of a master controller, positioned for ease of operation by the left hand, which shall contain a reverser control handle and a controller handle for power level selection. It is desired that the master controller shall generally be a desktop-style master controller. The reverser handle shall act as the cab master controller key, and shall comply with Chapter 1. The cab console must provide sufficient space for reverser handle movement. Braking shall be controlled by the Operator by means of a brake controller, located for ease of operation by the right hand, as specified in Chapter 7. Between the two controllers shall be a flat area suitable for use as a writing surface by the Operator.

D. The vertical instrument and control panels flanking the windshield shall be arranged to be angled toward the Operator, so that critical displays are located at a 90° angle to the Operator's field of view. All indicators and annunciator lights shall be LEDs, which shall have a lamp test feature. A 3-position rotary dimmer switch shall be incorporated in the cab to control the intensity of all indicators and annunciator lights from bright to normal to dim, and shall not have an OFF position.

E. All operating controls, displays and all indicators shall be positioned within the Operator's normal reach and normal line-of-sight when seated. Controls shall be located, such that they can be conveniently operated, based on their importance or frequency of use. Controls or indicators, associated with a specific side of the train, shall be positioned on the associated side of the console or indicator panel. Wherever possible, controls shall be laid out similarly to CTDOT's existing cab car fleet.

F. All switches, controls and indicators on the control console or adjacent panels shall be rugged, high quality devices suitable for rail vehicle application and readily available from commercial sources. A minimal number of different types of devices shall be used, and individual functional designations shall not be marked on the device. Designations shall be permanently attached to or engraved on the

console. Multi-position controls shall have all positions identified. Adhesive bonded tags shall not be permitted. All device types shall be subject to approval by the Engineer.

16.03.02 Center Console

A. The center console located in front of the Operator at the bottom of the windshield shall be generally arranged as a flat desk sloped downward toward the Operator. All control devices shall be logically installed to provide an integrated appearance. Mounting hardware and all interface connections for the propulsion and braking controllers shall provide ease of access for maintenance or removal. The console shall be designed so that liquid spilled on the surface will not damage or interfere with operation of components, apparatus or wiring. Its finish shall be easily cleaned with a soap and water solution. Unless otherwise specified, all controls and indicators used on both Operator's and Observer's side cabs shall be identical components.

B. The Contractor shall arrange control switches frequently operated to be used by the right hand, since the left hand is required to operate the propulsion controller. The Operator's side center desktop console shall contain the following, generally from left to right:

1. Bell ringer valve
2. Master controller
3. Sanding switch
4. Writing space for train orders
5. Horn sequence pushbutton
6. Headlight control switch
7. Acknowledge pushbutton (cab signal/alerter/ACES)
8. Horn control valve lever
9. Reading light/cab lighting rocker switches and dimmers
10. Brake controller with integral display screen
11. Auxiliary light control switch
12. Windshield wiper control

16.03.03 Other Controls, Switches and Gages

A. The following controls, switches and gages shall be positioned at appropriate locations in proximity to the Operator to provide optimum access to the Operator, with minimal hindrance to visibility. Potential areas include the vertical control panel on the right and the upper panel.

1. 10 in. (254 mm) video monitor
2. Fault display panel
3. ECP Display for initialization of ECP System (Chapter 7)
4. Conductor communicating signal pushbutton switch
5. Fault reset switch
6. Gauge light dimmer
7. Heated windshield switch
8. Cab heater rotary switch
9. Car number plate (at optimum viewing location)

10. Two duplex air gauges (at optimum viewing location)
    a. Main reservoir/equalizing reservoir
    b. Brake pipe/brake cylinder
11. Radio and communications control
12. Emergency locomotive shutdown pushbutton
13. Locomotive type (electric/diesel) toggle switch
14. Locomotive alarm bell silence pushbutton switch (bell inside panel)
15. Main circuit breaker open/closed toggle switch (guarded) (*electric mode, only)
16. Bulletin order clipboard
17. Cab signal departure test panel
18. Cab signal cutout and bypass switches
19. Cab signal train type selector switch
20. Indicator LED and annunciator panel
21. Aspect display unit with 150 mph (241 kph) speedometer (at optimum viewing location, with 4 in. (102 mm) additional space below ADU for future expansion of display)
22. Non cab signal territory mode switch
23. Pantograph up push button switch (*electric mode, only)
24. Pantograph down toggle switch (guarded) (*electric mode, only)
25. Traction mode selector switch, diesel/electric
26. Alerter panel
27. Marker light switch
28. Headlight/auxiliary light status indicators (centered)
29. Locomotive dynamic brake fault
30. Wheel spin-slip warning buzzer
31. Conductor's emergency brake valve
32. Locomotive alarm bell pushbutton switch (bell inside panel)
33. HVAC Damper Control lighted, momentary, Push-on/Push-off pushbutton

NOTE: * these devices and functions shall only be operable when traction mode and vehicle type switches are in the "ELECTRIC" position

B. The following switches are to be sealed in the normal (down) position using a secure plastic tie seal method. A 0.1015 in. (2.6 mm) (No. 38 drill) diameter hole shall be provided in each switch toggle and in an adjacent sealing wire standoff for each switch:

1. Propulsion/doors interlock bypass switch
2. Speed interlock bypass switch
3. Friction brake interlock bypass switch
4. Traction master bypass switch
5. Spare switch location

C. Ideally, a vertical control panel to the left of the Operator shall be avoided to provide improved visibility.

D. The area above the windshield shall be used for infrequently used devices.

16.03.04 Not Used

Not Used.

16.03.05 Other Controls, Switches and Gages – Observer's Side

The Observer's side will contain the following equipment and controls under keyed access panels to prevent passenger access when the cab is configured in the quarter-width configuration:

A. B-3-B emergency brake valve

B. Track warrant holder with spring clip

C. Car number plate

D. Reading light switch Ceiling light switch

E. Heated windshield switch

F. Windshield wiper control

G. Speedometer

H. Observer's side cab reading light dimmer

I. Indicator LED and annunciator panel

J. Two duplex air gauges

16.03.06 Lower Cab

The area under the console and above the floor shall be clear of all piping and obstructions to provide room for the crew members' feet and legs. A raised platform, approximately 6 to 8 in. (152 to 203 mm) above the floor, shall be provided in front of the cab seat. An approved full-width footrest shall be provided as well as all specified foot switches. A properly identified and recessed horn system and bell pneumatic cutout cock and associated pressure switches shall be located below the center console where it can be easily reached by the Operator. A heavy-duty moisture-sealed acknowledgment foot switch shall be attached to a spring-loaded transverse bar located under the console which can be conveniently operated by either foot. A sealed pneumatic cutout cock to disable the penalty brake application shall also be provided.

16.03.07 Master Controller

A. The propulsion commands for the train shall be produced by manipulation of a compact, all electric master controller provided in each cab. Activation of the master controller and the cab controls shall be accomplished by use of the reverser handle. The proper ergonomics of the design and operation of the master controller is of great importance, and it shall be as reviewed and approved by the Engineer, taking into account the human factor guidelines referenced in Chapter 2. [CDRL 16-012]

B. The master controller shall directly produce trainline command signals through the actuation of heavy-duty cam switches. The camshaft shall be directly driven by a single handle to control all operations of the propulsion system. A mechanically interlocked reverser activated by the reverser handle driving a smaller camshaft shall select the direction of motion. The master controller handle axis of rotation

shall be horizontal, with an ergonomically comfortable arc travel, and a maximum turning force of 12 lbf (53 N). The controller shall be rugged and designed for the railroad or transit cab environment. Rubbing surfaces shall be enclosed to exclude dust and dirt. Internal components shall, as much as possible, consist of parts common to the propulsion system of other recently produced cars, and where not possible shall be of an equal quality level. The master controller top plate shall be removable without any disassembly of the controller mechanism other than handle and knob removal.

C. The master controller shall have a COAST position, which shall be furthest from the Operator, and eight power positions (POWER LEVEL 1-8). Each position shall have a medium detent tactile indicator sufficient for the Operator to sense that the controller contacts are fully closed. The COAST position shall have a more noticeable detent that is readily detectable. The controller top shall have approved raised and painted markings to easily identify each position. Power shall be applied by moving the handle toward the Operator.

D. The reverser and main controller handle shall be interlocked mechanically as described below. The main controller handle shall be permanently attached. It shall be possible to move the reverser handle only with the master controller handle in the COAST position. With the reverser handle in the NEUTRAL position or in the OFF position, the master controller handle shall be mechanically immobilized in the COAST position. The mechanical interlocking mechanism shall be robust and require no lubrication, cleaning or maintenance other than at the major overhaul periods for the rest of the car equipment. The electrical connections between the controller and the car wiring shall be by means of electrical connectors per Chapter 18. The controller shall be bolted to the cab. The bolts shall have open access, and the entire controller shall be easily removed and replaced for maintenance purposes. The details of the controller shall be approved by the Engineer.

16.03.08 Control Functions

A. The reverser handle interface of the master controller shall have four positions, OFF, REVERSE, NEUTRAL and FORWARD, and shall control other cab equipment (other than the cab air brake system) to produce the following functions. In the OFF position, the cab shall have all cab operating systems other than the cab signal/ATC equipment rack shut down. In NEUTRAL all operating systems other than propulsion control shall be powered, and the master controller handle shall remain mechanically locked. In FORWARD and in REVERSE all systems shall be operable. The reverser handle shall be removable in the OFF and NEUTRAL positions. The cab air brake system shall be controlled by the brake handle controller, per Chapter 7.

B. Circuits needed to establish the controlling cab and provide the interface with all the other car systems, such as doors, annunciators, etc., shall be carefully designed for safety, reliability and simplicity. Since such circuits can contain single-point failure locations that are capable of incapacitating a cab or a train, the Contractor shall treat them as a subsystem worthy of special attention. In evolving its designs, the Contractor shall treat the need to operate from other than the lead cab of the train as potentially hazardous and as a solution of last resort. When design has reached the appropriate stage, the Contractor shall prepare a document which contains four items for the Operator's approval: [CDRL 16-013]

1. An analysis of potential failures, their operational importance and how they will be annunciated to the Operator.
2. Explanation of how each of the identified failures can be overcome by the train crew, i.e., what provisions have been incorporated in the design for reestablishing train operability.
3. Explanation of how the recommended troubleshooting procedures, test equipment supplied and features of the basic circuit design will direct the attention of maintenance personnel to the point of failure.
4. A Failure Mode and Effects Analysis (FMEA) to confirm that no hazardous failure modes exist.

16.03.09 Audible Alarms

All required audible alarms and signals shall be electronic and shall be provided in the cab, located so as to be clearly audible to the Operator under conditions of loud ambient noise, and be readily accessible for maintenance. Audible signals requiring different actions shall have different sounds as specified below. Audible signals shall be no louder than necessary to be clearly audible in the cab under worst case conditions such as passing another train in a tunnel. The final audio levels shall be determined during acceptance testing. The audible alarms and signals shall include, but not be limited to:

A. Loco alarm (Sonalert) 2.9 KHz intermittent fast pulse tone

B. Conductor communicating signal (Buzzer) 4.5 KHz continuous tone

C. Wheel slip/brake warning (Sonalert) 1.9 KHz continuous tone

D. Alerter panel

E. Alerter audible alarm (yelp)

F. Cab Signal Downgrade & ATC Overspeed (Sonalert, 6 pulses/sec, 2900Hz)

G. ACSES Alarm (Sonalert, 1 pulse/sec, 2900Hz)

16.03.10 Main Circuit Breaker and Pantograph Control (Electric Mode)

Trainlined controls for opening the main circuit breaker and raising and lowering the pantograph of an electric locomotive shall be provided in the cab. These controls shall be active only when the cab car is in control of the electric-mode capable locomotive.

The PANTOGRAPH UP control shall be a spring-loaded push button switch. The PANTOGRAPH DOWN control shall be a single pole, single throw switch, shielded to prevent accidental operation. The upper position shall be labeled as NORMAL and shall permit the PANTOGRAPH UP control to function.

The lower position shall be labeled as DOWN and shall immediately lower all locomotive pantographs.

The main circuit breaker control shall be a double pole, 3-position switch (momentary close, maintained open, spring return to center off), shielded to prevent accidental operation, labeled open/closed; this device/function can be applicable to an electric-only (e.g., ACS-64) locomotive.

16.03.11 Indicator Lights

The following indicator lights shall be provided in the left and right side panels in Engineer-approved locations and groupings. Each indicator shall be backlit with the specified color when illuminated. Activation of each indicator must be clearly discerned by the Operator even under conditions of bright sunlight or other ambient illumination. Each indicator shall be a long-life LED, and be provided with a self-test feature (individual or group).

Note that the cab signal/ATC and ACSES system function indicators listed below will be contained in the aspect display unit along with additional indicators and may be different than what is described herein.

Light Group	Condition	Indicator Light Color
Operating status	MU control power on	Green
	PCS open	White
	Sanding (loco or Cab car)	Amber

	Wheel slip (loco)	White
	Dynamic brake warning	Red
	Loco trainline alarm	Red
	No power brake	Red
	Main Circuit Breaker OPEN	Red
	Spare	White
	High beam	Yellow
	Spare	Red
Safety equipment status	ACSES Failure	Amber
	ATC cutout	Red
	Alerter cutout	Red
	Suppression	Amber
	Maximum Authorized Speed (ATC/ ACSES)	Amber (x2)
	Spare	Amber
	ACSES cutout	Red
Cab Car status	Heated windshield on	Amber
	HEP on	Green
	HEP off	Red
	No battery charge	Red
	Cab Holding/Park Brake	Amber/flashing
	Spare	Red
	Spare	Amber
Train status	Brakes applied	Amber
	Brakes released	Green
	Car doors closed	Green
	Car hot journal	Red
	HVAC Damper CLOSED	Red

16.04 Electrical Circuits

16.04.01 Cab Switch Panels

Low voltage cab setup switches, circuit breakers, etc. shall be mounted on a panel on the upper console in the cab, accessible to the seated Operator, in a location approved by the Engineer. All devices will be clearly labeled by name and position. An instruction label will be included which provides instructions for switch and circuit breaker positions for lead and cutout operation. Switches shall be provided, at a minimum, for the following:

A. Locomotive control

B. Dynamic brake cutout

C. Engine run switch

D. Generator field switch

E. Door Closed Traction bypass switch (sealed)

F. Heated windshield

G. Windshield defogger

H. Cab heat

I. Auxiliary lights

J. Number signs

K. Radio

L. Indicator and gauge lights

M. Cab Signal/ATC

N. PTC/ACSES

O. Event recorder/alerter/speedometer (sealed)

P. 72VDC single plug outlet/receptacle

Q. 120VAC duplex outlet

R. Spare

S. Headlights

T. Pantograph up (Electric Mode, only)

U. Pantograph down (Electric Mode, only)

V. Main Circuit Breaker Open/Close (Electric Mode, only)

W. Traction mode selector diesel/electric

X. End of Train Set-Up (End Of Train/OFF)

16.04.02 Propulsion (MU) Control Circuits

A. Trainline requirements

The cab car shall be capable of operating in push-pull mode (loco/cab car) when operating with a diesel road locomotive or an Amtrak ACS-64 electric locomotive equipped with a standard 27-point MU control trainline. The cab locomotive controls and communications shall be interfaced using the existing propulsion trainline protocol in APTA-PR-E-RP-017-99. The 74VDC control power for the MU functions will be provided from the locomotive via the number 13 (positive control) and number 4 (negative control) MU control trainline circuits.

B. Trainline circuit protection

A two pole, 15 amp circuit breaker shall be provided between the number 13 (positive control) and number 4 (negative control) MU control trainlines and the cab car MU control electrical equipment. This circuit breaker shall protect the cab equipment from faults in the MU trainline system, and shall be used to provide an ON/OFF switch function to activate or deactivate the cab. A green MU control

power indicator light shall be provided on the load side of this circuit breaker, to provide the Operator an indication that MU trainline power is available from the locomotive.

C. Trainline functions

The MU control trainline functions shall conform to the control pin assignments of APTA-PR-E-RP-017-99. The following special trainline features shall also be provided:

1. Trainline Circuit 2 (Alarm Signal): Faults which trigger this alarm shall include traction engine shutdown, HEP engine shutdown and HEP loss that are either local or trainline. An ALARM SILENCE pushbutton switch shall be provided to allow the Operator to silence the loco alarm. This shall be via a self-latching relay so that if the loco fault clears, the cab alarm will be automatically restored to normal condition, and will respond to a new alarm.
2. Trainline Circuit 3 (Engine Speed): Pressing the MU EMERGENCY LOCOMOTIVE SHUTDOWN switch shall shut off the power feed to any throttle/dynamic brake commands. If the trainline circuit 3 alone is energized, it shall shut down all the diesel engines in the locomotive consist.
3. Trainline Circuit 26 (Ground Relay Reset): A pushbutton shall be provided to apply 74V to this trainline to reset the locomotive.

D. Power knockout functions

1. Power knockout (PKO) to disable locomotive propulsion shall occur in response to emergency or penalty brake applications in the cab car. The MU propulsion control system will receive the PKO message from the brake system, and shall immediately remove traction power by de-energizing MU Control trainlines 6 (GF), 15 (AV), 12 (BV), 7 (CV) and 3 (DV), and in addition shall illuminate the PCS OPEN indication on the cab console. Operation of this interface will be subject to design review.
2. To restore locomotive traction from an emergency brake application, the Operator must be required to perform the following actions:
   a. Place brake handle in emergency brake position;
   b. Wait for brake system timeout from the application of emergency brakes;
   c. Place throttle handle in coast;
   d. Move brake handle to release position; and
   e. Move throttle handle to a power position.
3. To restore locomotive traction from a penalty brake application, the Operator must be required to perform the following actions:
   a. Place brake handle in suppression position;
   b. Place throttle handle in coast;
   c. Perform actions that satisfy the system that initiated penalty (i.e., acknowledge alerter);
   d. Move brake handle to release position; and
   e. Move throttle handle to a power position.

16.05 Heating, Ventilation and Air Conditioning

16.05.01 Climate Control

A. The cab shall be provided with quiet, forced air supply of conditioned air from the car's main HVAC system, along with two separate cab heater systems. See Chapter 10 for additional details. Full climate control with air supply through a fully adjustable ceiling diffuser shall be provided.

B. The overhead diffuser(s) shall direct air towards the cab side windows to assist in defogging/defrosting.

C. The cab interior temperature and stratification shall meet the interior requirements as specified for the passenger area.

16.05.02 Cab Heaters

A. The local cab heaters shall be controlled independently of the HVAC unit with an Operator adjusted thermostat control. Both cab heaters shall be controlled by the same thermostat. The fans shall include a low and a high speed. The heaters shall have low heat and high heat options.

B. The thermostat shall be variable adjustable, providing ventilation without heat at the lowest position and providing no less than 80°F (26.6°C) supply air in the highest position under all exterior temperatures.

C. The cab heater shall be protected by over-temperature with a thermostat that cycles the control circuit and a backup circuit which opens the heating circuit after a failure of the control circuit. A manual reset shall be provided to reset the backup thermostat.

D. The noise level from the cab heater shall be no greater than 70 dBA in the high speed.

E. The cab heater shall include a manual damper that provides full airflow to the side windows or full airflow the Operator's feet. The damper shall provide incremental adjustments.

16.05.03 Windshield Heater

A. Cab windshields shall be heated. The windshield heat density shall be no less than 0.5watt/in^2 (6.5W/cm^2).

B. The windshield heater shall have the ability to defrost the windshield in 20 minutes or less when covered by .080" (2 mm) of ice.

C. The windshield heater shall be protected from over-temperature.

D. The windshield heater shall be operational when the vehicle is in both leading and trailing modes.

16.05.04 Air Distribution

The cab shall have durable individually adjustable diffusers for the Operator and Observer with manual direction and volume, infinite adjustment between maximum and minimum air volume and direction. The diffusers shall not create drafts on the Operator's or Observer's back or neck. The diffusers shall allow complete blockage of the cab air. The volume of conditioned air delivered to the cab through each diffuser shall be a minimum of 300 cfm (509 m^3/hr) when the diffuser is fully opened.

16.06 Cab Lighting

16.06.01 Headlights and Auxiliary Lights

A. Two headlights located at the upper center of the carbody, and two auxiliary lights located approximately at the bottom of the end sheet, one toward each outboard edge, shall be provided at the F-end of each cab car using approved fixtures, located such that they produce a triangular lighting appearance. The lights shall be suitably located and recessed to prevent damage when the F-end of the cab car is coupled to other equipment (including a cab car) and operated under all track conditions identified in PRIIA Specification 305-001. The fixtures shall comply with the requirements of 49 CFR Parts 229.125 and 229.133. All exterior lighting shall be powered from the low voltage power supply. All lamps shall be designed for ease of replacement from the car interior by access hatches, unless otherwise approved by the Engineer. All lighting fixtures shall be weather tight, of stainless steel construction and hardware, and recess mounted into the carbody to preclude snagging of car washer brushes. Materials surrounding and facing the headlights and auxiliary lights, including a coupled car, shall be capable of withstanding the heat caused by leaving these lights on bright indefinitely on a clear summer day with maximum ambient temperature. Both ends of the cab car shall also be equipped with incandescent marker lights which comply with the requirements of 49 CFR Part 221.

B. The headlight shall use an Engineer approved PAR 56, 30VDC, 200W sealed beam lamp, type 200PAR. The auxiliary light shall use an Engineer approved PAR 56, 30VDC, 350W sealed beam lamp, type 300PAR. The headlight fixture cover glass shall be Pyrex or approved equivalent. Voltage dropping resistors shall be provided to obtain 30V at the headlight in the bright mode and 17V in the dim mode when 74VDC is supplied. They shall be sized for continuous duty and appropriately located to prevent surrounding surfaces and equipment from being damaged by the heat dissipated by the resistor. Failure of a single lamp shall not cause the other lamps to be subjected to increased voltage. Rated lamp life shall be a minimum of 500 hours. The means of voltage reduction shall be approved by the Engineer. The headlight and auxiliary light fixtures shall be easily adjustable for horizontal and vertical alignment, and shall be provided with a locking device. Bezel design shall assure correct rotational alignment. The design and location of the light fixtures shall be approved by the Engineer. [CDRL 16-014]

C. The headlights shall be under the control of an easily-reached Operator's cab console mounted three-position rocker switch (BRIGHT, OFF, DIM), which shall be functional in the cab which has been activated and is in control of the train. An amber LED identified as HIGH BEAM located on the cab console annunciator panel shall be illuminated when the headlight switch is set to HIGH.

D. The auxiliary lights shall be under the control of a second easily-reached Operator's cab console mounted four-position rotary switch (OFF, ON, AUTO, FLASH), which shall be functional in the cab where headlight control is either DIM or BRIGHT. The headlight switch DIM position shall automatically dim the auxiliary lights. In the ON position, the auxiliary lights shall be on continuously. In the AUTO position, the auxiliary lights shall be on continuously when the headlights are set to BRIGHT, and not illuminated when the headlights are set to DIM or OFF. In the FLASH position, the auxiliary lights will flash alternately at a rate of 80 flashes per minute (40 flashes per minute per bulb) in accordance with 49 CFR Part 229.133. In all three operating modes the sounding of the horn or activation of the bell, as detected by a pressure switch downstream of the horn or bell control valve, shall cause the auxiliary lights to immediately flash alternately until the bell is silenced. A set of four green indicator LEDs telltales in an approved arrangement shall be provided in the cab above the windshield to indicate the functional status of each headlight and auxiliary light bulb (on steady, flashing, etc.). An approved momentary contact switch shall be provided to permit the Operator to dim the auxiliary lights for an adjustable time period, initially set for 20 seconds, to avoid blinding an oncoming train Operator. All cab switches shall be clearly identified with permanent labels. The auxiliary light controller shall have a set of red and green diagnostic LEDs on its enclosure.

16.06.02 Interior Cab Lighting

A. For general area illumination, the cab area shall have at least two red lens and two white lens light fixtures, suitably placed in the ceiling to illuminate the Operator's console, Observer's console and the general cab area and avoid glare on the windshield. LED light fixtures shall be used. These lights shall be controlled by a three-position (RED-OFF-WHITE) rocker switch with an adjacent three-position rotary dimmer control (bright-normal-dim). The minimum lighting intensity provided by the white ceiling lights shall be 15 foot-candles (161 lx) on both the floor and the console.

B. For reading purposes, additional recessed, focused, gimbal-type ceiling Operator and Observer's reading lights shall be provided. It shall comply with the requirements of 49 CFR Part 229.127, and shall produce at full intensity a minimum of 25 foot candles (269 lx) at an elevation of 2 ft 9 in. (838 mm) above the floor in the Operator's and Observer's work area. The reading lights shall be controlled by two-position (ON-OFF) rocker switches with an adjacent three-position (bright-normal-dim) rotary dimmer control.

C. These lights shall not reflect onto the windshield or interfere with outside observation during night operation, and shall be capable of location adjustment by the Operator/Observer. All lights shall be powered by the battery circuit. All light fixtures shall be dust tight, designed for ease of re-lamping. The type and location of the lights shall be approved by the Engineer. [CDRL 16-015]

D. The speedometer in the aspect display unit, the duplex air pressure gauges and the exterior car number signs shall be illuminated by the low voltage power supply whenever the cab has been activated and is in control of the train. The complete cab lighting arrangement shall be included and reviewed in the cab mockup.

16.07 Alerter and Event Recorder System

16.07.01 General

The cab shall be equipped with a combination alerter and event recorder system which shall be Wabtec Train Trax model TTX-REC-M5, or approved equivalent, installed in an Engineer approved location. Its functions shall be configured by the Contractor to operate similar to that on the existing Amtrak ACS-64 electric locomotives. All aspects of the design and installation shall be approved by the Engineer during design review. [CDRL 16-016]

16.07.02 Alerter System

A. The Operator's activities shall be monitored over a specified time period. If the Operator is inactive during this time period and no system reset is generated, the alerter system display shall issue a combination pulsing audible/visual alarm for a specified time interval. Continued lack of Operator activity shall result in a continuous audio alarm, a continuous visual alarm and a penalty brake application with power knockout. To recover, the brake controller must be moved to the suppression position, the alerter must be reset by normal reset actions (acknowledge, etc.), the Operator shall wait for the PCS light to extinguish, and the Operator shall then release the brakes. It shall not be necessary to stop the train.

B. An alerter system shall be reset each time the Operator performs one of the following:

1. Throttle change
2. Change of direction
3. Automatic brake incremental change (±) of more than 5 psi
4. Cab signal/ATC acknowledgement

5. Activate the horn
6. Activate or deactivate the bell
7. Presses the alerter reset (ACKNOWLEDGE) pushbutton
8. ACSES acknowledgement

C. The alerter reset interval shall decrease with train speed, in conformance with the interval/speed function exhibited on the existing Amtrak electric locomotives. The alerter shall become dormant if it meets the same criteria for dormancy as employed on the electric locomotives, or if the automatic brake valve is cutout. It shall be possible to perform a self-test of the system with the car stationary.

D. If the alerter system fails, the Operator shall be able to cutout the system through the use of a sealed switch or sealed cutout cock with yellow handle, located adjacent to the overspeed and ATS cutout cocks. Activation of the alerter cutout shall provide an indication on the cab console indicator panel.

16.07.03 Event Recorder

A. The event recorder, including memory and download modules, shall be designed and installed in accordance with 49 CFR Part 229.135. These components shall be located in the secure top portion of the cabinet behind the Operator's cab.

B. The memory module shall be crash-hardened, tamper resistant and waterproof. The system shall retain data during extended loss of power to the system, shall provide physical protection during vehicle catastrophic occurrences, be flame resistant and contain constraints against accidental or deliberate data erasure or over-writing. The system shall retain, at a minimum, the last 100 days of data collected in normal railroad operation.

C. Train operating data will also be provided to the non-removable memory module to record operational performance data. Minimum scan rate occurs as a result of a change. Data retained will cover a period of at least 100 days in normal railroad operation. Recorded data will be capable of convenient download on demand to a compatible Windows-based computer and a removable memory storage device. The list of recorded inputs is to be submitted for Engineer approval. [CDRL 16-017]

D. The parameters to be recorded, and the rate of scan for those parameters, shall be provided to the Engineer for review. Time, date, car number and distance traveled shall also be recorded.

E. The event recorder system shall be installed in an approved location. The recorder memory and download modules shall be painted orange for easy identification following an accident.

F. The minimum parameters to be recorded shall be as follows, subject to revision during design review:

No.	Type	Description
1	Digital	Brake cylinder pressure 15 psig (bench mark)
2	Digital	Alerter reset
3	Digital	Brake pipe charging cut-off (port 53)(lead/trail)
4	Digital	Operator initiated emergency brake
5	Digital	Bell use
6	Digital	Horn use (full volume horn blast, air signal)
7	Digital	Self test of alerter
8	Digital	Alerter control override (electric cutout)
9	Digital	ATC enabled (combination electronic & pneumatic)
10	Digital	Generator field excitation

No.	Type	Description
11	Digital	Throttle valve A
12	Digital	Throttle valve B
13	Digital	Throttle valve C
14	Digital	Throttle valve D
15	Digital	Direction of travel forward
16	Digital	Direction of travel reverse
17	Digital	Dynamic brake setup
18	Digital	Sand magnet valve
19	Digital	Penalty brake (output to alerter magnet valve)
20	Digital	Headlight switch – headlights on (high or dim)/off
21	Digital	Headlight switch – auxiliary lights on
22	Digital	Horn sequencer switch
23	Digital	HEP on/off
24	Digital	Door closed summary circuit (doors closed/not closed)
25	Digital	Parking brake applied
26	Digital	PCS open
27	Digital	ATC acknowledge
28	Digital	ATC request for acknowledgement
29	Digital	Horn
30	Digital	Pantograph up/down
31	Digital	Cab signal high overspeed select (ATC is cut in)
32	Digital	Door closed summary circuit status (normal/bypass)
33	Digital	Main Circuit Breaker open/close
A1	Analog	Brake pipe pressure
A2	Analog	Brake cylinder pressure
A3	Analog	Headlights high/dim/off
A4	Analog	Auxiliary lights on/flashing/off
A4	Analog	Not used
A5	Analog	Cab signal code rate
A6	Analog	Not used
A7	Analog	Not used
F1	Freq.	Speed (1 mph increments)
F2	Freq.	Not used
F3	Freq.	Not used
F4	Freq.	Not used
N1-TBD	TBD	ECP Data as recommended by the Brake Supplier. Interface method and details of recording TBD.

16.07.04 Data Collection

Train operating data will also be provided to the non-removable memory module to record operational performance data. Minimum scan rate occurs as a result of a change. Data retained will cover a period of at least 100 days in normal railroad operation. Recorded data will be capable of convenient download on demand to a compatible computer and a USB memory stick without erasing the recorder memory.

16.07.05 Data Retrieving

A. The event recorder shall be supplied with a Remote Download Port (RDP), which provides an access point for connecting a laptop computer to an event recorder for data download and diagnostics. In addition, the RDP shall have a USB socket that allows the insertion of a standard USB thumb drive for data downloading. The Event Recorder shall connect to and allow downloading from the Ethernet Car Network, including via cars attached via the Ethernet Train Backbone.

B. The RDP shall be provided power through a single cable connection to the event recorder. The RDP shall be located in the event recorder locker or in the cab per Engineer approval. Event recorder download capability shall be available at any time, including during train operation. Downloads of the complete event recorder memory shall be accomplished to USB memory device or to laptop computer within 15 minutes. The PTU and memory device shall be adjusted to accomplish downloads based on duration, date range, and download size. The download of 24 hours of event recorder memory shall be accomplished within 5 minutes.

16.07.06 Deliverables

Prior to the delivery of the first cab car, the Contractor shall deliver to the Engineer 10 complete sets of the event recorder diagnostic software required for retrieving and reviewing the recorder data, all proper download connection cables and memory cards. Instructions for using the software will be provided. The software packages shall incorporate all methods to download data. All deliverables shall comply with the Materials and Workmanship requirements of Chapter 18, and shall be updated as required until the expiration of the warranty period. There shall be no additional costs nor restrictions associated with this software to the Engineer. [CDRL 16-018]

16.07.07 Speed Signal

The Contractor shall coordinate all suppliers' work such that a single speed signal is used for the cab speedometer display, alerter system, event recorder, cab signal system and ACSES system, in order to keep all systems in agreement. End of axle drive type speed pickups shall not be used. The design of the system shall minimize pickup and wiring vulnerability of damage from wayside debris, and shall be subject to approval during design review.

16.08 Sanding

A. In addition to the trainlined control from the cab car of the locomotive sanding system, each cab car shall also be equipped with a local sanding system, configured to deliver sand to each rail in front of the first axle at the F-end when the cab car is in control of the train. The cab car sanding system shall be electrically activated from the activated cab console and pneumatically operated. Manual operation of the cab car sanders shall be controlled by a momentary contact switch on the cab console. A cab car emergency brake application shall cause an automatic application of sand until zero-speed is reached. Automatic sanding activation shall not function when the train is stopped, to prevent waste of sand. Use of the locomotive sanding or cab car sanding switches shall illuminate the sanding console indicator.

B. Two stainless steel sand storage boxes, one for each rail, shall be located on the underside of the F-end of the cab car. Each sandbox shall have a capacity of at least 5 ft (0.14 m^3), be shielded from debris damage and located to minimize the length of sand piping. Each box shall be configured to allow refilling alongside the car from both pneumatic sand storage tower hoses and manually from bagged sand. They shall be entirely constructed of stainless steel, have a coarse cover screen to keep out debris when refilling, be fitted with watertight hatch covers, and have suitable cleanout openings near the bottom. The angle of the sand box slope shall be greater than the angle of repose of the sand, to ensure that the sand will freely dispense when requested. Solenoid control valves shall be

Salem 500-BS or approved equivalent. Sand traps shall be Salem 277-2, or approved equivalent, with integral rotary sand shutoffs and quick disconnects. Sand shall be delivered at an adjustable rate, initially set to 12 oz (148 ml) per minute from each nozzle. A manually operated pneumatic cutout valve shall be provided at each sander. The sander nozzle for each rail shall be attached to the truck frame to provide accurate sand placement on curving track. Details of the design, arrangement and installation of the sanding system shall be submitted to the Engineer for approval during design review. [CDRL 16-019]

16.09 Radio System

16.09.01 General

A. The cab car shall be equipped with an approved VHF locomotive voice radio system, independent of the car's passenger communications systems. This system shall be a single transmitter/receiver (T/R) unit complete with control faces, flush mounted in an approved location on both sides of the cab, and arranged to facilitate easy removal and replacement. It is intended that control of the radio will be performed by Operator's use of the radio faceplate controls, microphone and speaker. No separate control head shall be provided. It is therefore critical that the radio be located for ease of single hand operation by the Operator, and orientated for proper microphone voice recognition. This shall be verified during design review and in the cab mockup.

B. The radio system shall be similar to the standard Ritron RCCR-NXR locomotive radio but must support both narrowband and NXDN technologies, or as otherwise specified by the Engineer. All wiring, connector plugs and mounting systems shall be fully compatible with the Ritron RCCR-NXR locomotive radios currently used by Amtrak. The radio shall be manufactured specifically for installation on a locomotive, and shall comply with all pertinent AAR specifications and recommendations for locomotive voice radio in effect at the time of delivery. The transceiver power input circuitry shall be provided with protective devices to avoid damage from both reverse polarity and transient overvoltage. The electrical power input of the transceiver shall also be provided with an over current protection device, such as a fuse or circuit breaker, to minimize damage to the transceiver in the event of a short circuit.

C. The mountings shall provide adequate access for servicing in compliance with AAR Specification 12-10, Figures 122-2 and 122-3. Sufficient cable slack shall be provided for ease of servicing or replacement. It is intended that the control head be flush mounted in the cab console panel, using a slide-out mounting. The control head as installed shall be orientated to the Operator to permit convenient operation of controls and clear observation of the displays. The faceplate, controls and displays shall be highly resistant to impact, abrasion, and water intrusion.

D. The radio equipment in each cab shall be operable when the cab has been activated by the Operator. The Contractor shall be responsible for radio purchase, programming and integration into the vehicle. Special attention shall be paid by the Contractor to the suppression of conducted and radiated electromagnetic interference effects on radio equipment operation from other car subsystems and on car control subsystems from radio transmissions. All equipment must meet or exceed the standards of the Electronic Industries Association and the rules and regulations of the Federal Communications Commission in addition to those specified herein. The radio system components and design shall be approved by the Engineer. [CDRL 16-020]

16.09.02 VHF Antenna

A low-profile mobile antenna shall be installed at each cab and connected to the adjacent radio transceiver. Orientation shall be so as to avoid damage from mechanical carwash brushes, and to also maximize signal strength. The antenna shall be designed for severe environmental conditions. The antenna shall be the Amtrak standard, Sinclair Technologies, Inc. model ST221, or approved equivalent.

The antenna shall be adjusted, if necessary, for maximum signal strength in the 160.800 MHz range prior to car delivery. The antenna cable shall be Teflon high temperature jacketed type RG-303/U MIL-C-17D coaxial cable, with approved connectors, and shall be run in conduit to the radio.

16.09.03 Power Requirements

The cab radio system shall be powered from the low voltage power supply with automatic backup by the battery in the event of power loss, and shall have sufficient capacity to meet all peak power requirements. The radio system shall use individual circuit breakers and suitable interference suppression line filters. Transient filter protection shall be provided as an integral part of the equipment, in accordance with the manufacture's recommendations. Adequate protection shall be provided against transients with peak amplitude of 3.0 kV and a total energy of 90 joules. The Contractor shall provide all wiring, connectors, enclosure and suitable installation hardware.

Table 16-1: Controls and Switches (other than throttle, reverser and brake)

Location	Switch Function	Switch Type/Color
Desktop	Acknowledge Switch (Alerter reset, Cab Signal/ATC Acknowledge, ACSES Acknowledge)	Yellow, mushroom- style push button
	Horn	Blue, mushroom-style push button, 2 position (Off, On)
	Bell control	Yellow, square, two button, push button (On, Off buttons)
	Sand	Blue collar type push button
Floor (foot space)	Horn automatic sequence	Pedal (yellow) (Square-D AW-13)
Left auxiliary console	Headlight selector	4-position rotary (Electro Switch Corp 101405A-S)
	Marker Lights	3-position rotary (F-end/off/B-end)
	Cab reading light dimmer	Rotary dimmer switch with off detent
	Windshield wiper	Rotary switch with variable speed
Right side overhead console	Defogger	Rotary (On/Off)
	Defroster	Rotary (On/Off)
	Console light dimmer	Rotary switch
	Cab ceiling light	Rocker switch (NKK SW3821D/328)
	White reading light	Rocker (NKK SW3821D/328)
	Red reading light	Rocker (NKK SW3821D/328)
	Inter car end door light	Rocker (NKK SW3821D/328)
	Locomotive trainline alarm silence	Red collar type push button

	TL GRD/EAB loco fault reset	Black collar type push button
	Emergency locomotive shutdown	Push button, red jumbo mushroom type. Two position – push to activate, pull to reset
	Door Bypass	Illuminated rotary (normal/cutout)

Additional Controls for Electric Locomotive, to be located upon cab review:

Location	Switch Function	Switch Type/Color
To be determined	Pantograph up	Spring return push button
	Pantograph down	2-position guarded toggle switch
	Traction motor selector (diesel/electric)	3-position, spring return to center-neutral/off toggle switch
	Main Circuit Breaker Open/Close	3-position, momentary closed, maintained open, spring return to center-neutral/off guarded toggle switch

16.10 Contract Deliverable Requirements List

CDRL #	Title	Car Type
16-001	Cab Design Details	Cab
16-002	Pressure Switches and Sensors, and Pneumatic Cutout Cocks Locations	Cab
16-003	Operator Cab Compartment Interior General Arrangement	Cab
16-004	Sample Cab Window	Cab
16-005	Cab Door Functionality	Cab
16-006	Sun Visor Design and Placement	Cab
16-007	Seat Design Details and Color Schemes	Cab
16-008	Seating System Ergonomic Analysis and Report	Cab
16-009	Sample Seat	Cab
16-010	Horn Installation Details	Cab
16-011	Bell Installation Details	Cab
16-012	Master Controller Design and Operation	Cab
16-013	Control Functions Failure Analysis Document	Cab
16-014	Headlight and Auxiliary Light Fixtures Design and Locations	Cab
16-015	Interior Cab Lighting Type and Location	Cab
16-016	Alerter and Event Recorder System Design and Installation	Cab
16-017	Event Recorder Recorded Inputs List	Cab
16-018	Event Recorder Diagnostic Software	Cab
16-019	Sanding System Arrangement and Installation	Cab
16-020	Radio System Components and Design	Cab

* End of Chapter 16 *

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Technical Specification

CTDOT Single-Level Passenger Rail Cars

Chapter 17

Emergency Equipment

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17.00 Emergency Equipment

17.01 Overview

Each rail car shall be equipped with emergency equipment per the requirements of 49 CFR Part 239.101. Emergency equipment provided shall include fire extinguishers, pry bars, first aid kits, chemiluminescent snap lights and posted passenger safety information signs. Additionally, an Automatic External Defibrillator (AED) and an associated storage container shall be provided in the cab car.

17.02 General Requirements

Emergency equipment as provided shall meet all applicable regulations, standards and specifications. Equipment provided shall be located and installed in a manner that facilitates identification and access of the emergency equipment when needed by passengers and crewmembers without the use of keys or tools, unless otherwise specified. Emergency equipment shall be located as to be available to passengers in the range from the 5th percentile female to the 95th percentile male, and in accordance with applicable ADA regulations. All emergency equipment shall be new and shall be qualified for use for a minimum of one year after delivery of the car. Each car shall be shipped with a full complement of emergency equipment unless otherwise specified by Engineer.

17.03 Emergency Equipment Lockers

17.03.01 General

A. An emergency equipment locker shall be provided on each car; in the B-end vestibule. The location of the locker shall be in compliance with all applicable ADA requirements. The design and layout of the emergency equipment locker shall be proposed by the Contractor. [CDRL 17-001]

B. The emergency equipment locker shall be recessed into the wall and shall have a clear Lexan front panel. The panel shall be hinged with a stainless steel piano hinge and secured with a paddle latch. The paddle latch shall have a tamper-seal hasp. The Lexan panel shall be mounted in an equipment locker door equipped with a pencil-lock release so crewmembers can access the emergency equipment without breaking the seal.

C. The locker shall be marked with emergency equipment signage that is compliant with federal emergency signage standards and compatible with Amtrak standard signage for the safety equipment contained therein.

D. At a minimum, the emergency equipment locker shall be designed to include emergency tools, a fire extinguisher, a first aid kit and snap lights. The equipment shall be securely attached to the interior of the locker and shall not be loose within the locker, but shall be easily removed in the event of an emergency.

17.03.02 Emergency Tools

Each emergency equipment locker shall include an 18 in. (457 mm) pry bar. It shall be installed in a manner that will prevent vibration and rattling and be readily available for emergency use.

17.03.03 Fire Extinguisher

A. The extinguisher shall be securely mounted in a manner that will prevent vibration and rattling and allow its prompt removal in case of fire. The installation shall conform to the requirements of NFPA

Specification No. 10. The fire extinguisher shall be clearly marked with instructions in accordance with NFPA Specification No. 10.

B. A dry-chemical, 10 lbs (5 kg) fire extinguisher, UL rated 2A-40 type B/C shall be included in the emergency equipment locker of each car.

C. A fire extinguisher, identical to that specified above, shall also be mounted in the emergency equipment locker behind the cab area of the cab car.

D. Fire extinguishers shall have all required certifications prior to shipment of the car.

17.03.04 First Aid Kit

A. A first aid kit, compliant with the requirements of 49 CFR Part 239.101, Pac-Kit p/n 6311AMT, shall be included in the emergency equipment locker.

B. First aid kits, identical to those specified above, shall be located in the emergency equipment locker behind the cab

17.03.05 Snap Lights

Each emergency equipment locker shall include one package (quantity 10) of 6 in. (152 mm) yellow 12-hour chemiluminescent snap-lights, Cyalume p/n 9-01360, or approved equivalent.

17.04 Automatic Electronic Defibrillator (AED)

The Contractor will provide an Automatic Electronic Defibrillator (AED) and an associated storage container. They will be installed in a location accessible to crewmembers in the cab car. If the AED is to be lifted vertically out of the holder, a minimum clearance of 24 in. (610 mm) must be provided above the top of the holder. The container shall securely retain the AED under all regulated accelerations. Appropriate signage shall identify the location of the AED unit. Details of location and installation of the defibrillator shall be submitted for Engineer review and approval.

17.05 Safety Information Signage

A. The Contractor shall develop the artwork for wall-mounted safety information signs illustrating the type, location and use of all safety features, emergency equipment, emergency signage and emergency exit pathways for each car type. These safety signs shall be designed in the format of both Amtrak's "Passenger Safety Instructions" and CTDOT's style guide and shall include a clear Braille overlay. Artwork is to be provided for Engineer review and approval. [CDRL 17-002]

B. Electronic artwork, suitable for printing, shall be provided to the Engineer prior to the delivery of the first vehicle.

17.06 Contract Deliverable Requirements List

CDRL #	Title	Car Type
17-001	Emergency Equipment Locker Design and Layout	All
17-002	Safety Information Signage Artwork	All

* End of Chapter 17 *

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Technical Specification

CTDOT Single-Level Passenger Rail Cars

Chapter 18

Materials and Workmanship

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18.00 Materials and Workmanship

18.01 Overview

This chapter defines the requirements for materials and workmanship that shall apply to the design and manufacture of systems and subsystems for assembly into CTDOT's passenger vehicles. This chapter shall apply to all phases of the project. It shall be the responsibility of the Contractor to inform his suppliers of the requirements of this section as well as enforce them.

18.02 General Requirements

18.02.01 Applicability

This section defines the requirements for all material and workmanship which shall apply to the design and manufacture of the vehicles, and all systems, subsystems and components contained therein, that are to be built to this specification. All materials and methods of assembly shall be in conformance with the applicable requirements of this section, and all applicable standards, specifications and references. Those references, standards and specifications listed constitute a partial listing; the Contractor shall be responsible for identifying and complying with all applicable regulations, industry standards and material specifications whether listed herein or not. The revision of these references that are current at time of issuance of Notice To Proceed (NTP) shall apply.

18.02.02 Marking and Storage

A. All materials intended for use on these vehicles shall be marked or stored so as to be readily identifiable and shall be adequately protected during handling and storage.

B. All stored material subject to corrosion shall be protected by waterproof covers, coatings or packaging.

C. Equipment covers, cable entrances and openings shall be closed to prevent ingress of water or dirt.

D. All dated material shall have the expiration date clearly marked. Expired material or material expiring within one year of car acceptance shall not be used, except caulks and sealants, which may be used if not expired.

E. Material or components, which require maintenance during storage, shall be properly maintained per the component(s) manufacturer's instructions. The Contractor shall document such maintenance, and provide these records as requested by Engineer.

F. Rejected material shall be clearly marked and stored in an area specifically designated for that purpose.

18.02.03 Prohibited Materials

The following materials shall not be used in the construction of the vehicle:

A. Polyvinyl Chloride (PVC)

B. Asbestos

C. Lead in brake shoes

D. Urethane foam

E. Chlorinated Fluorocarbons (CFCs) that may cause environmental degradation or handling hazards

F. Materials that, in their normal installed state, emit products that are known to be toxic or irritants

18.02.04 Material Reporting Requirements

A. Whenever a commercial material is not covered by a specification or standard, the Contractor shall identify the material by the commercial trademark, name and address of the Supplier. The Contractor shall submit a description and the technical data specifications of the material composition for approval at the design review

B. The Contractor shall keep on file a Material Safety Data Sheet (MSDS) for all chemical materials (paints, solvents, adhesives, etc.) used in the manufacture, maintenance, operation or repair of the vehicles, and shall provide a copy of each MSDS in the appropriate maintenance manual. [CDRL 18-001]

C. The Contractor shall keep a running list of all materials used in the vehicle. The Contractor shall submit this list along with material certifications and material property test reports to the Engineer as part of the material certification test requirements. See Chapter 19.

D. The Contractor shall maintain records that trace all materials to their manufacturers and production specifications and methodologies.

18.03 Joining and Fastening

18.03.01 General

A. Certain combinations of materials require particular care in joining to avoid the possibility of corrosion. Isolating and moisture-proofing materials, appropriate to the materials being joined, shall be used at all times where these combinations exist.

B. The Contractor shall submit joining and fastening data, specifications and standards for all types and methods of fastening and joining used to the Engineer for review and approval at the design review. [CDRL 18-002]

C. The Contractor shall submit to the Engineer a dissimilar metals report, identifying all locations where dissimilar metals or metals and wood are joined, and describing the methods used for mitigating galvanic or chemical corrosion at those locations. These methods shall be subject to review and approval by the Engineer. [CDRL 18-003]

18.03.02 Joint Fitting

A. Joints shall be properly fitted, whether exposed or concealed. When not otherwise specified in drawings or specifications, gaps between joints shall be held to a dimension not greater than 10% of the thinner material being joined, or 0.002 in. (0.050 mm), whichever is greater. Gaps shall be uniform in width. The edges of panels shall have a smooth, finished appearance.

B. Where excessive gaps (greater than those permitted by approved drawings or standards) are found to exist at the facing surfaces of structural bolted or riveted connections, metal shims of the same material as that of the deficient part may be used, but only with the written permission of the Engineer. Shims, if used, shall be permanently fastened to one of the base parts being joined. The use of epoxy or other plastic filler at such locations is prohibited.

18.03.03 Metal-to-Metal Connections

Where metals contact each other, the contact surfaces shall be free of dirt, grease, rust and scale. Unless specified otherwise, the contact surfaces shall be coated with a metal-based primer that conforms

to GSA Federal Standard TT-P-664D. Metal primer may be omitted for like-stainless steel to like-stainless steel joints.

18.03.04 Wood-to-Metal Connections

A. Where wood and ferrous metal surfaces are placed together, the wood shall be coated with aluminum paint conforming to GSA Federal Standard TT-P-38E, and the metal shall be coated with a primer that conforms to GSA Federal Standard TT-P-664D.

B. All bolts or rods passing through wood shall be coated with aluminum paint conforming to GSA Federal Standard TT-P-38E.

18.03.05 Wood-to-Wood Connections

Where wood and wood are placed together, both abutting surfaces shall be coated with aluminum paint conforming to GSA Federal Standard TT-P-38E.

18.04 Fasteners

18.04.01 General

A. The Contractor and all suppliers are responsible for selecting fastener types, sizes, styles, lengths, materials, grades and finishes that will meet the requirements of this Specification. The Contractor shall minimize the number of different sizes and styles of fasteners used. Whenever a maintenance process requires the removal or application of a fastener, consideration shall be given to the ease of access to such fasteners.

B. Fasteners used throughout the vehicle shall be inch standard fasteners, except as provided otherwise. All fasteners used on the vehicle shall be specified under one of three categories: electrical and electronic; structural and safety-related; or decorative.

C. All threaded fasteners shall be 0.25 in. (6.35 mm) diameter or larger. Smaller fasteners may be accepted on a case-by-case basis.

D. Safety-related fasteners include, but are not limited to, those applied to trucks, bolsters, brake equipment attachment, couplers and attachment of interior components or other fasteners as identified by the Engineer. A fastener is safety related if a single fastener failure will create an unsafe condition. All safety related fasteners shall incorporate a locking mechanism. Self-tapping screws shall not be used without written Engineer approval.

E. Structural adhesives hook & loop materials (Velcro) or interlocking plastic tapes, such as 3M Dual-Lock, shall be allowed on a case-by-case basis after review with the Engineer. Adhesives shall only be allowed once accelerated aging and temperature range tests prove the material has an acceptable service life.

18.04.02 Threaded Fasteners

A. All inch-standard threaded fasteners shall conform to ANSI Standard B1.1 or Industrial Fasteners Institute 1970 Fastener Standards.

B. Prevailing-torque type locknuts shall be nylon insert type, ESNA or approved equivalent, conforming to IFI Fastener Standards or Military Standard MS-21044. Distorted thread locknuts shall only be used where there is insufficient clearance to install ESNA type locknuts, or where the locknut may be exposed to temperatures above 200°F (93°C).

C. When making connections to heat producing apparatus, thermal expansion of the components shall be taken into consideration for selection of fastener materials. If the joined components are high expansion alloys such as copper or austenitic stainless steel, austenitic stainless steel fasteners shall be used. If the joined components are low expansion materials such as carbon steel or ferritic stainless steel, zinc plated carbon steel fasteners of minimum Grade 5 shall be used.

D. All screws or bolts used to secure access panels to the interior, undercar, or roof equipment shall be made captive to the panel in which they are used.

E. When bolts are used to secure apparatus where the bolt head is not accessible, a reusable mechanical locking device shall be used to prevent the bolt head from turning when the nut is being turned. Threaded inserts shall not be permitted without prior written Engineer approval.

F. At least 1.5 screw threads shall be visible beyond all nuts. When used without elastic stop nuts, bolts shall not project more than 1.5 threads plus 0.25 in. (6.35 mm) for bolts 0.25 in. (6.35 mm) diameter or less and shall not project more than 8 threads for larger diameter bolts. With elastic lock nuts, bolt threads shall not project more than 0.25 in. (6.35 mm), regardless of bolt size, unless approved otherwise by the Engineer.

18.04.03 Metric Fasteners

A. Subject to Engineer approval, specific components, control groups, or individual units that are supplied by a supplier or sub-supplier to the Contractor, may be supplied with metric fasteners meeting ANSI B1.13M (ISO-metric) Standards. All internal fasteners and threaded components of the approved assembly shall have ISO-metric threads. Internally, there shall be no mixing of metric and inch threaded fasteners. External mounting fasteners and threaded connecting components shall have ISO-inch threads to ANSI B1.1 Standards. Each unit, component, or group assembled with or containing ISO-metric threads shall be indelibly identified, in a manner and a conspicuous location approved by the Engineer, to signify that the unit was assembled using metric threaded fasteners or components. All repair and maintenance manuals shall be conspicuously marked on each page where metric threaded fasteners were used within the unit. Replacement, repair or maintenance parts supplied under this Specification shall contain all necessary replacement fasteners of the correct size and grade.

B. Metric fasteners shall be marked as required in Metric Fastener Standards, Industrial Fasteners Institute, latest edition.

18.04.04 Structural Fasteners

A. All structural fasteners shall have documentation identifying manufacturer and purchase specifications available for examination by the Engineer at the Contractor's Quality Assurance (QA) department. This documentation shall include the fastener material or grade, and finish including plating material and specifications, when applicable. Whether the purchaser is a subcontractor, supplier or the Contractor, the Contractor shall obtain and hold this documentation for a period of not less than the expiration of the warranty period of the last vehicle accepted.

B. All safety-related fasteners shall either: a) be manufactured, tested, and distributed in accordance with ASME Standard B18.18.3M, including the requirements of ASME accreditation or b) 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 equivalent. A production lot is defined as one size of fastener, from one manufacturer, and produced during one continuous production run. Fasteners not meeting this definition of production lot shall be treated as separate lots. Testing shall be performed using sample quantities as proposed by the Contractor and approved by the Engineer. Tests conducted shall confirm that fastener material meets specified chemistry and strength requirements. The purchaser shall obtain certified test results from the testing laboratory and the Contractor shall obtain and hold

the documents for a period of not less than the expiration of the warranty period of the last vehicle accepted.

C. Fasteners or fastener components with hardness greater than or equal to 32 HRC (320 HV) are susceptible to hydrogen embrittlement when these parts are pickled and/or electroplated. This may cause these fasteners to fail at relatively low loads even if stress relief annealing (baking) is performed after plating. Examples of hardened fasteners are steel bolts - US Grade 8 (Metric property class 10.9), hardened steel washers, spring washers, etc. These types of fasteners shall be mechanically plated per ASTM B695-00 Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel to avoid hydrogen embrittlement. All safety-related fasteners that are plated or chemically cleaned shall have certifications showing freedom from hydrogen embrittlement. If non-standard, structural, or safety related fasteners are plated by other than the Original Equipment Manufacturer (OEM); a representative sample of these fasteners shall be tested for hydrogen embrittlement by the Contractor or supplier. If any failures occur the entire lot shall be rejected.

D. All structural bolts for undercar equipment shall be a minimum Grade 5 with a minimum 3/8" diameter shall be used to attach the equipment, but the allowable stresses shall be based on Grade 2 fasteners. The fasteners shall be vibration-resistant. Stronger fasteners shall be used if the application requires. The mounting and attachment bolts for undercar mounted equipment and equipment support structures or brackets shall be sized to the design strengths required. Undercar mounted equipment shall be supported by brackets or other structures and not be supported by bolts in tension or shear. Bolts or screws used for structural connections shall have full size bodies in areas subject to bearing and/or shear loads.

18.04.05 Decorative and Appearance Fasteners

A. All interior fasteners exposed to view shall be either bright or finished to match the surfaces being joined, and installed such that the fastener head is flush with the mating surface. Bright finished fasteners used for stanchions shall be austenitic grade stainless steel. Bright finished interior fasteners may be either austenitic or plated martensitic stainless steel. Type A sheet metal screws shall not be used.

B. All exterior fasteners visible to passengers shall be austenitic stainless steel for stainless steel car bodies. Exterior aluminum shall be joined by austenitic stainless steel, as appropriate to the design and appearance requirements. Fasteners used on the side sill to attach heavy equipment brackets shall be considered structural fasteners.

C. All fasteners used to secure access covers or panels to equipment boxes or interior panels shall be made captive to the panel in which they are used. Where access for service is expected more often than every five years, access panels shall be equipped with quarter-turn stainless steel fasteners. Quarter-turn fasteners shall have a minimum shank diameter of 0.25 in. (6.35 mm) and be of adequate strength.

D. All decorative and appearance fasteners shall have documentation that identifies the manufacturer, base material, plating or finish if applied and the fastener type. The Contractor or supplier shall maintain this documentation on file for the Engineer to review for a period of not less than the expiration of the warranty period of the last vehicle accepted.

E. All fasteners exposed to the riding public shall be tamper-proof.

18.04.06 Torquing

A. All safety-related fasteners, including truck and brake equipment bolts and all fasteners exposed to fatigue loads, shall be torqued to a minimum preload equal to 75% of their proof load and "torque striped" after torquing by paint or other approved means. All other fasteners shall be torqued to a value appropriate to the application, so that they do not loosen in service.

B. Fastener installation torque for standard oiled or waxed bolts with standard or heavy hex nuts may be calculated from Industrial Fasteners Institute, *Fastener Standards*, latest issue, equations using values for "K" of 0.18 for unplated and 0.15 for plated threads. Locknuts shall be torqued in accordance with their manufacturer's recommendations or the Contractor may conduct tests to determine installation torque. For those nuts or bolts requiring "torque striping", the Engineer may require bolt torque-tension tests to verify that installed preload is equivalent to 75% of proof loads.

18.04.07 Washers and Lock Washers

A. Washers shall be used under the heads of all bolts and under all nuts. Where high strength fasteners are applied, washers shall be hardened and comply with IFI Fastener Standards, latest issue.

B. Helicoidal lock washers, when applied, shall conform to IFI Fastener Standards, latest issue. Helicoidal lock washers shall not be used for fatigue applications where the fastener must be torqued and marked. If applicable, prevailing torque nuts shall be used for these applications.

C. Other types of washers, including Belleville washers, may only be used for special applications with the Engineer's approval.

18.04.08 Rivets and Lock Pins

A. Rivets and lock pins exposed to passengers or crew shall be austenitic stainless steel or aluminum, as appropriate to the materials being joined. Structural steel rivets shall conform to ASTM A502-03 or ANSI B18.1.2 Standards. Rivets may be hand driven when hot and shall completely fill the rivet holes. Rivets driven cold shall be mechanically driven.

B. Exposed heads shall be concentric with the shank and free from rings, fins, pits and burrs.

C. Swage-locking (Huckbolt type) fasteners shall conform to Military Specification MIL-P-23469/1B. All rough surfaces of the collar end of these fasteners shall be machined or ground smooth where accessible to passengers, crew or maintenance personnel performing routine maintenance functions.

18.04.09 Plating of Fasteners

A. All carbon, alloy and martensitic steel fasteners shall be plated with zinc, unless specifically waived by the Engineer.

B. Zinc plating shall conform to ASTM Standard B633-07, Type II SC2, SC3 or SC4.

C. Alternate plating may be proposed for consideration by the Engineer.

18.04.10 Rivet and Bolt Holes

Rivet and bolt holes shall be accurately located and aligned, and, when necessary during assembly, holes shall be reamed round to specified size in position. Bolt hole clearances shall not exceed the Industrial Fasteners Institute's requirements. All removed and replaced rivets shall have the holes reamed to the size required such that the next larger rivet may be driven securely. Match drilling shall not be used.

18.05 Stainless Steel

18.05.01 General

A. Required alloys of stainless steel are indicated throughout this Specification. No other alloys shall be used. Finish shall be as specified. Color and finish of pieces abutting on any surface shall match.

B. All stainless steel surfaces subject to paint application shall be cleaned and painted in accordance with an Engineer approved general paints and corrosion protection process.

C. Finishing methods: surface finishes shall be uniform and of such texture that the original finish will be maintained through repeated brush washings.

D. Buffing and polishing of stainless steel, where required, shall be done without the use of any composition-containing iron or iron oxide.

18.05.02 Chemical Composition

A. Chemical composition and "L" grades of stainless steel alloys used for structural purposes shall conform to ASTM Standard A666 except that the carbon content shall not exceed 0.03% and type 301L may contain up to 0.25% nitrogen.

B. Chemical composition of stainless steel alloys used for non-structural purposes shall conform to ASTM Standard A666.

C. The material shall be free from precipitated carbides and from surface imperfections of a magnitude which would prevent its meeting bend requirements.

18.05.03 Mill Reports

A. It shall be the responsibility of the Contractor to ensure that all material for each use shall be of a quality conforming to ASTM Standard A666. Mechanical properties of Low carbon ("L") grades of stainless steel alloys used for structural purposes shall be submitted to the Engineer for approval if they differ from ASTM Standard A666 requirements.

B. All reports shall be included in the vehicle history books and submitted as a package on delivery of the last vehicle. [CDRL 18-004]

18.05.04 Design Stresses

A. Stainless steel structures shall be designed so that the sum of the stresses to which any part is subjected under fatigue loading conditions shall not exceed the corresponding allowable stress values that will be selected by the Contractor and approved by the Engineer.

B. In selecting the allowable stresses, the Contractor shall make appropriate consideration for the effects of column, flange and web stability; local discontinuities and other stress concentrations; strength reduction at welded regions; fatigue loadings; etc. Sources for selection of the allowable stress values shall be cited, or fatigue test results shall be submitted for approval of selected values by the Engineer.

18.05.05 Testing

Tensile strength shall be determined with a testing machine having a maximum head speed of one-half inch per minute. The bend test shall be made with the axis of the bend parallel to the direction of rolling; after bending, no cracks shall be visible to the naked eye. Gauge (thickness) tolerances of materials shall be in accordance with standard industrial tolerances.

18.05.06 Flatness Tolerance

Coil stock shall meet standard mill flatness tolerances, unless otherwise specified. Sheet stock shall be of stretcher-leveled quality. The camber of the sheet stock shall not exceed 0.25 in. (6.35 mm) in 8 ft (2,429 mm).

18.05.07 Finishing Methods

Unless otherwise specified, all smooth sheets exposed to passengers shall be given a medium-grit finish on the exposed side using a belt or oscillating sander. Grain shall be in a direction to suit the decorative treatment in the interior of the car.

18.06 Low-Alloy High-Tensile Steel

18.06.01 General

A. It is preferred that LAHT steels used for welded structure meet specified weld- and heat-affected zone toughness requirements without post-weld heat treatment or heat-generated stress relief. As a minimum, LAHT steels shall conform to the requirements of High Strength Low-Alloy steel (HSLA) in ASTM Standard A941.

B. Exposed sheet steel shall have a smooth surface free from pitting. Mill test reports for each heat of steel used in the construction of these vehicles shall be retained on file by the Contractor shall be available for inspection by the Engineer upon request and submitted with the vehicle history book as requested.

C. Heat treated parts made of LAHT steel shall be certified. A record of this certification, including hardness test results, shall also be retained on file and available for inspection by the Engineer upon request. All reports shall be included in the vehicle history books and submitted as a package on delivery of the last vehicle. [CDRL 18-005]

18.06.02 Design Stress

Structures of LAHT steel shall be designed so that the sum of the stresses to which any part shall be subjected under fatigue loading conditions shall not exceed the corresponding allowable stress values that shall be selected by the Contractor and approved by the Engineer. In selecting the allowable stresses, the Contractor shall consider the effects of column, flange and web stability; local discontinuities and other stress concentrations; strength reduction at welded regions; fatigue loadings; and similar conditions. Sources for selection of allowable stress values shall be cited, or fatigue test results shall be submitted, for approval by the Engineer of the selected values. [CDRL 18-006]

18.07 Steel Castings

18.07.01 General

A. Steel castings shall comply, shall be tested, inspected and accepted in accordance with procedures of the applicable AAR standards.

B. The quality of steel castings shall be checked in accordance with the requirements of AAR Standard M-201. Any radiographic testing shall be per ASTM using reference radiographs to ASTM Standard E446-98(2004)e1 or E186-06, as may be applicable. The radiographic sensitivity shall be at least 2% (2-2T) for section thickness less than 0.75 in. (19 mm) and 2-2T for section thickness greater than or equal to 0.75 in. (19 mm). Acceptance levels for the radiographic testing shall be submitted to the Engineer for review and approval. The surface quality of the steel castings shall be evaluated in accordance with ASTM Standard A802-95 to acceptance level IV. All weld repairs shall meet the requirements of ASTM Standard A488/A488M-07. When castings are found to be unacceptable, they shall be repaired in the original factory of manufacture prior to shipment or by another repair process approved by the Engineer.

C. The Contractor shall prove the quality of castings by either destructive or nondestructive means. Following the establishment of a satisfactory procedure, quality control shall be maintained by testing one or more of each lot at a frequency to be determined by the Engineer, the Contractor and the subcontractor. This frequency shall be influenced by the critical requirements of the part.

18.07.02 Heat Treating

A. All steel castings used in the truck structure shall be made of electric furnace or controlled open hearth steel and shall be heat treated.

B. Where physical strength is gained by heat treating, a physical test shall be conducted on each treating charge of each heat of castings. Where more than one heat is represented in a treating charge, a physical test shall be conducted on each heat represented in each treating charge.

18.07.03 Castings

Steel castings used in locations not specifically referred to shall be selected by the Contractor or its subcontractor for composition and characteristics best suited to the application but shall be subject to review by the Engineer.

18.07.04 Couplers and Drawbars

Cast-steel couplers and drawbars shall conform to AAR Specification M-201, Grade C or better. Maximum allowable compressive stress for cast-steel car body structural elements shall be 50% of the material's yield strength, for the car body subjected to its own weight plus that of the specified absolute maximum loading, and shall be 90% of the material's yield strength for the maximum compression loadings specified at the collision posts and at the coupler anchorage. Maximum allowable tensile stress for such elements shall be 80% of the above maximum allowable compressive stress values.

18.07.05 Axles

A. Axles should be forged steel conforming to SAE/AISI Standard 4140, normalized, oil-quenched and tempered to give Brinell 220-270, minimum ultimate tensile strength of 100,000 psi (690 MPa), elongation of 20% in 2 in. (51 mm) minimum, reduction of area at 50% minimum, yield strength of 1,000 psi (6.9 MPa) minimum.

B. All reports shall be included in the vehicle history books and submitted as a package on delivery of the last vehicle [CDRL 18-007].

18.07.06 Wheels

A. The wheels shall be heat treated, multiple-wear type, 36 in. (914 mm) diameter, Class 'B' of a low stress wheel design, hub stamped in accordance with AAR Standard M-107/M-208 latest revision, including APTA Standard PR-M-S-012-99 Revision 1.

B. All reports shall be included in the vehicle history books and submitted as a package on delivery of the last vehicle [CDRL 18-008].

18.08 Aluminum

18.08.01 General

A. Aluminum alloy mill products shall be identified by designations prescribed by The Aluminum Association and shall conform to specifications contained in the Association's publication *Aluminum Standards and Data*. Aluminum alloy castings shall only be used for trim and for door thresholds. Such castings shall conform to ASTM Standards B26, B85 or B108 for, respectively, sand, die or permanent mold castings. Aluminum alloy forgings shall conform to ASTM Standard B247-02a. Copies of all test reports for sheet, extrusions, and forgings used shall be retained on file by the Contractor, shall be available for inspection by the Engineer upon request and submitted with the vehicle history book as requested.

B. Unpainted aluminum used for interior surfaces exposed to contact by passengers and the crew shall have a clear (natural) anodic coating, with a minimum coating thickness of 0.0004 in. (0.011 mm) and a minimum coating weight of 21 milligrams per square inch (mg/sq. in.).

C. All aluminum surfaces of the car body, including not only surfaces in contact with dissimilar metals but also surfaces in contact with aluminum and surfaces not in contact with any materials at all, but excluding exterior uncolored surfaces, shall be cleaned and given one coat of zinc chromate primer.

D. Aluminum used for heat sinks shall be nickel plated to minimize contact corrosion and surface pitting.

18.08.02 Fabrication and Fastening

A. The forming of aluminum parts, their joining by bolting, riveting, and welding, and the protection of contact surfaces shall conform to the requirements of the Aluminum Company of America's (ALCOA) Technical Report Number 524 *Specification Covering Use of Aluminum in Passenger Carrying Railway Vehicles*, except as specified otherwise.

B. The specific measures to be taken to prevent risk of contact and resultant possible electrolytic corrosion shall depend upon determination of the most suitable method which shall be adapted to the design involved, and the following instructions are provided for general guidance. These instructions shall not supersede recommendations of the aluminum manufacturer.

C. Aluminum alloy surfaces shall not be secured to, nor make direct metal-to-metal contact with, the surfaces of copper, brass, bronze, silver, nickel and nickel-plated parts or alloys thereof, lead, tin and ferrous materials. The surfaces of aluminum alloy parts secured to steel parts shall be protected with a one-part polysulphide sealant, zinc chromate paste, or a silicone sealant used as the joint compound. Alternatively, an insulating material shall be non-hygroscopic and, if fibrous, shall be impregnated with bitumen or other water-repellent substance.

D. Wood shall not be placed in contact with aluminum alloy except with written permission from the Engineer.

E. Some form of surface covering or insulation shall be provided for all bolts, rivets, securing clips and devices to prevent contact with the aluminum alloy, if the bolt or other device does not also consist of a compatible aluminum alloy. Stainless steel and carbon steel fasteners, including washers and nuts, plated in accordance with provisions of this Specification shall be coated with a protective non-chromate paste before installation. Where possible, only the head and unthreaded portion of the shank of the bolt shall be in contact with the aluminum part when secured in place. Suitable bushings may be used in place of the protective non-chromate paste. Rivets driven hot shall be considered to be covered by a protective oxide coating due to the heating; but the method of riveting shall, if possible, always be with the formed rivet head in contact with the aluminum alloy.

18.08.03 Gauge

Aluminum sheet gauge size shall be in accordance with the American or Browne and Sharp Standard Gauge.

18.09 Elastomers

18.09.01 General

A. All elastomeric parts shall be of neoprene, or approved equal, unless otherwise specified. The elastomer shall be compounded and cured to perform satisfactorily in the temperature range specified. The elastomers shall have high resistance to ultraviolet and other solar radiation, weather, all CTDOT car washing fluids, and the longest possible life consistent with other specified characteristics. All elastomeric parts shall be resistant to ozone, oxidation, heat, oil, grease and acid.

B. All resilient mounts shall be of neoprene. Natural rubber compounds may be substituted for neoprene only when approved for a specific application.

C. All elastomers parts are lot controlled at the time of supplier manufacture and at the time of receipt of the material by car builder, and the car manufacturing facility is to use a first-in-first-out inventory process. Products such as air hoses shall be labeled per AAR requirements.

18.09.02 Tests

A. All tests shall be conducted according to the latest revisions of the specified ASTM test procedures, unless otherwise specified. All resilient, neoprene mounts and elastomeric truck suspension components shall be tested in accordance with the performance requirements for the following and must be provided by the manufacturer: ASTM D2240-05, ASTM D412-06ae2, ASTM D1149-07, ASTM D573, ASTM D395-03 (Method B), ASTM D624-00 (die C) and ASTM D746-07. All joints shall be vulcanized.

B. The durometer hardness shall be suitable for the construction and conditions specified.

C. The manufacturer shall provide test equipment and test specimens and shall perform, at its expense, the following tests at an independent testing facility:

1. ASTM C1166-06: Flame Propagation Test

2. ASTM E 662: Smoke Density Test

D. All materials interior to the carbody must pass ASTM C1166-06 with a burn length = 4 in. (102 mm). They must also have a smoke density of Ds(1.5) = 100 and Ds(4.0) = 200 in both the flaming and non-flaming modes when tested according to ASTM E 662. The toxicity of the materials must be specified in SMP 800-C.

E. Unless otherwise agreed by the Contractor:

1. ASTM D412-06ae2 tensile strength shall be 1,500 psi (10.3 MPa) (min.)

2. ASTM D412-06ae2 elongation for sheet material shall be 300% (min.)

3. ASTM D412-06ae2 elongation for extruded material shall be 275% (min.)

4. ASTM D573 loss in tensile strength shall be 15% (max.) when subjected to 168 hours at 158°F (70°C).

5. ASTM D1149-07 shall have no cracks when subjected at 100 parts per hundred million (pphm) at 104°F (40°C) for 100 hours and a specimen elongation of 20%.

6. ASTM D2240 hardness shall be 45 to 75, durometer A

7. ASTM D471 oil aging resistance after 72 hours at 158°F (70°C), ±30% maximum change in volume.

8. ASTM D395 permanent set resistance shall be 25% or less.

F. Unless otherwise agreed by the Engineer, the maximum gas concentrations shall be defined as follows:

Gas	Critical Concentration (*ppm) (max.)
CO	3,500
CO2	90,000
NO + NO2 (Nox)	100

Gas	Critical Concentration (*ppm) (max.)
SO2	100
HC1	500
HF	100
HBr	100
HCN	100

** parts per million (ppm)*

G. The test specimens shall be cut out from the extruded material, and at least one tensile strength and elongation test and one accelerated aging test shall be made on the material used for each order. If the compound or cure, or both, are changed during the production of material for one order, at least one test of each type shall be made for each different batch.

H. The ozone resistance of the elastomer shall be tested in accordance with ASTM Standard D1149 using an ozone concentration of 100 ppm, an exposure time of 100 hours at 100°F (38°C), and a specimen elongation of 20%. The elastomer shall not exhibit any cracks during the test period.

18.09.03 Life Expectancy

For all parts made by vulcanizing an elastomer to metal, any premature failure (less than five years) between metal and the elastomer or in the elastomer, occurring when the parts are used in normal service and according to the provisions of this Specification, shall be considered as having been caused by defect of materials or workmanship.

18.09.04 Metal Parts

Metal parts to which elastomeric material is vulcanized shall be made of SAE 1020 or 1045 hot-rolled steel, except for air brake equipment.

18.09.05 Bonding

The joining of elastomeric pieces shall be conducted by the hot vulcanization process. Bonding of elastomers shall not be allowed unless the Contractor submits the application, bonding procedure, and bonding agent technical data for approval prior to the purchase of any materials.

18.09.06 Truck Parts

Truck bumpers and snubbers shall be made of neoprene or approved equal. They shall be compounded to be resistant to abrasion, oil, grease and acid.

18.09.07 Glazing Strips

A. Glazing strips shall be of neoprene conforming to ASTM Standard C542-05, or of Styrene-Butadiene rubber. The compounding of the rubber shall be such as to preclude discoloration or staining of neighboring areas, particularly from water drainage.

B. Window glazing sections shall be service proven and constructed of high-quality elastomeric compounds containing neoprene subject to approval by the Engineer. Glazing strips and other elastomeric extrusions shall be continuous and made from neoprene or other compounds suitable for the purpose and shall be free of major defects of material or workmanship.

18.10 Glazing Materials

18.10.01 General

A. All window glass shall be provided with tints, screens, or other solar/thermal limiting measures as required by the Heating, Ventilation and Air Conditioning (HVAC) design. The tints shall not preclude passengers from being seen from outside the car or limit their vision when looking out the bodyside windows.

B. Glazing used shall meet the following material criteria:

1. Windshield glazing shall be a single-glaze, certified FRA Type I clear laminated safety glass, meeting all the applicable requirements of ANSI Standard Z-26.1 and U.S. Code of Federal Regulations, 49 CFR Part 223, including Appendix A. The glazing shall incorporate an anti-spall shield on the interior side. The glazing shall be clear tint. The glazing shall be a minimum of 0.560-in. (14.2 mm) thick. The glazing's maximum solar energy transmittance shall not exceed 70%.

2. End door window glazing shall be a single-glaze, certified FRA Type I clear laminated safety glass, meeting all the applicable requirement of ANSI Z-26.1 and U.S. Code of Federal Regulations, 49 CFR Part 223, including Appendix A. The glazing shall be clear tint. The glazing shall be a minimum of 0.560-inch (14.2 mm) thick. The glazing maximum solar energy transmittance shall not exceed 90%.

3. Side door window glazing shall be a single-glaze, certified FRA Type II laminated safety glass, meeting all applicable requirements of ANSI Z-26.1 and U.S. Code of Federal Regulations 49 CFR Part 223, including Appendix A. The glazing shall be 0.375 inch (9.5 mm) thick. The glazing's maximum solar energy transmittance shall not exceed 94%. The visible light transmission shall be 24%, matching the side windows.

4. Cab car control station sliding window assemblies shall be double-glazed. The outer pane shall be 0.250-inch (6.35 mm) thick, clear laminated safety glass. The inner pane shall be 0.250-inch (6.35 mm) thick, clear laminated safety glass. The double-glazed assembly shall have a 0.250-inch (6.35 mm) thick clear air space separating the inner and outer panes. The double-glazed assembly shall be certified FRA Type II and meet all the applicable requirements of ANSI Z-26.1 and U.S. Code of Federal Regulations, 49 CFR Part 223, including Appendix A. The double-glazed assembly shall be clear tint.

5. Side window assemblies (emergency and non-emergency) shall be double-glazed. The outer pane shall be 0.250-inch (6.35 mm) thick, gray-tinted tempered safety glass unless specified otherwise by the Engineer. The inner pane shall be 0.375-inch (9.5 mm) thick, clear tempered safety glass. The double-glazed assembly shall have a 0.375-inch (9.5 mm) dead air space separating the inner and outer panes. The double-glazed assembly shall be certified FRA Type II and meet all the applicable requirements of ANSI Z-26.1 and U.S. Code of Federal Regulations, 49 CFR Part 223, including Appendix A. The double-glazed assembly shall be a gray tint unless specified otherwise by the Engineer. The double-glazed assembly's visible light transmission shall be 24%. The double-glazed assembly's maximum solar energy transmittance shall not exceed 50%.

18.10.02 Flatness

When an individual window of glass is laid on a truly flat surface, such as a surface plate, the glass shall not indicate a bow of more than 0.030 inch (0.76 mm) per linear foot (305 mm).

18.10.03 Dimensional Tolerance

The overall dimensions of any window supplied shall not exceed ± 0.060 in. (± 1.52 mm) dimensional deviation.

18.10.04 Overlap Tolerance

The overlap of one laminate of the window with respect to the other at an edge shall not exceed 0.03125 in (0.80 mm). Corners and burrs shall be ground smooth and all edges shall be treated in accordance with SAE Z26.1, Section 6.

18.10.05 Color

When new, there shall be no more than ± 4% variation in the color of individual windows of laminated sheet glass when examined over a white background.

18.10.06 Haze

All the laminates of the safety glass shall be so nearly free from haze that the laminated glass shall have approximately the same clarity as non-laminated plate glass of the same nominal thickness of plate glass.

18.10.07 Specks and Scratches

A. Occasional specks of foreign material and scratches are permissible, provided such specks do not exceed 0.020 in. (0.51 mm) in greatest dimension and scratches do not exceed a total of 3 in. (76.2 mm) in length and neither are within the central three-quarters area of the window. The Engineer reserves the right to determine which windows are to be rejected.

B. The visual inspection criteria for laminated glazing shall be submitted for an Engineer approval as part of the glazing design review. [CDRL 18-009]

18.10.08 Bond Separation

The bond between two sheets of glass and the membrane shall be of such quality that when the glass is broken by twisting or by direct impact, there will be no separation between the glass sheets. Windows that contain un-bonded areas shall not be used.

18.10.09 Marking

A. All safety glass shall be marked with proper identification in accordance with FRA 49 CFR Part 223 requirements. The window shall be installed so that the identification marking can be read from the inside lower right-hand corner.

B. Each window shall be marked for identification by the supplier in legible letters 0.125 in. (3.175 mm) to 0.25 in. (6.35 mm) high in the lower right-hand corner as viewed from the inside of the vehicle. This identification shall be no closer than 0.375 in. (9.525 mm) to the edge. The identification shall give the product name, the manufacturer, the serial number and FRA Type designation. Markings shall be legible and permanent for this application and shall be applied in such a manner so as not to reduce the integrity of the coating. Markings are to be in accordance with 49 CFR Part 223. The window shall be installed so that the identification can be read from the inside.

18.10.10 Shipping

The material shall be carefully prepared for shipping and shall be properly protected to prevent damage. If a pressure sensitive masking is used, it shall be easily strippable from the material and not leave a gummy or sticky residue.

18.11 Rubber Floor Covering

18.11.01 General

The floor covering shall be rubber sheet or approved equal. The covering shall meet ADA visibility and coefficient of friction requirements, with a static coefficient of friction of at least 0.6 on level surfaces and 0.8 on ramps, even when wet. Rubber floor covering shall contain 20% (nominal, by weight of compound) butadiene styrene rubber, shall be non-staining, non-discoloring, and 100% non-oil extended. Only high-quality hard clay shall be used as filler. No whitening (limestone) shall be used in the compound. At room temperature, the rubber flooring shall bend around a 0.75 in. (19 mm) diameter mandrel without breaking, cracking, crazing or showing any change in color. The rubber flooring material shall be fully homogeneous throughout and shall meet the requirements of ASTM F1344-04. Rubber flooring shall conform to the criteria below.

18.11.02 Thin Skinned Blister

A thin-skinned blister is a blister, which when finger-pushed, will collapse upon itself. Thin skin blisters of the indicated sizes will be permitted as follows and shall be repaired as indicated:

A. Maximum Size - 0.03 in. (0.76 mm) height, 0.8 in^2 (516.2 mm^2) area with longest dimension of 2 in. (51 mm).

B. Maximum Population - 3 blisters in a 12 in. (305 mm) by 12 in. (305 mm) area, and there shall be only one other blister within 3 ft (915 mm) of this area.

C. Repair Method - using a hypodermic needle, apply just enough Super Bond 420 or Bostik 1685 to bring to a flush surface.

18.11.03 Thick Skinned Blister

A thick-skinned blister is a blister, which when finger-pushed, will collapse and then return to its original condition. Thick skin blisters of the indicated sizes will be permitted as follows and shall be repaired as indicated:

A. Maximum Size - 0.03 in. (0.76 mm), 0.8 in^2 (516.2 mm^2) area with longest dimension of 2 in. (51 mm).

B. Maximum Population - 3 blisters in a 12 in. (305 mm) by 12 in. (305 mm) area, and there shall be only one other blister within 3 ft (915 mm) of this area.

C. Repair Method - no repair authorized.

18.11.04 Lumps

A lump is a blister without a void, consisting of solid material. Lumps of the indicated sizes will be permitted as follows and shall be repaired as indicated:

A. Maximum Size - 0.03 in. (0.76 mm) height, 0.8 in^2 (516.2 mm^2) area with longest dimension of 2 in. (51 mm).

B. Maximum Population - 3 lumps in a 12 in. (305 mm) by 12 in. (305 mm) area, and there shall be only one other lump within 3 ft (915 mm) of this area.

C. Repair Method - no repair required.

18.11.05 Holes

A hole is a defect, which is 100% through the material. Holes of any size or population will not be permitted nor shall holes be repaired.

18.11.06 Thin Area

A thin area is a defect where the sheet is below thickness locally. Thin areas of the indicated sizes will be permitted as follows and shall be repaired as indicated:

A. Maximum Size - 0.03 in. (0.76 mm) deep at the lowest point, 3 in^2 (1,936 mm^2) area with the longest dimension of 5 in. (127 mm).

B. Maximum Population - one thin area in a 40 in. (1,016 mm) by 40 in. (1,016 mm) area, and there shall not be another thin area within 3 ft (915 mm) 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.

18.11.07 Color and Marbling Distribution

Tolerances for color and marbling variation shall be submitted to the Engineer for approval during preliminary design review. [CDRL 18-010] If the base coloring is not within 5% between production runs, or the marbling is not consistent over the entire surface, the roll shall be rejected.

18.12 Lumber and Paneling

18.12.01 Lumber

A. Lumber shall be thoroughly air seasoned or kiln dried before using and shall be dressed on all surfaces to full dimensions and treated to meet the testing requirements of Chapter 19. Lumber shall be straight grained, free from dry rot, knots, checks, and other defects which may impair its strength and durability or mar its appearance.

B. Except where specified, the use of wood in the car shall be limited to specifically approved applications.

C. Melamine shall be pressure bonded to marine grade plywood using industry approved adhesives. No contact bonding of melamine to plywood is permitted.

D. The term "cored panels" means honeycomb panels bonded to melamine or to metal faced hard-board (similar to Metalcomb, as marketed by Cored Panels, Inc., Farmingdale, New York).

E. Such panels must comply with United States Department of Agriculture Forest Products Laboratory Report No. 1937, *Shear-Fatigue Properties of Various Sandwich Construction*.

18.12.02 Plymetal

A. The term "plymetal" as used in this Specification covers metal-faced plywood and shall conform to the following requirements:

Test Conditions	Minimum Metal to Wood Average Shear Value (or 80% Wood Failure)
Dry shear	250 lbf/in^2 (1,723 kPa)
Boil shear, 3-hour boil, tested wet at room temperature	150 lbf/in^2 (1,034 kPa)
Soak shear, 48-hour soak wet at room temperature	150 lbf/in^2 (1,034 kPa)
Creep or cold flow, under static load for 48 hour, at room temperature	250 lbf/in^2 (1.7 MPa,723 kPa)

B. Plymetal that is faced with melamine shall have the melamine bonded to the metal sheet in accordance with this Specification, and the melamine-faced metal sheet shall then be laminated to the plywood core in accordance with this section.

18.12.03 Plywood

All plywood shall be manufactured to conform to the requirements of Grade - Structural I of the National Bureau of Standards Voluntary Product Standard (American Plywood Association) PS 1- 85, and then stored under cover. All plywood panels shall be formed from one piece and shall be sealed with two coats of epoxy paint on all edges and cutouts as soon as possible after fabrication. All exposed edges of the panels; joints between panels, fastener heads and openings of panels used in areas accessible to moisture shall be waterproofed and sealed in accordance with MIL-P-8053, paragraph 3.4, prior to installation in the car.

18.12.04 Honeycomb Panels

A. The term "honeycomb panels" as used in this Specification refers to an assembly of honeycomb material bonded to melamine-faced metal panels or to metal panels. Aluminum honeycomb material shall be commercial-grade meeting the requirements of MIL-C-7438G. Bonding shall be sufficient to develop the full strength of the honeycomb material. Stainless steel honeycomb panels shall be constructed in accordance with the requirements of MIL-A-9067C. The adhesive bond strength of the honeycomb core to the stainless steel face shall not be less than 15 lb/in. (2,679 g/cm) climbing drum strength when tested in accordance with SAE-AMS-STD-1. The adhesive bond strength of the integral stainless frame to stainless steel face shall not be less than 30 lb/in^2. (207kPa) climbing drum strength when tested in accordance with SAE-AMS-STD-401. Stainless steel honeycomb panels shall be tested in accordance with SAE-AMS-STD-401 to demonstrate the following requirements.

B. Test results shall be subject to Engineer review and approval.

1. Core shear yield at 200°F (93°C) 250 lbf/in^2 (1,723 kPa)
2. Flatwise tension at 200°F (93°C) 250 lbf/in^2 (1,723 kPa)
3. Beam flexure at 200°F (93°C) 75,000 lbf/in^2 (516,750 kPa)
4. Core shear fatigue at R.T. 150 lbf/in^2 (1,034 kPa) @ 106 cycles
5. Flatwise tension at R.T. 250 lbf/in^2 (1,723 kPa) @ 106 cycles
6. Beam flexure at R.T. 50,000 lbf/in^2 (344.75 kPa) @ 106 cycles

C. Honeycomb panels meet the relevant flammability and smoke emission requirements. Results shall be subject to Engineer review and approval. No other honeycomb materials will be permitted. [CDRL 18-011]

18.12.05 Melamine-Faced Aluminum

A. Melamine-faced aluminum panels shall be constructed by laminating melamine to aluminum sheets as follows: The melamine impregnated papers shall be directly molded to the aluminum sheets at temperatures of no less than 270°F (132°C) and pressure no less than 1,000 psi (7 MPa). The surface characteristics, after manufacture, shall be no less than that required of type GP (General Purpose) in the NEMA Standards Publication No. LD-3-2005, or latest revision. The melamine and the required binder sheets shall be 0.02 in. (0.51 mm) ± 0.005 in. (0.13 mm) thick. The aluminum sheets shall not be less than 0.025 in. (0.635 mm) in thickness when used as a facing on plywood. The aluminum sheets shall not be less than 0.081 in. (2.06 mm) in thickness when not laminated to a substrate such as plywood. Aluminum sheets shall be properly cleaned by etching, sanding or other approved process to ensure full, permanent, acceptable adhesion.

B. The use of any adhesives to bond the melamine sheets to the aluminum backing will not be acceptable. The bond between the melamine and aluminum sheets shall, as a minimum, meet the following requirements:

ASTM D952 Internal Bond	2,600 lbf/in^2 (17.9 MPa)
ASTM D790 Flexural Strength - (S)	with grain: 26,500 lbf/ in^2 (183 MPa) crossgrain: 25,300 lbf/ in^2 (174 MPa)
ASTM D790 Modulus of Elasticity - (E)	with grain: 2.8 x 106 lbf/ in^2 (19.3 GPa) crossgrain: 3.1 x 106 lbf/ in^2 (21.4 GPa)
ASTM D638-08	Tensile strength with grain: 22,300 lbf/ in^2 (154 MPa) crossgrain: 20,300 lbf/ in^2 (140 MPa)

18.12.06 Melamine Panels

Unbacked melamine panels may be used in the vehicle interior. The panels shall be a minimum of 0.125 in. (3.175 mm) ± 0.005 in. (0.127 mm) thick. The surface characteristics shall be no less than that required of type GP (General Purpose) in the NEMA Standards Publication No. LD-3-2005, or latest revision. Sidewall panels shall be of unbalanced melamine. However, ceiling panels located under air ducts must be balanced melamine to prevent warpage from duct condensation.

18.12.07 Phenolic Composite Floor Panels

The floor panels shall be manufactured from phenolic composite material. Phenolic composite floor panels shall be designed to withstand the following physical requirements with no visible or audible indications of delamination of the panel skin from the core and permanent deformation of the top surface shall be less than 0.010 in. (0.254 mm) unless otherwise specified. There shall be no puncture or damage to fibers of the top surface. There shall be no separation of any internal core from the top or bottom skin. There shall be no fracture of the balsa core.

A. Indentation Resistance – The floor panel shall withstand a concentrated load of 300 lbs (136 kg) applied to a test dowel that has an overall 0.375 sq. in. (242 mm^2) surface area, with a 0.0625 in. (1.59 mm) radius on bottom edge of test dowel.

B. Static Load Test - Average Loading – A representative sample section of the flooring (without rubber floor covering attached) shall be supported on beams spaced at the maximum spacing used on the car using production bonding and fastening techniques. A uniformly distributed load in accordance with the crush loading requirements of Section 2 shall be applied to both sides of the joint (butt and/or shiplap). There shall be less than 0.088 in. (2.24 mm) deflection.

C. Static Load Test – Maximum Loading – Using the identical floor panel-mounting configuration as described above, a uniformly distributed load of 200 lb/ft^2 (9.7 kPa shall be applied to both sides of the joint (butt or shiplap).

D. Small Area Static Load Test – Using the identical floor panel mounting configuration as described above, a 300 lb (136 kg) load shall be applied to a 1 in. (25.4 mm) by 3 in. (76 mm) contact area directly over the midspan, 6 in. (152 mm) from the outer car body sidewall edge. The footprint shall be machined flat within 0.01 in. (0.25 mm) and the edges shall have a radius of not more than 0.125 in. (3.175 mm). There shall be less than 0.2 in. (5.1 mm) deflection as a result of the load applied.

E. Small Object Impact Test - Using the identical floor panel mounting configuration as described above, a 16 lb (7.26 kg) standard bowling ball shall be raised directly over the mid-span, 24 in. (610 mm) from the edge of the panel and dropped from height of 60 in. (1,524 mm). Permanent deformation of the top surface shall be less than 0.0625 in. (1.59 mm).

F. Large Object Impact Test - Using the identical floor panel mounting configuration as described above, a 150 lb (68 kg) load shall be dropped upon a 3 in. (76 mm) by 8 in. (203 mm) contact "footprint" pad located directly over the midspan, 24 in. (610 mm) from the edge of the panel and dropped from a height of 12 in. (305 mm). The "footprint" pad shall have a rubber pad on the downside surface with a Shore D 70 minimum, at a 1 in. (25.4 mm) thickness machined flat within 0.06 in. (1.52 mm) with edges having a radius of not more than 0.03 in. (0.76 mm). Permanent deformation of the top surface shall be less than 0.03 in. (0.76 mm). Some damage to the top phenolic composite skin will be allowed.

G. Rolling Load Test - Using the identical floor panel mounting configuration as described above, a four-wheeled cart with a load of 200 lbs (91 kg) per wheel shall be rolled on the panels laterally, longitudinally and in a circular path 24 in. (610 mm) radius. The wheels shall be 3 in. (76 mm) in diameter, 1 in. (25 mm) wide with a 0.125 in. (3.18 mm) radius on each edge with a Shore A durometer of 80.

H. Flammability and Smoke Emission Tests – Floor panels meet the relevant flammability and smoke emission requirements of 49 CFR Part 238.103.

18.13 Seats

18.13.01 Construction

A. The passenger seats shall be arranged in transverse fashion. Seats shall employ armrests and head rests. Seat frame will be fabricated from HSLA steel. All exposed frame material shall be stainless steel, if applicable.

B. Seat and back cushions shall be removed and replaced without the need to remove hardware or fasteners. Underseat arrangement shall be suitable for fitting of natural convection heaters, if required to comply with the heating requirements of Chapter 11.

C. All materials shall comply with the smoke flame and toxicity requirements of this specification as well as 49 CFR Part 238, with emphasis on Appendix B.

D. Sample seats shall be provided to the engineer for review and approval prior to static and dynamic testing. [CDRL 18-012]

18.13.02 Seat Components

Seat Construction

Seat Fabric	Entransit, Rhino vinyl, Naugahyde or equivalent
Cushions	Chestnut Ridge Safguard or Bisco MF1

Seat back	Sabic, Lexan or Kydex
Armrest	316 Stainless steel cover over seat back material
Grab Handle	Neoprene

18.14 Countertops/Work Tables

18.14.01 Counter Surfaces

A. Corian, or equivalent acrylic polymer and alumina trihydrate material, shall be the used for all work tables and toilet room basin and countertop. If a material other than Corian is proposed, all technical data shall meet or exceed the results of Corian, including the smoke flame and toxicity results

B. Corian surfaces shall be 0.5 in. (12.7 mm) in thickness. All corners shall be radiused. Edge treatment for the work tables shall provide a finished appearance and serve as a lip to prevent items from sliding off the table.

C. The surfaces colors and patterns shall blend with the interior arrangements. Several samples shall be submitted for the Engineer for review and acceptance. [CDRL 18-013]

18.15 Welding and Brazing

18.15.01 Responsibility

A. The Contractor shall be responsible for the quality of all welding and brazing, whether done by Contractor's employees or a subcontractor. All welders employed in the making of welds on structures or products built under this Specification shall have been tested and qualified to determine their ability to operate the welding equipment to be used in making the types of welds required hereunder and to produce satisfactory welds therewith.

B. All steel welding practices shall be according to requirements of AWS Standard D1.1, Structural Welding Code – Steel; AWS Standard D1.2, Structural Welding Code – Aluminum; AWS Standard D1.3, Structural Welding Code – Sheet Steel, AWS Standard D1.6, Structural Welding Code – Stainless Steel, and the AWS Handbook. AWS Standard D1.1 shall apply to steel of 0.125 in. (3.18 mm) and greater thickness, and AWS Standard D1.3 shall apply to steel less than 0.125 in. (3.18 mm) thickness. Requirements for dynamically loaded structures shall be applied. Cast steel welding shall be according to ASTM Standard A 488/488M, Steel Castings, Welding, Qualification of Procedures and Personnel. Resistance welding shall be in accordance with AWS Standard D17.2/17.2M, Specification for Resistance Welding in Aerospace Applications.

C. Aluminum welding as covered by this section shall conform to Aluminum Company of America's Technical Report Number 524 *Specification Covering Use of Aluminum in Passenger Carrying Railway Vehicles* and AWS Standard D1.2/D1.2M *Structural Welding Code, Aluminum*. Requirements for dynamically loaded structures shall apply.

D. All welding practices not specifically covered in this section shall be in accordance with the applicable requirements and recommendations of the American Welding Society (AWS), as contained in the *Structural Welding Code- Steel* (AWS Standard D1.1/D1.1M), *Structural Welding Code- Sheet Steel* (AWS Standard D1.3/D1.3M), *Specification for Resistance Welding in Aerospace Applications* (AWS Standard D17.2/D17.2M), and the AWS *Welding Handbook*. Should the Contractor propose an alternate standard, it shall be subject to the Engineer's approval. Requirements and recommendations of the AWS for new bridges shall have precedence over those for new buildings.

E. All Welding Procedure Specifications (WPS) shall be fully qualified by the Contractor, accompanied by Procedure Qualification Records (PQR) containing welding test results, and subject to approval by the

Engineer and a Certified Welding Inspector. Prequalified WPS, or WPS purchased from AWS, shall be qualified by the Contractor before application to production. The use of WPS qualified per AWS Standard B2.1 shall not be permitted in their original form. WPS and PQR originally qualified per AWS Standard B2.1 may be rewritten to conform to the requirements of the applicable structural welding code and used within the limitations of that code.

F. Welders shall make only those welds for which they have been qualified according to the requirements of the applicable AWS code, ASME Section IX, ASTM A 488/488M, or other approved qualifying procedures. Records of welder qualification tests shall be made available for review.

18.15.02 Test Welds

A. The Engineer shall have the right to require an operator to make test welds to determine his/her ability to produce satisfactory welds of any given type. The Engineer shall also have the right to require the making of test welds to settle any question that shall arise as to the suitability of any welding method or procedure used during production. The recommendations of the AWS shall be followed in the making of tests and the settlement of other questions that may arise hereunder regarding welding practice.

B. Allowable stresses for LAHT shall be established in accordance with AWS Standard D1.1, Section 2.6. Fatigue allowable stresses for LAHT shall not exceed the fatigue limits of AWS Standard D1.1, Section 2.16.

C. Weld Heat-Affected Zones (HAZ) and weld metal in austenitic stainless steels shall be limited to maximum allowable static stress values in AWS Standard D1.6, Section 2.3. The Contractor shall provide proposed fatigue stress provisions for austenitic stainless steels, including the considerations of AWS Standard D1.6, Section 2.3.3. These fatigue allowable stresses shall not exceed the provisions of AWS Standard D1.1, Section 2.16. Higher fatigue stress values may be applied if qualified by Contractor tests and approved by the Engineer.

18.15.03 Cleaning

Prior to welding, parts to be joined shall be properly cleaned of coatings and films such as rust, oxide, mill scale, oil, grease, corrosion products, and other foreign materials. Cleaning materials and processes shall be in accordance with applicable parts of Section 2, MIL-HDBK-132, *Protective Finishes*. Finished welds shall present a clean appearance.

18.15.04 Support

All parts which shall be joined by welding shall be adequately supported during welding by tables, jigs or fixtures.

18.15.05 Welding Rod

A. All welding rod, wire, electrodes or filler metal; shall be chosen by the Contractor or subcontractor with respect to manufacturer, type and size necessary to achieve the highest quality work. The Contractor shall have full responsibility for the character of the work produced. It shall be purchased in packages of convenient size, which shall be marked with the Manufacturer's name, Manufacturing Lot and the specification, diameter, and net weight of the material.

B. The material shall be stored in accordance with recommendations of the AWS *Structural Welding Code* so as to protect it from damage, and so that it shall be easily identified. Material shall be issued and handled in such a way as to prevent it from being mixed with that of another specification.

C. The ferrite number for austenitic stainless steel welds shall be between WRC4 and WRC10, or as proposed by the Contractor and approved by the Engineer.

D. In case a question arises regarding the suitability of welding rod, wire, electrodes or filler metal, the provisions of AWS Standard D1.1/D1.1M shall govern.

18.15.06 Control

Current, voltage, distance, flame and other variables shall be so controlled as to give a smooth weld, free of gas pockets, oxide inclusions, variations in width and thickness, wandering and spattering.

18.15.07 Penetration

Penetration of weld metal into the bottoms of angles and vees and fusion, shall be complete. Weld metal shall run into the base metal at the finished surface of the weld in a smooth curve approximately tangent to the surfaces of the base metal so as to avoid sudden change of section and resultant concentration of stress. Undercutting shall not exceed 10% of the thickness of the thinnest element, or 0.03 in. (0.76 mm), whichever is less.

18.15.08 Warpage

The method of depositing weld metal shall be chosen so as to minimize warpage and locked-up stresses. Tack welding, skip welding, offset welding and other comparable procedures shall be used for this purpose.

18.15.09 Intermittent Weld Spacing

Intermittent fusion-weld spacing pitch shall not exceed 5 in. (127 mm) for 2 in. (51 mm) (minimum) weld lengths, such that a minimum weld length of 40% of the overall joint length is achieved, unless specifically approved by the Engineer.

18.15.10 Fusion Welding

Manual fusion welding by the gas process may only be used on sheets more than 0.09375 in. (2.38 mm) in thickness. Any other application of this process must be approved by the Engineer.

18.15.11 Resistance Welding

A. Resistance welding shall be in accordance with AWS Standard D17.2/D17.2M Class B for structural applications and Class C for non-structural applications. Stainless steel parts shall be joined, insofar as possible, by resistance welding. This procedure shall employ accurate control of current, time, electrode size and shape, and tip force, to produce uniform welds of specified strength which shall not be subject to surface corrosion. Resistance welds in materials other than austenitic stainless steel shall be arranged to avoid tension or "peeling" forces on the welds under any anticipated loading condition.

B. Sample resistance welds in all materials shall be made with calculated settings of current, time and tip pressure, static (pull) tested and, in the case of austenitic stainless steel elements, chisel tested to verify adequacy; and a record shall be made which includes the settings and ultimate shear strength. (A chisel test shall be made by inserting a chisel between two resistance-welded plates to verify that a weld nugget shall be pulled out of one of the plates). Sample welds shall be made and tested at the beginning of each shift and, in addition, whenever there shall be a change in any of the following:

   1. Operator

   2. Material, material thickness, or combination of thicknesses

   3. Electrodes

   4. Settings

C. Spacing of resistance and spot welds shall be appropriate to the design. Spacing shall not exceed 2 in. (51 mm) plus twice the weld nugget diameter for any structural application, including car body side sheets. For any corrugation application, if the pitch of the corrugation nodes does not allow the above weld spacing, there shall be two spot welds between each node.

D. Surface indentation shall not exceed 20% of material thickness (t) or 0.01 in. (0.25 mm), whichever is greater. However, for exterior resistance-welded areas exposed to passenger view, indentation shall not exceed 10% of material thickness or 0.005 in. (0.13 mm), whichever is greater. For exposed welds, the Contractor shall vary welding parameters and conditions within their acceptable ranges to minimize indentations. Surface burn and discoloration shall be removed by chemical cleaning, or an approved equal method, and sanding or polishing to match the surrounding surface.

18.15.12 Laser Welding

Laser welding shall comply with AWS Standard C7.2, Recommended Practices for Laser Beam Welding, Cutting, and Drilling, or ISO 15609-4, Specification and Qualification of Welding Procedures, part 4: Laser Beam Welding.

18.15.13 Special Welding

A. Procedures for structural welding of stainless steel to HSLA, or other combinations of metals or conditions not covered by AWS specifications or codes, shall be submitted for approval. [CDRL 18-014]

B. Austenitic stainless steel electrodes or wire shall be used to join carbon or HSLA steels to stainless steels.

C. For the application of welding processes not addressed in other parts of this specification, the Contractor shall submit equipment qualifications, procedure qualification records, and welding procedure specifications either conforming to identified industry standards or consistent with the approach of AWS Standard D17.2/17.2M, *Specification for Resistance Welding in Aerospace Applications*.

D. Standards that may apply to selected processes include:

1. AWS Standard D17.3/D17.3M, Specification for Friction Stir Welding of Aluminum Alloys for Aerospace Applications.

2. ANSI/AWS Standard C7.2, Recommended Practices for Laser Beam Welding, Cutting, and Drilling.

3. ANSI/AWS Standard C7.4/C7.4M, Process Specification and Operator for Laser Beam Welding.

4. ISO/DIS Standard 15609-4, Specification and Qualification of Welding Procedures for Metallic Materials - Welding Procedure Specification - Part 4: Laser Beam Welding.

E. Galvanized steel shall not be welded to stainless steel. Brazing shall not be used to join stainless steel to either stainless steel or to any other metals.

18.15.14 Toughness of Welded Assemblies

The Contractor shall prove all welded steel structures are above the ductile-brittle transition temperature for the specified environmental exposure. Specifically, the weld Heat-Affected Zone (HAZ) and base metal shall resist service impact loads at the lowest specified operating temperature without brittle failure. If the Contractor's approved design does not require greater toughness, the minimum impact value for Charpy V-notch specimens shall be 15 ft-lbf (20 Nm) of absorbed energy at the lowest specified operating temperature. The Engineer shall have the right to require impact tests to verify the specified toughness.

18.15.15 Torch Brazing

All brazing, characterized by heating above 840°F (449°C), shall follow the recommendations contained in the AWS *Welding HandBook*, Volume 2. Procedures and personnel who do brazing work shall be qualified in accordance with AWS Standard B2.2, *Standard for Brazing Procedure and Performance Qualification*.

18.15.16 Torch Soldering

All structural (not electrical) soldering, characterized by heating below 840°F (449°C), shall follow the recommendations contained in the AWS *Welding HandBook*, Volume 2. Procedures and personnel who do torch soldering shall be qualified in accordance with AWS Standard B2.3/B2.3M, *Specification for Soldering Procedure and Performance Qualification*.

18.16 Exterior Marking Films and Graphics

18.16.01 General

Graphics shall be transportation grade materials, printed on opaque background with clear, vandal resistant overlayment. All graphics materials are to be approved by Engineer. [CDRL 18-015] Application techniques shall be in accordance with manufacturer's recommendations.

18.16.02 Physical Properties

A. Surfaces shall be properly cleaned in accordance with the manufacturer's instructions prior to the application of any materials.

B. Material shall be able to withstand long-term exposure to all environmental and operating conditions specified in PRIIA Specification 305-912.

C. Lettering film shall be sufficiently opaque so that, when applied, films shall completely hide any contrasting background and shall be readily legible.

D. There shall be an initial 60-degree gloss value of 40% ±5% when tested in accordance with ASTM Standard D523-08.

E. Films shall retain adhesive properties after one week of continuous exposure to a temperature of 151°F (66°C).

F. Films shall be able to conform to moderate contours of the vehicle's interior and exterior surfaces at locations where decals are to be applied.

G. Overall thickness of processed film shall be between 0.004 in. and 0.008 in. (0.10 mm and 0.20 mm).

H. Films shall withstand immersion in either distilled water or SAE No. 20 motor oil for 24 hours at temperatures from 70°F to 90°F (21°C to 32°C) without any appreciable degradation in adhesion, color or general appearance.

I. Marking films shall withstand effects of detergents and brushes used in washing procedures for removal of graffiti.

J. Films shall use a removable grade adhesive that upon removal does not require use of solvents or secondary operations.

K. Square or rectangular graphics shall have rounded corners of suitable radius.

L. A sign with a retro-reflective border, and contrasting color shall be applied to the outside of each roof access point. The sign shall read "EMERGENCY ACCESS".

M. Other emergency access points (emergency access windows and exterior manual door releases) shall also be designated with retro-reflective material.

N. Additional locations requiring retro-reflective material shall be proposed by the Contractor for consideration by the Engineer. [CDRL 18-016]

18.17 Paints and Coatings

18.17.01 Materials and General Requirements

A. Where used, painting of the car serves two primary purposes: 1) to protect the vehicle from corrosion and 2) to contribute to the overall aesthetic quality of the vehicle. Paint coatings should also assist in the overall maintenance of the vehicle by providing easy to clean surfaces. The vehicle must be fully and properly coated to achieve its service life with regular maintenance intervals

B. The surface preparation, including cleaning, pickling, primer, paint and graphics applications, shall ensure that the car can operate at least fifteen years between major exterior finish repairs or replacement.

C. Preparation of the painted surface and application of painting materials for brushing or spraying shall be in accordance with the paint supplier's recommendations. Each coat shall be uniformly applied over all surfaces to be covered, and shall be free from runs, sags, or other application defects.

D. Painted surfaces shall develop full adhesion to the substrate to which they are applied. Testing for adhesion between the paint and the substrate surface shall be done on a random basis and shall conform to ASTM D3359, 3a Classification, using Permacell® #99 adhesion test tape.

18.17.02 Paint Process Documentation

A. All paint used on the carbody, exterior components, and exterior of equipment boxes shall be an automotive fleet quality urethane paint system (e.g. DuPont Imron 5000 / 6000 or equivalent) consisting of primers, color coat, and clear topcoat. Painted exterior surfaces shall receive a minimum of two coats of primer, one coat of surfacer, and a minimum of two coats of color, and one coat of clear.

B. Scratch test samples for each surface and process shall be prepared in accordance with ASTM D3359 and presented to the Engineer for review.

C. The Contractor shall prepare a paint coating and application document containing procedures for surface cleaning and preparation, priming, surfacing, and painting for the car body and all equipment that is painted or powder coated. A detailed paint schedule showing the equipment painted, recommended thickness, and other pertinent information shall also be included. This document shall be included in the maintenance manuals. It shall meet PRIIA Specifications 305-904 and 305-905, except 305-905 Appendix A. [CDRL 18-017]

18.17.03 Painting Restrictions

A. Any equipment or parts of equipment which would be damaged or suffer impaired operation from painting shall not be painted and shall be corrosion resistant.

B. The following items shall not be painted:

1. Copper tubing, piping, and fittings

2. Wire and cable
3. Heat transfer surfaces
4. Elastomeric portions of air and refrigerant lines
5. Grounding pads and straps
6. Wheels
7. Axles
8. Brake rotors
9. Brake shoes and pads
10. Air hoses
11. Pedestal liners
12. Elastomeric parts
13. Grease fittings
14. Linkages
15. Threaded parts used for adjustments
16. Electrical equipment
17. Couplers
18. Wearing surfaces
19. Corrosion Protection

C. Concealed surfaces capable of rusting or oxidation shall be properly cleaned, then primed with a rust inhibiting paint, and painted with an approved finish coat of paint.

D. All exposed surfaces shall be suitably finished to prevent corrosion during storage and operation, in accordance with the following requirements:

1. Areas exposed to dirt shall be designed to minimize retention of dirt and moisture, and sections that may retain moisture or dirt shall be provided with adequate drainage and ventilation and shall be accessible for cleaning. Under-pans or covers, suitably sealed, may be used where applicable to protect underframe sections.

2. Joints and crevices shall be sealed with a polysulphide, butyl rubber, or equivalent sealant which is resistant to the operating environment, shall not absorb moisture and shall remain resilient and maintain its sealing properties for the life of the vehicle.

3. Metal surfaces shall be treated with surface preparation and primer materials specific for the metal with due consideration for the severity of exposure to which the surface is subjected.

4. Any corrosion protection removed for welding shall be replaced after welding is completed.

5. Where arc welding is performed on joints between stainless steel and other materials.

18.18 Insulation

18.18.01 Acoustical Insulation

A. To reduce movement, structurally-borne sound and noise generated by the vibration of the roof, floor and side sheets, panels, air conditioning ducts and other metal surfaces, in particular the doors, damping material shall be applied to the inner side of these surfaces (exterior of the HVAC ducts).

B. Korfund Vibrodamper Compound, Aquaplas DL-10-HV or Engineer approved equal shall be applied to the interior of the complete structural car shell including the roof, sides, floor, ends, webs of all posts, carlines, floor beams and other structural elements, however, if acoustic requirements can be fulfilled by car shell design (e.g., local stiffness) then a partial application of the compound would be sufficient.

C. Application of this damping compound and the surfaces to which it shall be applied shall be in accordance with recommendations of the manufacturer of the compound. The thickness of the damping material shall be such that acoustic requirements are fulfilled.

18.18.02 Thermal Insulation

A. The roof, sides, under floor, and ends of the vehicles, including the inside faces of posts and structural members shall be fully insulated.

B. The density, thickness and type insulation shall be determined by U value requirements established by the HVAC calculations and shall be in accordance with the requirements of these Technical Provisions.

C. General - Insulation materials shall be rigid, nonrigid or spray-on type. Materials shall be non-absorptive of fluids and gases, self-extinguishing, and vermin-proof, and shall have the required properties to meet the noise, vibration and heat loss limits as specified herein. All materials shall be graded and labeled as standard with the recognized industry associations or societies. Labels shall be permanently affixed to, or imprinted on, the packages or containers of the materials.

D. Installation - All insulation materials shall be installed in accordance with the Manufacturer's recommendations. Rigid and non-rigid preformed insulation shall be secured with mechanical fasteners or fire-resistant adhesive, or both. Spray- on insulation shall be applied over surfaces free from dirt, grease and other contaminants that might affect the adherence of the material. Parts subject to corrosion shall be given required protection prior to applying the insulation. The Contractor shall take care to avoid thermal shorts in the insulation as installed.

E. Materials - The following materials are acceptable for use on the vehicle:

1. Rigid insulation
2. Glass fiber preformed board
3. Non-rigid insulation
4. Spun glass fiber in flexible rolls or mineral wool batts
5. Carbon fiber-based insulation

F. Insulation Performance

Insulation materials shall be certified to conform to the following requirements:

Property	ASTM Test Method	Requirement
Flame Resistance		

Property	ASTM Test Method	Requirement
Glass Fiber Board	E162 E662	Flame spread 25 max Ds(4.0) – 100 max
Non-rigid Insulation	E162 E662	Flame spread 25 max Ds(4.0) – 100 max.
Spray-on Insulation	E162 E662	Flame spread 25 max Ds(4.0) – 100 max.
Vapor Barrier		
Rating	C353 Water Method	2.5 perm at 90°F (32°C) and 50% relative humidity

Note: A vapor transmission rate of one grain of water vapor per square foot per hour at a pressure difference of one inch of mercury is defined as one perm.

G. The thermal conductivity of insulation materials shall be certified when tested in accordance with ASTM C177-04 at 75°F (24°C) mean temperature.

H. A vapor barrier shall be applied to all exposed insulation to prevent moisture saturation.

I. Floor insulation material shall be compatible with the material used at locations in the vehicle structure and shall not mold, rot, or sustain vermin.

18.19 Flammability and Smoke Emissions

18.19.01 General

A. The vehicle and its components shall comply with the requirements of 49 CFR Part 238.103, Appendix B and APTA-PR-PS-RP-005-00. Compliance of the materials with these requirements shall be fully documented with test reports and certificates. For test reports submitted from previously performed tests, the Contractor shall demonstrate that materials included in the test report are identical to the actual materials used on the construction of the vehicles. Test data from these reports shall be dated no more than five years old from the Contract award data and shall be submitted to the Engineer for approval. The Contractor shall provide a listing of all these tests of all materials in a searchable, tabular format. [CDRL 18-0118]

B. A matrix showing the total weight of each combustible material, where used, supplier's name, flammability and smoke emission test identity, test facility, test requirements, test results, nature and quantity of the products of combustion, and heating value in Btu/lb and Btu/hr shall be submitted by the Contractor during detailed design review. [CDRL 18-019]

C. Maximum limits for smoke emission shall be determined using the smoke propagation mode which generates the most smoke.

D. Should the Contractor believe that the quantity of a particular material is such that it would not contribute significantly to a fire, the Contractor may request a waiver from testing for this material. The waiver shall be submitted in writing and shall include the total weight of the material to be used, the location and the distribution of the material in the vehicle, and any previous test reports available. Waivers shall be accompanied by proper justification and will be reviewed on a case-by-case basis. The Contractor shall be responsible for complete conformance with these standards for itself and its subcontractors and suppliers. The Engineer may, at its discretion, require that the current batch of material being provided for this Contract be retested for conformance with these standards.

18.19.02 Electrical Fire Safety

Electrical equipment shall conform to NFPA Standard 130, Section 4-3, except where more restrictive requirements are imposed by this Specification.

18.19.03 Combustible Content

The design of the vehicle shall minimize the total combustible material content of the vehicle.

18.19.04 Toxicity

A. Those materials and products generally recognized to have highly toxic products of combustion shall not be used.

B. All materials used in the vehicle construction, except for materials used in small parts (such as knobs, rollers, fasteners, clips, grommets, and small electrical parts) that would not contribute significantly to fire propagation or to smoke or toxic gas generation, shall be tested for toxicity using Boeing Specification Support Standard BSS-7239 or Bombardier Standard SMP 800-C.

C. The tests shall be run in the flaming mode after 240 seconds using the NBS Smoke Density Chamber for sample combustion. The gas sampling may be conducted during the smoke density test. The test report shall indicate the maximum concentration (ppm) for each of the above gases at the specified sampling time.

18.20 Piping

18.20.01 General

A. All piping shall be deburred and blown out after cutting or forming. After installation, the piping runs shall be cleaned using an approved method and procedure.

B. Piping shall be installed free of low spots to provide complete drainage away from control devices and to prevent damage by freezing. All piping shall be adequately clamped (clamps not welded to pipe) to prevent vibration, using an approved elastomeric tape between the clamp and the pipe. Copper tubing shall be sheathed at clamps or sheathed clamps shall be used. Piping through bulkheads or structure shall be positioned to avoid chafing the use of clamping and/or grommets.

C. All piping shall be installed using a minimum number of fittings. Unions shall be used only where necessary to permit replacement of apparatus. Hoses shall be provided with swivel type fittings to allow replacement without disturbing surrounding piping or apparatus.

18.20.02 Air Brake Piping and Fittings

A. All air brake tubing, piping and fittings shall comply with current AAR standards.

B. Air brake tubing and piping shall be of good commercial quality, free of burrs and scale.

C. Car body air lines 0.5 in. (12.7 mm) nominal and smaller, and in protected locations, shall be of seamless copper tubing, in accordance with Federal Specification WW-T-799F, Type "K", with wrought copper or cast brass sweat type fittings in accordance with ANSI Standards B16.22 and B16.18, or stainless steel with stainless steel flare fittings.

D. All air piping on trucks and car body air lines larger than 0.5 in. (12.7 mm) nominal or where subjected to flying debris shall be black pipe conforming to ASTM Standard A53/A53M (schedule 80) with black malleable iron welded fittings, all painted the same as the underframe. Stainless steel pipe and welded stainless steel fittings may also be used. Bends in piping shall utilize large bend radii

whenever possible to prevent restriction to the free flow of air. Threaded fittings may be used only where approved on a case-by-case basis. Malleable iron street ells or close nipples shall not be used, except at brake valve exhaust ports.

E. Hoses shall be allowed only to allow for coupler motion, glad-hand connections and connections to brake cylinders from truck body piping. Truck piping shall employ a minimum number of fittings and hoses.

F. Brake system piping shall be installed in accordance with the recommendations of AAR Standard S-400. Brake piping shall have no low spots (traps) or any 45º or 90º elbows that form "doglegs" in piping runs. The highest point in the Brake Pipe shall be the branch pipe connection to the brake control unit.

G. Any piping or tubing which could be disconnected during servicing (event recorder air manifold, etc.) shall be permanently labeled to enable the piping to be reconnected correctly when reassembled.

18.20.03 Air Conditioning and Refrigeration System Piping and Fittings

A. Air Conditioning and refrigeration refrigerant lines shall be fabricated using type K copper tubing and wrought copper sweat type fittings. This shall also apply to lines within supplier furnished apparatus except that finned tubing in evaporators and condensers need not be type K. Instead of elbows, tubing may be bent by means of a tubing bending tool. All tubing shall be deburred after cutting.

B. Piping shall be routed to keep the number of bends to a minimum. All inaccessible runs of tubing shall be without joints. All suction lines and those subject to sweating shall be insulated. If necessary to limit transmitted noise and vibration to the carbody or to protect the refrigerant compressor from external vibrations, vibration isolators shall be used in the piping connections to the refrigerant compressor.

C. After fabrication, the system shall be cleared of all dirt and foreign matter using an approved procedure. The completed refrigeration system shall be evacuated and charged with refrigerant using an Engineer-approved procedure.

D. The discharge of condensate drain lines shall be directly to the roadbed avoiding car structure, electrical cables and other undercar equipment.

18.20.04 Soldering of Piping and Fittings

Copper air brake and refrigerant tubing shall be continuously purged with an inert gas during joining and shall be joined using silver solder conforming to Federal Specification QQ-B-654A, BCuP-5, or BAg-5. Condensate drain tubing and car body air brake tubing shall be joined using silver solder. Soldered joints shall be wiped, and the flux cleaned from the tubing and fittings after soldering.

18.20.05 Water Piping and Fittings

A. All water and waste system piping shall be seamless stainless steel tubing approved for water service applications. ASTM A269 or A312 austenitic stainless steel tube or other Engineer-approved materials shall be used, along with matching fittings. The use of copper waste system piping is expressly prohibited, due to extensive corrosion experienced in Amtrak service. All water systems being supplied shall comply with the design requirements of PRIIA Specification 305-902. All piping shall be clamped with necessary sound insulation to prevent rattle, and must be sloped to allow drainage.

B. If use of copper piping is approved by the Engineer for water supply applications, it shall be Type K drawn (H temper) seamless copper tube per ASTM B88. All joints for copper tubing shall utilize fittings of wrought copper in accordance with ANSI Standards B16.22 and B16.88, and shall be joined using silver solder.

C. After installation, the complete water system shall be sanitized. The sanitizing procedure shall be approved by the Engineer. [CDRL 18-020]

D. The piping shall be routed and sloped to allow for proper drainage. Low points in piping shall be equipped with Ogontz or equivalent automatic drain valves (specified in respective Sections), each equipped with a heater, which shall discharge all the water in the vehicle to the tracks whenever the air temperature at the valve falls below 38°F (3°C). This shall be demonstrated during the climate room testing described in Chapter 19. To ensure complete drainage, venting valves shall be provided to operate in conjunction with the drain valves. At each automatic drain valve, a manual drain valve shall be piped in parallel. Sufficient manual drain valves shall be provided to allow complete draining of the car. Valves shall be labeled in accordance with PRIIA Specification 305-908.

E. Drains from the water system shall be routed to discharge directly onto the ground, avoiding car structure, electrical cables and all other undercar equipment.

F. Electrically powered freeze protection, such as heat trace tape secured with conductive aluminum tape, shall be provided for the water fill housings, underfloor and/or equipment area water piping, water system drain pipes, and water tanks. A blanket heater may be used to protect the water tank.

18.20.06 Sewage Piping and Fittings

A. A non-metallic waste line shall be provided, conforming to PRIIA Specification 305-911.

B. All connections shall be of a compression type such as Hydro-Flow fitting, or approved equivalent. All 90- and 45-degree turns shall be large radius sweeps using the flexible non-metallic pipe. The non-metallic piping shall run from each toilet tailpiece to the vacuum pump in the equipment room or underfloor, based upon the car series design. The piping system must be capable of holding a 15 in. (381 mm) vacuum at all times, since some cars are a constant vacuum type operation. All new non-metallic pipe shall be supported to prevent chaffing and vibration under normal train operations. When in use, the components shall not vibrate. Where possible, components requiring maintenance or replacement at overhaul shall be replaceable as individual units.

18.21 Fiberglass-Reinforced Plastic

18.21.01 General

A. Fiberglass-Reinforced Plastic (FRP) shall be a glass-fiber-reinforced, laminated material, composed of a gel coated surface, fiberglass reinforcement and a polyester or other approved thermoset resin. FRP shall withstand, without any physical deformation or structural damage, the environmental conditions in PRIIA Specification 305-912, be resistant to acids, alkalines and cleaning solutions used by the Engineer.

B. FRP shall be manufactured by the matched die molding or open molding process. Production techniques shall ensure that the glass fiber reinforcement is distributed throughout the final product in such a manner as to avoid resin-rich or resin-starved sections. A structural analysis shall be provided to confirm that the construction method chosen is adequate for its intended purpose.

C. FRP parts shall have a greater thickness at attachment points and edges. Exposed sharp edges will not be allowed on any parts.

18.21.02 Resin

The resin shall be of high-quality, commercial grade, thermosetting, polyester, phenolic or vinyl ester material selected to meet the requirements of the Contractor and manufacturer molding process requirements.

18.21.03 Reinforcement

The fiberglass reinforcement shall be mat, fabric woven roving, continuous roving, chopped spun roving, or swirl mat as required to meet the physical properties of this Specification and the molding process requirements. The glass content shall be a minimum of 20% by weight.

18.21.04 Gel Coat

The gel coat shall be a high gloss finish resistant to scuffing, fire, weather and cleaning agents. The gel coat shall have a minimum thickness of 0.015 in. (0.38 mm). If the surface of the FRP panel is to be painted, a primer gel coat shall be used, and the part shall be painted in accordance with manufacturer's specifications. If the FRP panel does not receive paint, then the gel coat shall be pigmented to match the color selected by the Engineer. The reinforced composite component shall be gel-coated on all exposed surfaces. The surfaces shall withstand, without any physical deformation or structural damage, the environmental conditions and resistance to acids, alkalis and cleaning solutions recommended by the Contractor.

18.21.05 Additives

A. Additives, fillers, monomers, catalysts, activators, pigments, fire retardants and smoke inhibitors shall be added to the resin mixes to obtain finished products with the required physical characteristics of this Specification.

B. Mineral filler shall not exceed 28% of finished weight for any preformed matched die molding process.

18.21.06 Strength Requirements

Independent laboratory test certificates shall be provided stating that the reinforced plastic material complies with the requirements of the following standards. Test specimens shall be conditioned in accordance with ASTM D618-08. [CDRL 18-021]

Mechanical Property	ASTM Test	Open Moldings		Matched Die Molding	
Tensile Strength	D638-08	10,000 lbf/in^2 (68,900 kPa)		12,000 lbf/in^2 (82,680 kPa)	
Compressive Strength	D 695	18,000 lbf/in^2	(124,020 kPa)	22,000 lbf/in^2	(151,580 kPa)
Flexural Strength	D790	15,000 lbf/in^2	(103,421 kPa)	22,000 lbf/in^2	(151,580 kPa)
Impact Strength	D 256	6 ft lb per in. of notch		8 ft lb per in. of notch	
Hardness	--	45 Barcol		45 Barcol	

18.22 Thermoplastic Sheet

18.22.01 General

A. Thermoplastic sheet used in the construction of the vehicle shall withstand, without any physical deformation or structural damage, the environmental conditions described in Amtrak Specification 429, and shall be resistant to the Engineer cleaning solutions. Thermoplastic sheet shall be used as extruded or vacuum-formed.

B. Thermoplastic sheet shall be homogeneous and extruded from virgin stock which does not include any regrind of vacuum formed parts. Only UV stabilized pigments shall be used to create the specified color of the thermoplastic sheet. The color and surface finish of parts manufactured from this material shall be approved prior to the production run of any parts.

18.22.02 Quality

The finished parts shall be free of waves and quilting on both sides. Degraded polymer in the sheet shall not be allowed, and if present, shall be cause for rejection of the piece. Voids, lumps and contamination shall also be cause for rejection of parts if the defects are larger than 0.01 in. (0.25 mm), and the population of these defects is greater than one defect in 4.0 ft^2 (0.37 m^2).

18.22.03 Strength Requirements

Independent laboratory test certificates shall be provided stating that the thermoplastic sheet complies with the requirements of the following standards. Extruded sheet in the surface finish specified shall be used for testing. [CDRL 18-022]

Mechanical Properties	ASTM Method	Value
Specific Gravity	D 792	1.20 to 1.45
Tensile Strength	D638-08	5,500 lbf/in^2 minimum
Flexural Strength	D790	8,000 lbf/in^2 minimum
Flexural Modulus	D790	3.3 x 105 lbf/in^2 (15.8 Mpa)
Hardness Rockwell	D 785	90 to 110 ("R" Scale)
Heat Deflection (annealed)	D 648 @ 264 lbf/in^2 (12.64 kPa)	160°F (71°C) minimum
Impact Strength (Fabricated Parts)	D 3029 Gardener Dart Drop 0.5 in. (12.7 mm) dia. ball at 73°F (23°C)	160 in. lb (18 Nm) minimum

18.23 Air Filters

18.23.01 HVAC and Equipment Ventilation Filters

HVAC system air filters shall conform to PRIIA Specification 305-907 and shall be selected in accordance with the manufacturer's recommendations for the specific equipment involved. All filters shall have an integral frame. Filters shall be the throw-away type available in standard commercial sizes except reusable filters that may be approved for specific applications where throw-away filters are not available. Filters shall be designed to meet the performance requirements of each installation and shall be approved. All filters shall be freely accessible for maintenance.

18.23.02 High Pressure Air Filters

A. An air filter assembly with a replaceable filter element shall be provided in the air line that connects each subsystem to the main reservoir air supply system. The main reservoir air filter filtering capability, flow rate capability and overall size shall be appropriate for the application so that the filter replacement interval is greater than one year. Quality of compressed air supplied by the locomotive shall conform to APTA-PR-M-S-011-99 Revision 2. It shall be possible to gain access to the filter element for replacement without requiring any pipe fittings to be disconnected or loosened. Glass fiber mat types of filter media shall not be used for high pressure or high-volume applications. Filters shall be provided for each of the following systems and any others operated from the air supply system:

   1. Each air brake control assembly

   2. Waste system

   3. Door operators (if pneumatic)

4. Horn

5. Low pressure air filters

B. Replaceable media type filters shall use resin-bound, spun-glass fiber materials having an uncompressed thickness not less than 3.5 in. (88.9 mm). It shall be non-absorptive of fluids and gases, shall be processed in such a manner that material density increases progressively from air inlet to air exit side, and shall be coated with not less than 24 grams per square foot of a dust-retaining, viscous adhesive film. This film shall be stable at temperatures up to 150°F (66°C). The filter medium shall be cut not less than 0.5 in. (12.7 mm) oversize to ensure adequate sealing between the edge of pad and its integral frame.

18.24 Wire and Cable

18.24.01 General

A. All wire and cable used shall exhibit the physical and electrical properties for 230°F (110°C) rated wire and cable specified in Amtrak Specification 323. High temperature wire, used for heater circuits, shall be as defined as Amtrak Specification 323.

B. A minimum number of wire types and sizes shall be used in the vehicle. Selection of wire size and insulation shall be based on the current carrying capacity, voltage drop, mechanical strength and temperature and flexibility requirements and in accordance with APTA-PR-E-RP-009-98 and applicable AAR, ICEA, ASTM or MIL Specifications. The Contractor shall submit to the Engineer for review and approval, a procedure for installation of wiring and cable, including the criteria and procedures for the repair of damaged wire or cable. This procedure shall be included in the heavy maintenance manual. [CDRL 18-023]

C. In no case shall wire smaller than the following sizes be used:

1. Wire on electronic units, cards, and card racks - No. 22

2. Wire on connector - No. 16

3. All other wire - No. 14 unless approved by the Engineer

18.24.02 Wiring - General

All vehicle wiring shall be in conformance with APTA-PR-E-RP-002-98 and APTA-PR-E-RP-009-98, Chapter 3 of the National Fire Protection Association's Publication NFPA No. 70, and the AAR Manual of Standards, Section F S-538, *Wiring Practice and Rolling Stock Standard*, except where otherwise specified, and except that all wire shall be as required in this Specification. Design wire amperage capacity shall comply with NEC Table 310-18, 110C Column. When more than three conductors are applied in a raceway or cable, the amperage capacity shall be derated, as described in Note 8 of Table 310-16. Circuit protection shall be in conformance with Chapter 2 of NFPA publication No. 70, Article 240.

18.24.03 Data Communications Wiring

A. All data communications (Ethernet) wiring shall be able to support EIA/TIA 568 Cat 5e communications for data on rolling stock. It shall be suitable for use in undercar and inter-car applications when installed in flexible (polyimide) or rigid conduit; it shall be suitable for the application and shall maintain long-term electrical integrity for all aspects of the EIA/TIA requirements including impedance, cross-talk, attenuation, and shielding effectiveness. The cable will also meet environmental and safety requirements associated with rolling-stock cables. The cable shall be designed with rolling-stock requirements in mind, and will support high-speed data transfer for no less than 20 years in the rail environment. All accelerated life tests performed in the qualification are

specified with the intention of this service life. The cable shall be designed so that installation with normal care into new car shells or undercars will not damage its electrical integrity. The cable shall be designed so that installation in raceways with other cables is proper (cable will not be impacted by crushing or cable-to-cable abrasion). The cable shall be able to be terminated with M12 connectors. The cable shall have the following characteristics:

B. Construction

1. Conductors: Stranded silver-plated copper #22AWG (or 0.0008 in^2 [0.5 mm^2])
2. Insulation: Radiation cross-linked data grade polyolefin 300V
3. Component configuration: Wires are twisted or helically cabled to ensure electrical performance to Cat 5e standards (see table) – 100Z characteristic impedance on finished cable
4. Shielding: Foil and TC braid designed to meet 200MZ/m transfer impedance
5. Binders/tapes: As required to enhance integrity
6. Jacket: Radiation cross-linked polyolefin (low-smoke, halogen free) 0.03 in. (0.76 mm) minimum at thinnest point.

C. Electrical Requirements

1. Impedance: 100Z+/-5Z
2. Shielding effectiveness (30 Mhz-100 Mhz): 40dB
3. Voltage rating: 300V

Frequency (Mhz)	**Attenuation (dB/100m)**		**Next (dB) Pr/Pr**		**Next (dB) Pr/Pr**		**Return loss (dB)**		**Attenuation Unbalance Near End (dB)**
	Typical	Max	Typical	Min	Typical	Min	Typical >	Min	Min
1	2	3.2	80	65.3	79.5	-			40
4	4	6	76	56.3	70	-	35	23	34
10	6.5	9.5	67	50	65.5	43.8	35	25	30
31.5	10.5	17.1	60	42.9	58.5	33.9	35	23.6	25
62.5	14	24.8	56	38.4	59.5	27.9	33	21.5	22
100	18	32	53	35.3	67.5	23.8	33	20.1	20

D. Environmental Requirements

1. Cable jacket will withstand the following tests per AAR RP 585
2. Tensile and Elongation Section 5.1 and 5.2
3. Oil Resistance 5.3 and 5.4
4. Thermal Shock 5.8.4
5. Penetration 5.9.4
6. Abrasion 5.9.8.2
7. Corrosion resistance ASTM D2671-00(2007)e1

8. Temperature -40°F (-40°C)- 194°F (90°C)

E. Mechanical Requirements

1. Bending radius: 6x OD (fixed)

2. Car-to-car cables should have a test modeling the installed condition, with periodic measurement of electrical characteristics - 3,000K cycles - with no application-altering failure in electrical performance.

F. Smoke and Flame

1. NFPA 130 (UL1685) or equal i.e. UL 1581 (tray) or IEEE 383 1974

2. Bombardier SMP 800-C (for combustion products)

18.24.04 Wire Handling

A. All wiring shall be performed by qualified, experienced wiring personnel using appropriate tools for stripping insulation, cutting, tinning, soldering, harness making, attaching terminals and other wire fabrication tasks. All wiring tools and equipment shall be used as recommended by the tool and equipment manufacturer.

B. Wire shall be protected from damage during all phases of equipment manufacture. Wire shall not be walked on, dragged across sharp or abrasive objects, kinked or twisted, or otherwise mishandled. The ends of wire shall not be permitted to lay on wet floors or other damp areas where moisture may be absorbed into the conductors. When removing insulation, wire strands shall not be nicked or broken in excess of the requirements of FAA Specification No. AC 43.13-1A, Section 449, *Stripping Insulation*. Additionally, the following criteria apply:

Wire Size	Maximum Number of Nicked Strands*
Wires smaller than No. 10	None
No. 10 through 1/0	7.4 percent
Above 1/0 through 1600/24	4.4 percent
Above 1600/24	graduated scale
**Definitions:* *A cutoff strand shall count as two nicked strands.* *A nick is defined as 25% or more of the strand area damaged or cut more than 1/3 of its diameter.*	

18.24.05 Wire Harness

A. The layout of wiring, for both vehicles and equipment, shall be designed in advance of its installation and in cooperation with the suppliers of the related equipment. Wiring shall be pre-fabricated into standard harnesses, wrapped and tied with nylon wire ties or a high strength, waxed lacing cord designed not to invade the wire insulation. Harnesses shall be installed with identical arrangement and location in each vehicle having similar equipment. Separate harnesses shall be provided for major circuit groups or types, or as required for specified circuit separation. All circuits and branches shall be separable by means of terminal boards to isolate portions from others for troubleshooting. All circuits subject to periodic high potential tests shall be so arranged that they can be conveniently isolated for the tests.

B. Alternative methods for fabricating and installing wiring, which are standard carbuilder practice, will be submitted for consideration at the appropriate design review.

C. Harnessed wires shall not be installed in conduit. Wires from different conduits or other openings shall not be harnessed together with wires running within the box or entering the box through

another entrance point. Each harness or group of wires between equipment enclosures shall contain a minimum of 10% spares, but no fewer than two spares for each wire size.

18.24.06 Circuit Separation

A. Circuits shall be physically separated to reduce the possibility of unsafe conditions, electrical interference or equipment damage.

B. The following major circuit groups shall not be harnessed or bundled together, shall not run in the same conduit, and shall be physically separated and secured in enclosures, wire ducts, junction boxes, or other wire routing devices:

1. 480Vac HEP trainline
2. 27-point communications trainline
3. 27-point MU trainline
4. IITS/Cab Signal circuits
5. AC power circuits
6. DC control circuits
7. Communication circuits
8. Unprotected wiring (e.g., battery or HEP trainline to circuit breaker)
9. Data communications (Ethernet) wiring even though it might be in the same car-to-car 27-point communications trainline jumper

C. Exceptions shall be approved by the Engineer in case complete separation is not reasonably practicable.

D. Conductors which shall operate at potentials differing by 50 volts or more shall not be cabled together and shall not be placed in the same conduit, raceway, duct, junction box, or enclosure, except that 120VAC and 480VAC may be run in same conduits providing all the wire insulation is rated at 600VAC minimum. Where it is impossible to avoid having wires at different voltages in the same equipment enclosure, the wires shall be physically separated, bundled, and secured separately such that contact between wiring is not possible. All wiring within an enclosure shall be insulated for the highest voltage in the enclosure, unless Engineer approved otherwise.

E. Wiring connected to transient-generating apparatus shall not be run adjacent to wiring carrying signals to, from, or between semiconductor circuits, logic circuits, vital no-motion circuits, data transmission or communication circuits. In cases in which adequate physical separation is impossible, shielded wire shall be used for all conductors involved.

18.24.07 Wire and Cable Runs

A. Wire and cable runs shall be properly placed to be protected from the environment, debris and be arranged to allow for proper heat dissipation per manufacturer's requirements.

B. All wire and cable shall be free of kinks, insulation damage, insulation abrasions and nicked strands. Wire installation shall not be subject to accumulations of water, oil, or other foreign matter.

C. Cables shall be laid in place with sufficient slack at the bends so that cables will clear the inside bend surface of the strain relief device.

D. Conduit shall be attached to the carbody employing clamps; welding shall not be used under any circumstances.

E. Concealed wires, such as within conduits and wire ducts shall be such that wires may be replaced or added to without the removal of other than an access panel at each end of the wire. It shall not be necessary to disconnect or disassemble conduit to accomplish this task. Wires in conduits and wire ducts shall not utilize more than 40% of the interior cross-sectional area.

F. Wiring run in loom shall not be carried over a potential chafing hazard.

G. Wires entering any removable box shall be harnessed and secured to facilitate removal of the box.

H. All wires and cables shall be fully protected against any contact with any surface other than that designed specifically to support or protect them. This applies to all current carrying wires, cables or buses on the vehicle.

18.24.08 Undercar

A. The 480Vac trainline conductors shall be cleated in place; No. 6 AWG and larger may be cleated in place or run in rigid conduit.

B. All undercar wiring smaller than No. 6 AWG shall be run in Rigid Galvanized Steel (RGS) conduits in an approved manner. Conduits shall be of waterproof construction. Permanently retained watertight strain relief bushings, with insulated throat liners of an approved design, shall be used at locations where wires, cords or harnesses enter or exit conduit, junction boxes and equipment enclosures. In addition, strain relief bushings on equipment enclosures shall include a permanently retained O-ring type seal.

C. Wires or cables shall not pass through or over the battery compartment and shall not pass over heat generating equipment, even if the wires or cables are in conduit.

D. Rigid galvanized steel conduit shall be run to all rigid-mounted enclosures. RGS conduit shall be run as near as possible to resiliently mounted equipment, with flexible conduit, not to exceed 18 in. (457 mm) in length, completing the run.

E. Flexible conduit shall not be used for any application on the exterior or underside of the car without Engineer approval.

F. Open undercar wiring shall be protected over the trucks by running the wiring through RGS conduit, with suitable protective bushings applied at the ends.

G. Conduit routing and the connection to boxes shall minimize exposure to water entering the conduit: for example, conduit should not enter from the top of the enclosure if at all possible. Drip loops shall be employed as appropriate.

18.24.09 Exterior of Roof

A. All wiring to roof-mounted equipment shall be run in electrical metallic tubing steel or rigid galvanized steel conduits within the carshell.

B. Wires or cables exposed or in conduit shall not pass over or near heat generating equipment.

C. Conduit routing and the connection to boxes shall minimize exposure to water entering the conduit: for example, conduit should not enter from the top of the enclosure if at all possible. Drip loops shall be employed as appropriate. Boxes shall be raised above surfaces where water, snow/ ice could accumulate (including from plugged drains), to reduce the likelihood hood of water incursion.

18.24.10 Under Floor

Wiring run under the floor shall be either in conduit or wire duct. Care shall be taken to ensure water does not enter the conduit/ wire duct from above, such as from car cleaning.

18.24.11 Interior

A. Any wiring passing through the floor shall be run in rigid conduit. Wiring, even if enclosed in loom, must not be run through partitions without suitable bushings being provided at such points of passage. Conduit openings from below must extend at least 1 in. (25 mm) above the floor level to ensure water cannot enter the conduit from above, such as from a wet floor.

B. All 480V wiring above the car floor and within the sides, ends or roof of the car shall be carried in EMT or rigid steel conduits. Short runs, not to exceed 18 in. (457 mm), of flexible conduit may be employed to make final connections to equipment.

C. All wiring in the walls shall be in EMT or rigid conduit. Wiring in the roof shall be carried in thin-wall aluminum or steel conduit, in metal duct or "Panduit" material meeting the requirements of PRIIA Specification 305-903. All flexible non-metal conduits shall be installed in protected areas only, unless specifically approved by the Engineer. In wire ducts, wire shall be secured within and including each entrance and exit point, to prevent chafing movement.

18.24.12 Cable Cleating and Support

A. Open-run cable shall be supported by using split-block cleats of molded neoprene rubber, spaced no more than 4 ft (1 m) apart. Slack shall be allowed in the cable to accommodate both thermal expansion and contraction of cable.

B. Each cleat shall have a channel-shaped stiffener of at least 10 gage material on the side away from the mounting bracket which shall act to spread the bolt clamping force over the entire length of the cleat. Bolts shall have lock nuts.

C. Cleats shall be designed to grip each cable individually and firmly, but without causing any damage to cable insulation, including cold flow of the insulation. Cleats shall include spacers in the mounting holes to prevent crushing the cleat by overtightening the mounting bolts. Each cable in the cleat shall have its own cutout sized to the correct wire diameter. The cleat material shall be fire retardant insulating material with a durometer of 50 to 60.

D. Cleated cables shall be routed and supported such that they cannot, under any combination of forces and car movement, touch each other or any other part of the car, except the cleat cushioning material.

18.24.13 Wire Securement and Termination

A. All wiring shall be secured and protected against movement, chafing, and any contact with conductive, sharp, or abrasive objects including the inside surfaces of wire runs.

B. No wiring shall be secured directly to the vehicle structure, equipment enclosures, or any metallic surface. Wiring securing devices shall be either completely non-metallic or metallic with a resilient, insulating member between the wiring and the metallic portion of the device.

C. All wiring shall be located and secured such that normal equipment motions, maintenance access, heat sources and the environment do not damage or reduce the life of the wiring.

D. Junction boxes, with terminal boards, shall be used, as required, for wire terminations. Harness connections to the boxes, as well as internal wiring to terminal boards, shall be as specified. Exterior junction boxes shall be watertight.

E. Wire and cable dress shall allow for sufficient slack at equipment terminals to provide for movements induced by shock and vibration, equipment shifting, alignment, cover removal and component replacement. Sufficient lengths shall be provided at points of termination for additional re-terminations without applying tension to the wire and without splicing the wire, as follows:

No. 10 AWG and smaller	Three re-terminations
No. 8 AWG and large	Two re-terminations

F. A drip loop shall be provided on all exposed wires and cables to prevent fluid runoff into connected equipment.

G. Wire tying devices shall be of such material and construction that they will adequately retain the wires for the life of the wiring and shall be resistant to ozone and ultraviolet light. Wire and cable ties shall be trimmed using the proper tool and located to eliminate any hazard to personnel from sharp edges. Wire tying devices shall be snug, but shall not be so tight as to cause indentation and cold flow damage to the insulation. Wire tying devices shall be mechanically fastened to a permanent structure. Adhesive-installed mounting bases shall not be used for ties or for cable support.

H. Wire tying devices shall not be used:

1. For any external undercar application
2. To support wire under its own weight
3. To support/secure any type of conduit

I. Truck wiring shall be designed to ensure sufficient slack, for pivoting, spring action and jacking and shall be provided with clamp supports and abrasion protection. T-splices will not be permitted.

J. All jumpers, jumper heads and jumper receptacles shall be sealed in an approved manner to prevent the entry of water at any operational speed.

K. Any wiring needed to calibrate and test vehicle functions shall be a part of the permanent vehicle wiring to enable the Engineer to conveniently maintain the equipment. This wiring shall terminate in approved connectors in the respective control groups and cabinets.

L. The Engineer requires wiring and cabling to be accessible for repairs; the Contractor shall submit a complete wiring plan for evaluation at the appropriate design reviews. [CDRL 18-024]

18.24.14 Marking

A. All terminals boards and terminal posts shall be plainly marked with non-conductive hot stamping type markings so that they shall be easily identified. Devices shall be labeled via silk-screening onto panels, mechanically-attached plastic labels (adhesives are not acceptable alternate), or other permanent means approved by the Engineer in design review.

B. Wires shall be marked with sleeve-type labels with permanent typed-on lettering, such as Raychem TMS or approved equal, or with non-conductive hot stamping type markings. Both ends of each wire are to be identified. A wire 4 in. or less in length shall need only one label. For No. 16 and smaller wires, including multi-conductor cables, where individual wire marking would be impractical, color coding of each wire will be satisfactory.

C. No two devices, terminals, or wires shall have the same identification.

18.24.15 Cable and Wire Identification

A. The Contractor shall provide a listing of all wire codes and device and connector identification used on its equipment as part of the integrated schematics manual. [CDRL 18-025]

B. The identification system shall be designed to utilize the minimum number of alphanumeric characters to identify devices and interconnecting wiring. Device, terminal and wire identification is intended to provide unique, consistent, clear, concise and recognizable identification of wiring and devices as an aid to maintenance of electrical systems. The wire-designation system shall be one which relates the designation in some way to indicate where it shall go and where it shall come from. Each individual piece of wire shall be given its own distinct identification so that it shall be positively identified at its opposite end without the necessity for "ringing through." As much as possible, naming shall be consistent among all the Engineer equipment. This naming system will be employed on the following:

1. Electrical Arrangement Drawings
2. Electrical Schematics
3. Wiring Diagrams
4. Labels on hardware
5. Car Electrical Panels, etc.
6. Device names: circuit breakers, indicators lights, switches, relays, contactors, pressure switches, etc.
7. Car Wiring
8. The above categories on drawings provided by different vendors (for example, air brake schematic and electrical schematics)

C. By using the nomenclature and appropriate schematic, an electrician shall be able to easily identify any point in a circuit, such as an auxiliary contact, and locate that point on the hard-ware.

D. The identical name shall be used for a given component in all references - arrangement and schematic drawings, wiring diagrams, panel and switch plate legends, and maintenance manuals.

E. It shall be the Contractor's responsibility to ensure that:

1. All equipment suppliers conform to this Specification;
2. A consistent numbering system is used throughout the vehicles; and
3. Component device and wire names are not duplicated.

F. At a minimum, the following major electrical system components shall be identified:

1. Electrical panels
2. Contactors and motor starters
3. Relays and timers
4. Switches and circuit breakers
5. Electronic components
6. Terminal blocks
7. Connectors
8. Each wire

9. All labels shall be permanent and expected to be legible for the life of the vehicle.

10. Labels shall be easy to read and observable without having to disturb wiring, especially for:

    a. Relay names

    b. Contactor/Motor starter names

    c. Terminal block and terminal identity.

11. In cases where two or more identical panels are used, the respective panel names "A" and "B" (as appropriate) shall be affixed to the car body or mounting plate, not the panel.

12. Numbering system shall be consistent between Contractor and component supplier, such as floor heat wire names. It shall be possible for an electrician to connect all external car wiring to a panel without requiring a drawing.

18.24.16 Pulling Compound

Pulling compound shall be non-conductive, non-hygroscopic, non-odorous, and shall not attract vermin.

18.24.17 Solder

Solder shall be in accordance with ASTM Standard B32-08, Grade 60B. A flux of non-corrosive type shall be applied immediately before soldering and removed after soldering.

18.24.18 Tape

Electrical tape shall be polyvinyl chloride in accordance with UL 510, Standard *Insulating Tape*, CSA Standard C22.2, No. 197-M1983, *PVC Insulating Tape,* or equivalent approved railway practice. Electrical tape shall meet or exceed the voltage rating of wire where the tape is applied.

18.25 Wire and Cable Connections

18.25.01 General

A. All wire and cable shall be free of kinks, insulation damage, insulation abrasions and nicked strands. Wire installation shall not be subject to accumulations of water, oil, or other foreign matter.

B. Cables shall be laid in place with sufficient slack at the bends so that cables will clear the inside bend surface of the strain relief device.

C. Conduit shall be attached to the carbody employing clamps; welding shall not be used under any circumstances.

D. Concealed wires, such as within conduits and wire ducts shall be such that wires may be replaced or added to without the removal of other than an access panel at each end of the wire. It shall not be necessary to disconnect or disassemble conduit to accomplish this task.

E. Wiring run in loom shall not be carried over a potential chafing hazard.

F. Wires entering any removable box shall be harnessed and secured to facilitate removal of the box.

G. All wires and cables shall be fully protected against any contact with any surface other than that designed specifically to support or protect them. This applies to all current carrying wires, cables or buses on the vehicle.

H. All equipment enclosures and junction boxes shall be fitted with terminal boards or connectors. The Contractor shall submit the proposed design and product line for all connections for approval. Number 6 and smaller type terminal boards and quick-disconnect terminals, other than those stated herein, will only be permitted with approval. [CDRL 18-026]

18.25.02 Terminal Boards and Terminal Points

A. All electrical terminal points and terminal boards of wire size AWG 10 or larger shall have brass studs and connections, each of which shall be locked using a single brass nut with brass flat washer and a plated spring-type lock washer. Studs, nuts, and washers may also be made of corrosion-resistant plated steel, where approved. Each board or connector shall have the necessary number of terminations plus a minimum of 10% spares, but not fewer than one spare unless approved. Binding head screw type terminal boards will be permitted only where approved. All terminal boards shall be in accordance with Military Specification MIL-T-55164C.

B. All wires of size range AWG 12 to 14 shall use modular spring lock terminal blocks. The terminal block modules will be mounted on DIN-rails. The supplier shall provide standard 1.4 in. (35.5 mm) wide DIN-rail in 0.29 in. (7.4 mm), 0.6 in. (15.3 mm) and 2.3 in. (58.5 mm) heights. The DIN-rail shall meet RoHS (Restriction of Hazardous Substances Directive) standards and shall be available perforated or unperforated. Materials will include chromated-steel, copper, and aluminum. The modules shall be color coded for the ability to tell the signal type at a glance. The terminal blocks shall be available in the following colors/color combinations of gray, blue, red, yellow/green, black, yellow, orange and brown. The metal

C. Body shall contain a high strength spring steel spring element that will provide a gas-tight connection with the conductor.

D. Spring connection shall be stainless steel. The terminal blocks shall come with car body ground modules that are connected directly to carbody ground. The terminal blocks shall come with insertable shorting plugs. The terminal blocks will have snap in positive lock labels. Terminal Blocks shall have a method of labeling for easy identification which is universal across all connection technologies. The modules will have a place to label the terminal number as well as the terminal block name. Each wire shall have a ferrule on its end and be able to be inserted by engaging the spring with a standard 0.1 in. (2.54 mm) slot size screw driver.

E. Terminal block accessories and bridging systems shall be compatible and interchangeable with all connection technologies (screw, spring and IDC technology) including flexible bridging system, modular testing, standardized labeling system and pluggability features.

F. Threaded studs shall have a minimum of 2-1/2 threads exposed beyond the final nuts. Adequate space shall be provided to permit connecting wire terminals with standard tools. All terminals shall be properly torqued to assure sound connections. Spacers shall not be used.

G. Jumpers between terminal board points shall be brass or plated steel. Wire jumpers between adjacent terminals of terminal boards will not be permitted.

H. Terminal blocks located outside the carbody or operating at 480V or above will employ closed bottom blocks.

I. An approved permanent marking strip on each terminal board shall be provided and attached adjacent to the wire junction point to identify the wires attached thereto.

J. A maximum of two terminals shall be connected to any one binding screw. A maximum of four terminals shall be connected to any one threaded stud, provided that there is no interference between terminal barrels. On terminal boards, the wiring shall be arranged so that no more than two terminals are connected to a stud, from each side of the terminal boards.

18.25.03 Wire Terminations

A. Terminals and connections used throughout the vehicle shall be the mechanical, solderless, crimp type made by AMP Incorporated or other approved manufacturer with a comprehensive line of terminals, connector pins and application tools available. The Contractor shall submit the proposed product line for approval. Terminals shall be tested to Military Specification MIL-T-16366F for temperature rise, voltage drop, vibration, current overload and corrosion.

B. All wire terminations shall be accessible to remove or replace. Wire terminations shall not be covered by other wires.

C. Terminals and connections shall be attached to the wiring with proper crimping tools and dies as recommended by the manufacturer. Application tooling shall incorporate die or piston stops to prevent over crimping. To prevent under crimping, all application tooling shall incorporate a "full cycle" feature that once started, requires the tool to be brought to the stops before the crimped connection can be removed. The Contractor and his suppliers shall employ a certification process to ensure that all tooling remains within calibration to properly crimp the lugs.

D. Spade and hook-type terminals shall not be used. Corrosive protection shall be provided for all base materials.

E. Conductors subject to motion relative to the terminal shall be protected by suitable means to prevent breakage of the conductor at or near the terminal. Sufficient slack shall be provided in all wires and cables to prevent breaking or pulling out of bushings and terminals. A maximum of one wire shall be crimped in any one terminal.

18.25.04 Power Cable Terminations

Power cables shall be terminated with an approved compression terminal. Sufficient cable slack shall be provided to preclude breaking or pull-out from bushings or terminals and to allow two terminal changes. Cable conductors shall be clean prior to installation of terminals. Compression terminals shall be applied using tools and procedures recommended by the terminal manufacturer for that purpose. Swaging tools shall be of a type that ensures complete swaging in every case.

18.25.05 Cable Connectors

A. All equipment that may be maintained by removal and replacement shall be connectorized, to the maximum extent practical. All cable connectors shall conform to MIL-C-5015, or an equivalent standard as approved by the Engineer. They shall employ removable crimp contacts of the correct size for the wire being terminated. Except as noted below, the connector contact area shall be plated with a minimum of 0.00003 in. (0.00076 mm) of gold over a minimum of 0.00005 in. (0.00127 mm) of low stress nickel. For high current applications, the connector contact area shall be plated with a minimum of 0.0001 in. (0.0025 mm) of silver. Adjacent connectors shall either use different inserts or different insert orientations to prevent erroneous connections. One piece of all cable connectors shall be rigidly mounted.

B. Connectors shall be keyed so as to not be accidentally interchanged between adjacent connectors. Spare contact allocation shall be 10% to 15%, but no less than 4, per connector. Power and control wiring shall be separated in different connectors if they exceed 120VAC. Disconnected plugs will be supported so as to not drop to the ground, floor or other position in which they might be readily damaged. Connectors are to be mounted to provide convenient hand access so as to be easily mated and unmated.

C. All cable connectors used in exterior locations shall be of the environmental watertight variety and a molded type wherever possible (such as speed sensors). Cable connectors shall be equipped with sealing gaskets on the front mating surface and on the back where the cable enters. Bolts within the connector shall be long enough to ensure that there is sufficient room to terminate the cable wires

within the connector body. The cable jacket shall be held by a clamp within the connector body. Unused connector pin positions shall be sealed with either connector contacts or plastic sealing plugs designed for that purpose.

D. Plastic bodied connectors shall not be used.

E. Except as provided above, all cable connectors in exterior locations, shall be 1/4-turn, bayonet-lock, quick disconnect type connectors, or approved equal. They shall conform to all provisions in MIL-C-5015, or an approved standard, except for the screw coupling requirement.

F. In waterproof interior locations, the use of non-weatherproof connectors will be allowed as approved. All other connector requirements specified in this section which do not directly apply to weatherproofing shall be met.

18.25.06 Quick-Disconnect Terminals

Only Engineer-approved quick-disconnect terminals may be used. They shall be modular, and they shall provide positive terminal engagement and be shock and vibration proof. All terminals shall be provided with insulation equal to that of the wire. No "push-to-fit" (FAST-ON) type terminals will be permitted unless specifically approved by the Engineer for that unique application.

18.25.07 Grounding/ Bonding Connections

A. Grounding and bonding shall be done in accordance with APTA Standard PR-E-S-005-98. All grounding and bonding jumpers and straps shall be sized to handle fault current for which the voltage drop shall not exceed 25V. The bonding method employed shall not produce a dc resistance in excess of 0.0025 ohms, or more than 0.025 ohms at 150 kilohertz for any applied ac voltage. Grounding and bonding jumpers, and brazed shunt straps shall be flexible.

B. The car body shall be grounded to each truck frame by means of a separate cable which shall be sized to safely ground the car under normal conditions.

C. The 120VAC, 60 Hz, single-phase service shall be separately and firmly grounded to the car body structure and have a green indicating color band applied to the terminations.

D. All apparatus operating at 480VAC and not directly grounded to the car body through its mounting shall have grounding straps. This particularly applies to resiliently mounted equipment.

18.25.08 Wire Splicing

Splicing of conductors shall be avoided and shall be permitted only with approval on a case-by-case basis. Splicing of conductors in conduit will not be permitted. In the event a splice is approved, it shall be in a junction box and the spliced joint shall be mechanically as strong and have the same conductivity as any other part of the conductor. The splice shall be an insulated permanent crimp splice in accordance with Military Specification MIL-T-7928G, Type II, Class I, and shall be installed with the crimping tool and die of the splice manufacturer. All splices shall be insulated with a self-sealing, weathertight, seamless shrink tubing. The outside diameter of the spliced portion of the cable after the insulation is applied shall not exceed the outside diameter of the unspliced portion by more than 40%. Splices shall be identified in the integrated schematic.

18.26 Conduit

18.26.01 Types

Thin-wall EMT type conduit shall conform to Federal Specification WW-C-563A. Flexible metal conduit shall conform to Federal Specification WW-C-566C or MIL-T-81914.

18.26.02 Size and Fill

Conduit shall be sized such that the sum of the cross-sectional areas of the conductors and their insulation does not exceed 40% of the cross-sectional area of the conduit for three or more conductors. For two conductors, a limit of 31% shall be used, while for a single conductor, a limit of 53% will be permitted. Where conduit having a length not exceeding 24 in. (610 mm) without bends of more than 15º is used between enclosures, a maximum fill of 60% will be permitted.

18.26.03 Installation

A. A run of conduit between junction boxes and/or pulling outlets shall not contain more than the equivalent of four quarter bends, 360° total, including the outlet fittings. Bend radii at the inner surface of the bend shall be no less than eight times the nominal inside diameter of the conduit.

B. All conduit bends and offsets used shall be made by the use of special forms or tools and shall have the largest radius possible so that wires can be pulled without the use of tackle or power.

C. Conduit shall be securely clamped with all runs electrically grounded to make a continuous ground. Suitable approved insulation to prevent electrolysis shall be provided where steel and aluminum are in contact.

D. All conduit shall be arranged to prevent moisture traps and shall drain toward control boxes, except that all open-ended conduits shall be installed in such a manner as to ensure gravity drainage out the end. The conduit arrangement and installation shall be subject to approval. [CDRL 18-027]

18.26.04 Conduit Fittings and Junction Boxes

A. The conduit fittings and junction boxes for vehicle wiring shall be as manufactured by the Contractor or by a supplier of a comprehensive line of parts. The Contractor shall submit the proposed product line for approval. [CDRL 18-028] All conduit fittings and junction boxes shall be provided with gasketed covers.

B. Boxes

All exterior junction boxes shall be fabricated of material appropriate for exterior usage, such as stainless steel, or as approved by the Engineer. All exterior junction boxes shall be weatherproof and shall be connected in such a way that drainage from equipment groups will not pass through conduit into the junction boxes. Interiors of all junction boxes shall be primed and then protected with a white, insulating epoxy powder coating. If electrical faults within the box can be detected, the interior of the junction boxes may be left unpainted. Equipment areas containing non-insulated electrical devices at more than 120 volts to ground shall be plainly marked with warning signs worded DANGER – XXX VOLTS. Covers for electrical junction boxes shall be accessible at all times without having to remove other equipment. All exterior boxes shall be rated IP 55 or greater.

C. Conduit Interface

The open ends of conduit shall be provided with strain relief type fittings with extended rubber bushings, bell-mouth fittings, or insulated throat box connections as approved. All conduit entries into removable equipment boxes shall be secured by means of a bolt-on watertight access panel.

D. Covers

All junction box covers shall be retained by captive screws. All fasteners used in junction boxes shall be stainless steel. All covers shall be designed to accept or mate with a bulb-type clamp-on seal. Covers shall be grounded, either by hinge or ground strap(s).

E. Wireways

1. Wireways will be permitted in approved ceiling locations only. They will not be permitted in the car body sidewall area. Only conduit will be permitted in the car body.

2. All wireways shall be "Panduit", meeting PRIIA Specification 305-903, or of rigid steel with a coating to minimize the risk of oxidation and rust formation. The trays shall be adequately supported throughout their entire length in an approved manner. There shall be absolutely no sharp edges. The trays shall be completely de-burred before installation on the vehicles. Grommet clamps shall be provided at all locations where cables or wires enter or leave the wireways. Under no circumstances shall leads be draped over the edge of the wireways, with or without wireway edge protection.

3. Wireways shall be located to provide access to the harnesses contained within for maintenance action.

4. Bends in wireways shall be avoided; however, if they are required, approved protection shall be provided to avoid insulation chafing at the bends.

5. Wireways shall not contain more than 30 current-carrying conductors at any cross-section. The sum of the cross-sectional areas of all conductors contained at any cross-section of a wireway shall not exceed 40% of the interior cross-sectional area of the wireway.

6. All wire and cable shall be securely fastened within wireways to eliminate movement and resultant chafing.

18.27 Electrical and Electronic Designs

18.27.01 Reliability Standards

All electrical and electronic control systems shall be designed, and components shall be selected, using the *Reliability Design HandBook* No. RDH376 as a guide. All devices shall be derated to operate within the "Acceptable" region for electrical stress versus temperature for "Airborne Applications". If there is a conflict between guidelines given elsewhere in this Specification and the *Reliability Design HandBook*, the more restrictive condition shall govern. Other service-proven devices may be submitted for approval.

18.27.02 Ability to Repair

A. All electrical devices including such items as PC boards, relays, contactors, and filters shall be capable of being repaired by the Engineer in its electronics laboratory. It is recognized that some equipment, due to its complexity, cannot be economically repaired by the Engineer. In preliminary design reviews, the Builder shall identify all situations where this could be the case, for ruling by the Engineer, whose decision shall be final.

B. Units shall not be sealed, potted or constructed to prohibit repair by the Engineer. Units that must be potted or sealed by design other than Lowest Level Replaceable Units (LLRUs) shall have a minimum 10-year warranty.

18.27.03 Hardware

All hardware associated with electronic and electrical systems, including the case, heat sinks, mounting brackets, etc., shall be protected against moisture, oxidation and common airborne contaminants.

18.27.04 Wiring

Wire selection, routing and securement shall be accomplished with the goal of having the wire and cable last the life of the car body. All movement and chafing of wire and cable shall be eliminated. The use of

additional wear material(s) to extend life without elimination of the movement, wearing or chafing will not be permitted.

18.27.05 Optical Fibers

Any application of optical fibers shall be approved prior to implementation. This approval is not intended to discourage the use of optical fibers. Rather, it is to verify reliability and maintainability of the proposed application. In no case shall the on-car repair of an optical fiber require sophisticated or complex polishing and alignment. The connections between optical fibers and car-replaceable units shall be via approved "quick disconnects".

18.28 Electrical Devices and Hardware

18.28.01 General

All electrical devices shall be service-proven. Electrical connections shall use either captive screws or captive nuts, with crimp terminals.

18.28.02 Contactors and Relays

A. Contactors shall be defined as those devices, which control one kilowatt or more of electricity through their main contact tips. Unless specified, all contactors shall meet or exceed the requirements of PRIIA Specification 305-906, section 4.3-4.5.

B. Relays shall be defined as those devices which switch less than one kilowatt of electricity through their contacts. Unless specified, all relays shall meet or exceed the requirements of PRIIA Specification 305-906, section 4.3-4.5.

C. All contactor and relay coils shall be suppressed with a solid-state device to prevent transients being generated onto the low-voltage network.

D. All devices shall be satisfactorily tested for proper functioning in orientations up to 30° from the mounting plane as fitted in the vehicle. They shall be installed to be fully accessible for inspection, servicing, repair and ease of replacement. There shall be no more than two wires connected to any one terminal. Installation shall be such that, when required, arc spray is directed, by a non-asbestos arc chute, away from ground and adjacent electrical devices.

E. All devices shall be constructed and utilized in a fail-safe manner; that is, all failures shall be in a direction such that neither: the passengers, the crew, nor the equipment is placed at risk.

F. All magnetic devices shall be a heavy-duty type suitable for railroad service. They shall be constructed such that the main tips or contacts "make" and "break" with a wiping or rolling motion that minimizes build-up of deposits and/or pitting. Contact and/or tip replacement shall not exceed 5% of the total number during any annual inspection period.

G. Device contacts or tips shall not be placed in parallel to increase the total current load in excess of the rating for an individual contact or tip.

H. All devices shall be readily identifiable by means of a permanent, durable marking strip giving the device circuit designation. No identifications shall be obscured, or partially obscured, by wire routing. The identification strip shall be mounted adjacent to the mounting of said device.

I. Bifurcated contacts shall be used in low voltage applications whenever necessary due to dry contacts or low current switching requirements.

J. All time delay relays shall be of the R-C delay or solid-state type. No mechanical or pneumatic time delay devices will be permitted.

K. Where plug-in relays are approved, the relay shall be positively retained by means of a retaining clip or bar. This device shall be captive, of rugged construction and shall be easily positioned for relay installation and removal without the need for special tools. When the relay is removed, the retainer shall itself be retained so that it cannot come in contact with devices, which may have exposed energized electrical circuits, and it shall not interfere with the operation of any other device when in this position.

18.28.03 Switches

A. Switches are defined as those manually operated devices that control less than one kilowatt of electrical power through their contacts. Unless otherwise specified, switches shall meet the requirements of MIL-S-3950. Toggle and push button switches shall be per MIL-S-3950, MIL-S-8805, MIL-S-83731 or equal, as approved by the Engineer. All switches provided shall be of high quality and shall be fully suitable for the rigors of the Engineer's service environment, including cycle life. The design and selection of all switches shall be subject to review and approval.

B. Switches shall be provided with a "keying" feature such that after installation, the body of the switch will be constrained from mechanical rotation.

C. Under no circumstances shall poles of switches be placed in parallel in order to carry currents in excess of the contact pole rating given by the manufacturer.

D. There shall be a maximum of two wires connected to each terminal of the device.

E. Switches shall be individually replaceable without disconnecting or removing anything other than the mounting fasteners and electrical connections of the switch to be replaced.

F. All control switches, which are subject to water splash, which is defined to mean any switches mounted near windows or doors, or mounted on the Operator's control console, shall be environmentally sealed.

18.28.04 Circuit Breakers

A. All circuit breakers provided shall be extremely rugged and fully suitable for the service intended. They shall meet the requirements of Amtrak Specification 498, section 4.4. Design and selection of all circuit breakers not available within the Engineer's material control system shall be subject to review and approval.

B. The continuous current rating of thermal-magnetic trip circuit breakers shall be selected in accordance with ANSI C37.16 for the load and type of service specified. All thermal-magnetic trip circuit breakers shall conform to the requirements of ANSI C37.13 and ANSI C37.14.

C. All circuit breakers of the same rating shall be of the same manufacture and model throughout the vehicle. Circuit breaker current rating shall be clearly and permanently marked and shall be completely visible after installation.

D. The ON, OFF and TRIPPED positions of all circuit breakers shall be permanently marked on the handle or the case of the circuit breaker. The circuit breaker, when tripped, shall assume a distinct position between the ON and OFF positions to permit determination of the fact that it has been tripped by either its overcurrent or shunt trip elements.

E. Circuit breakers shall be individually replaceable without disconnecting or removing anything other than the mounting fasteners and electrical connections of the breaker to be replaced.

F. Each and every input power circuit shall be protected by an individual circuit breaker. Separate circuit breakers shall be provided for major assemblies or functions. No circuit breaker shall protect more than one circuit, nor shall any one circuit be protected by more than one circuit breaker. Circuit breaker terminals shall not be used as junction points.

G. All circuit breakers shall be sized by current rating and tripping time to protect both the associated equipment and the minimum size wire used for power distribution within the protected circuit without causing nuisance tripping. The thermal overloads of equipment shall not cycle as a means of interrupting the power circuit.

H. Each circuit breaker pole shall be equipped with adequate means of arc extinction to prevent flashover.

I. Circuit breakers shall not be intended for use as on/off switches. All circuits requiring on/off switches shall be so equipped.

18.28.05 Fuses

A. Circuit protection functions that can be performed by fuses shall normally be performed by appropriately rated circuit breakers. Fuses shall be used only where specifically called for in the Specification or where the use of circuit breakers is not technically feasible, and only with specific approval. Fuses may be considered in applications as follows:

   1. To protect solid-state equipment from catastrophic damage.

   2. Where current or voltage levels prohibit circuit breakers.

B. Fuses shall be permanently identified adjacent to the fuse, including functional name, fuse type and rating. The rating of each fuse shall be permanently and clearly marked directly on each fuse.

C. Fuses shall be readily accessible. All fuses mounted in exterior equipment boxes shall be accessible without going under the vehicle.

D. Fuse holders shall contain fuse retention devices at both ends.

E. Unless explicitly noted otherwise in this Specification, all fuse compartments shall have a spare fuse of identical size and rating for each "in-circuit" fuse and shall be mounted next to the respective "in-circuit" fuse with the fuse holder clearly marked SPARE FUSE. The spare fuse holder shall not be enclosed and shall not consist of any loose parts.

F. The use of current limit-type fuses is prohibited.

18.28.06 Bus Bars

A. Bus bars are to be fabricated from OFE (Oxygen Free Electronic) or ETP (Electrolytic Tough Pitch) copper (CDA 101). The bus bar conductivity shall be 100% IACS. All bus bar joints shall be silver or tin plated.

B. Current densities, other than at joints, shall not exceed 1000 amperes per square inch, and in any case shall not exceed a value which would cause a bus bar temperature rise greater than 86°F (30°C). Current densities in joints shall not exceed 150 amperes per square inch.

C. Bus bars shall be properly brazed together at joints unless bolted connections are found to be absolutely necessary for maintenance purposes and are approved. The overlap at bus bar joints shall be no less than 10 times the thickness of the bus material. Bus bar connection bolts shall be torqued to obtain a uniform bus bar connection pressure of 200 psi (1,380 kPa). Bolting hardware shall be plated steel with Belleville washers to maintain connection pressure.

D. Except for connection areas, bus bars shall be safety insulated, using a high-dielectric, powder coating or other approved means. Tape will not be acceptable. Bus bars that are behind insulating panels will be exempt from this requirement.

18.28.07 Capacitors and Resistors

A. Dry tantalum capacitors shall be used in place of aluminum electrolytics, except for high values which are not commercially practical or available, in which case long life grade aluminum electrolytics shall be used. Dry tantalum capacitors shall be in hermetically sealed metal cases, except for surface mounted types when hermetically sealed metal cases are not available.

B. Commutating capacitors shall be a paper or plastic film type, shall incorporate a non-toxic impregnate, and shall be chosen to give a service life of at least 20 years. Filter capacitors shall have high ripple current rating for long life.

C. Capacitors shall be derated 20% for voltage based on the nominal supply voltage and maximum case temperature. If filter capacitors are exposed to low ripple voltages, lesser values of derating may be accepted if it can be shown that reduced operating temperatures can be achieved due to lower dissipation; however, the sum of the dc and ac ripple voltages shall always be less than the capacitor's voltage rating at a maximum case temperature of 185°F (85°C).

D. All resistors shall be operated at less than 50% of their rated maximum power dissipation. Other power resistor applications may be submitted for approval of lower derating, on a case-by-case basis.

E. Use of trim potentiometers or adjustable resistors shall not be permitted without Engineer approval. Generally, the need for adjustments shall be avoided by use of the appropriate circuitry, and stable precision components.

18.28.08 Transformers and Inductors

Transformers and inductors shall be manufactured through a Vacuum Pressure Impregnation (VPI) process, rated to withstand twice the applicable peak-to-peak voltage.

18.28.09 Switch, Circuit Breaker and Fuse Panels

A. All switch, circuit breaker and fuse panels shall conform to IEC 60077.

B. Each switch and circuit breaker panel shall carry the necessary apparatus, arranged to be easily accessible to connections and designed to prevent operating or maintenance personnel from coming in contact with live parts when operating the switches or circuit breakers. All live portions of the protected circuitry shall be completely concealed so that no danger of electrocution or shock exists from the touching of the panel or any appurtenances or devices mounted thereto.

C. All switches, breakers, fuses, and indicating lights shall be provided with a nameplate of raised or recessed lettering on the dead front, clearly identifying the circuit which each control and its circuit designation. The dead front panel shall conform to NFPA No. 70, Article 384. A wiring gutter shall be provided along the top, sides and bottom, for the routing of high voltage leads to their designated circuit breakers.

D. The panel shall be secured by approved, captive fasteners and shall be configured for easy removal so that maintenance and repair action is not impeded.

E. Power distribution to circuit breakers and switches shall be from a bus bar or bus circuit. Distributing power by successive or "daisy-chained" connections between device terminals will not be permitted.

18.28.10 Battery Backup Circuits

Any device provided that requires a backup battery must be designed with a five-year battery life unless specifically approved by the Engineer. A list of batteries shall be provided for review and approval by the Engineer.

18.29 Semiconductor Standards

18.29.01 General

A. Semiconductors shall be selected to withstand all continuous and transient voltage and power demands present in the circuit application without damage or reduction in life. All circuit designs shall provide for the presence of high current switching equipment on the vehicle and the resultant induced voltages and currents in electrical equipment.

B. All transistors and diodes shall be silicon devices that meet or exceed the specifications of all of the original equipment devices; and shall secure proper operation over the full dynamic range for which each circuit shall be designed. Alternatively, semiconductor numbers traceable to the manufacturer and component characteristics shall be included in the maintenance and spare parts manuals.

18.29.02 Rating

A. Discrete semi-conductors shall have the following minimum voltage breakdown rating, dependent on the use:

1. Transistors and thyristors operated from the nominal battery supply, or those connected to trainlines, shall have minimum breakdown ratings of four times the maximum circuit rating. Suppression devices shall be provided as necessary to protect the devices and limit the circuit voltage.

2. Diodes operated from the nominal battery supply, used as suppression devices, or those connected to trainlines shall have a minimum Peak Inverse-Voltage rating (PIV) of 1000V.

3. All discrete semiconductors operated in inverters or other isolating devices shall have minimum breakdown ratings of two times the maximum circuit voltage (except where specifically detailed otherwise). Suppression shall be provided, as necessary, to protect the devices and maintain the circuit voltage and current operating conditions within all limits specified by the semiconductor manufacturer.

4. All diodes, transistors and thyristors shall have a PIV rating of at least twice the maximum normal operating voltage but in no case less than 800V. This requirement shall not apply to circuits operating from an isolated power supply and whose wires and circuits shall be kept physically separate from battery-supplied wires and circuits by at least one-half inch.

B. Semiconductors shall be placed in a clean and ventilated environment which shall favor easy replacement.

C. All semiconductor junction temperatures shall be limited to 302°F (150°C) (or to the maximum rated temperature for the device, whichever is less) or less at maximum ambient temperature and at maximum rated output power.

D. All semiconductors shall be operated at less than 50% of the maximum continuous current rating or maximum continuous power rating, whichever is more restrictive.

E. Integrated circuits operated from the battery supply through inverters or other isolating devices shall be operated within the voltage and current ratings specified by the manufacturer, derated to less

than 50% of the maximum stress level at the maximum operating temperature of the device as specified by the manufacturer.

F. Where the supplies to integrated circuits are regulated and surge protected, the voltage rating shall be 15% below the manufacturer's recommended maximum. In addition, the maximum power shall be limited to 50% of the manufacturer's specified maximum at the maximum operating temperature.

G. Integrated circuits shall be soldered into the printed circuit board; plug-in connectors are not permitted.

H. All gallium arsenide and similar optical semi-conductors shall be rated for operation over the temperature range of -40°F (-40°C) to +183°F (85°C).

I. All semiconductors shall be rated "industrial or automotive grade" for reliable operation over the temperature range of -40°F (-40°C) to +185°F (85°C), except for discrete power semiconductors (>=1 Watt) which shall be rated for temperature range of -67°F (-55°C) to +257°F (125°C). Exceptions shall not be taken without proper identification and written authorization from the Engineer prior to first article tests.

J. All suppliers of semiconductors shall be selected according to a recognized standard such as ISO-9002 Section 4.6 or better. Exceptions shall not be taken to the above provisions without proper identification and written authorization from the Engineer prior to the first article inspection.

18.29.03 Availability and JEDEC Registration

A. All thyristors, transistors and diodes shall be JEDEC registered and numbered, and must be available from at least two different manufacturers. Non-JEDEC registered devices carrying more than 10 amps may be used provided that the Contractor obtains prior approval based on submission of each item's completed procurement specifications and evidence of availability from two or more manufacturers based on those specifications.

B. All semiconductors shall be available from at least two manufacturers and available from U.S. distributors. Single source devices, such as high voltage power devices, microprocessors, ASICs and related support chips may be used only if approved. Such devices shall be essential to the proposed equipment, shall meet the service-proven requirements and shall be supplied by veteran manufacturers likely to support the device.

18.29.04 Burn-in

Either all integrated circuits shall be burned-in and screened for defects to MIL-STD-883G, Method 5004, Reliability Class B or all units shall be 24 hours burned in according to an approved process and re-inspected for defects. The records must be maintained for review by the Engineer's inspectors.

18.30 Printed Circuit Board Standards

18.30.01 General

A. Printed circuit boards shall be designed, constructed and inspected to MIL-STD-275, unless more stringent requirements are noted here. Traces shall be made as wide as practical, with the minimum width being based on a 50°F (10°C) temperature rise. Run spacing shall conform to MIL-STD-275.

B. Circuit board material shall be per MIL-P-13949, with a minimum thickness of 0.06 in. (1.52 mm) using type GB or GH base material. Type GE material may be used for boards which have no components whose power dissipation is greater than two watts and when said board is not mounted adjacent to components dissipating greater than two watts. The copper laminate shall be firmly

attached to the board and shall be resistant to blistering and peeling when heated with a soldering iron.

C. Components with pins shall be mounted only on one side. Connections shall be made to the other side or internal layers via plated through holes. Surface mounted components may be mounted on both sides if part of an approved existing design.

D. All circuit boards shall be inherently stiff or shall be reinforced to prevent damage due to vibration or handling. Unless otherwise approved circuit boards larger than 100 in^2 (64,516 mm^2) shall be centrally stiffened.

E. All equipment shall be designed using stable, high tolerance components to eliminate the need for adjustments. Compensation for manufacturing tolerances may be made through parallel precision resistors. All replacement printed circuit boards shall be directly interchangeable without any additional adjustments.

F. All printed circuit boards shall be of the "plug-in" type, with positive support against vibration, except where approved otherwise.

G. Not more than one PC board shall be stacked on each PC card.

H. Printed circuit board connectors shall be heavy duty, high reliability, and proven in prior successful rail service. All printed circuit boards shall plug into keyed sockets. Contact fingers and edge connectors shall have 0.00005 in. (0.00127 mm) thick gold plating.

18.30.02 Marking

A. All circuit boards shall be labeled with a part number, serial number and descriptive nomenclature.

B. All components shall be labeled on the board with component drawing references and such other information as may be required to repair and troubleshoot the board. The component and wiring sides of the board shall each be marked to indicate capacitor and diode polarity, and at least two leads or one lead and a graphic symbol indicating orientation of all transistors and thyristors.

C. Integrated circuits and other multi-terminal devices shall have an index mark on the component side of the board, visible with the component inserted, to indicate proper keying and insertion; the first pin on all integrated circuits packages shall be identified on the wiring side of the board.

D. For boards whose component density is greater than 2.25 components/in^2 (0.35 components/cm^2), the Contractor may submit an alternate marking plan for possible approval. Such a plan should include board marking, augmented by layout drawings.

18.30.03 Component Mounting

Components shall be fastened to the board in such a manner as to withstand repeated exposure to shock and vibration. Large components shall be supported in addition to the solder connections. Power resistors shall be mounted on standoffs so that the resistor bodies do not contact the board, spaced far enough away from the board so that resistor-produced heat will not discolor or damage the board or adjacent wires or components.

18.30.04 IC and Device Sockets

IC and device sockets shall comply with MIL-S-83502 and MIL-S-83734, as is applicable for the device.

18.30.05 Conformal Coating

A. Both sides of the assembled printed circuit boards shall be coated with a clear insulating and protective coating material conforming to MIL-I-46058C or approved equal.

B. The coating shall be easily removed with a brush-applied solvent or penetrated by a hot soldering iron when a component must be unsoldered. The coating solvent shall not adversely affect board-mounted components.

C. All IC sockets, connectors and test points shall be masked when the coating is applied.

18.30.06 Keying

All printed-circuit boards shall be "keyed" to prevent insertion into the wrong socket. Further, circuit boards in safety related control systems, such as friction brakes, cab signal, and systems which can cause damage or unsafe train operation if the vehicle is operated with a card removed, shall be connected through a safety circuit or checked through an auto test to disable the vehicle if a circuit board is removed.

18.30.07 Circuit Board Connectors

A. Printed circuit board connectors shall be heavy duty, high reliability, two-part type with a history of successful service in rail applications and shall be approved by the Engineer prior to commencing design. [CDRL 18-029]

B. Connectors which comply with MIL-C-55302, and which have plated contacts as described below, are considered to comply with the requirements of this section.

C. The connector contact area shall be plated with a minimum of 0.00005 in. (0.00127 mm) of gold over a minimum of 0.00005 in. (0.00127 mm) of low stress nickel.

D. Card edge connectors are prohibited.

E. All connectors within one panel assembly shall be keyed to prevent damage or malfunction due to incorrect insertion.

18.30.08 Testing

A. Sufficient clearance shall be provided between components to allow testing, removal and replacement without difficulty due to lack of space.

B. Test points shall be provided in appropriate locations on modules and printed circuit boards. A negative return test point shall also be provided. The test points shall either accept and hold a standard 0.08 in. (2.03 mm) diameter tip plug or shall be a turret lug similar to Cambion No. 160-1026-01-05, or approved equal, with sufficient clearance to permit it to accept a standard oscilloscope probe clip, and shall be identified by appropriate markings.

C. When test points are not suitable, as for complex circuits or micro-processor-based control system, self-diagnostic routines and/or special test equipment may be used to identify the failed Lowest Replaceable Unit.

18.30.09 Plated-Through Holes

A. In addition to the general guidelines of the Institute of Printed Circuits (IPC), the following requirements shall be met:

1. Plating Holes - Copper plate shall be a minimum of 0.001 in. (0.025 mm) minimum average thickness, and 0.003 in. (0.076 mm) maximum average thickness. Solder plates shall be 0.0003 in. (0.0076 mm) minimum average thickness and 0.0015 in. (0.038 mm) maximum average thickness.

2. Plated Hole Defects - No more than three voids per hole will be acceptable. Total area of the voids shall not exceed 10% of the total wall area. The largest void dimension shall not exceed 25% of

the core diameter or the board thickness, whichever is smaller. There shall be no pits, voids or cracks at the junction of the whole wall and terminal area to a depth of 1-1/2 times the total copper thickness on the surface.

3. Enclosures

B. All circuit boards that are rack mounted shall plug into racks containing the mating half of the circuit board connector. The circuit board rack shall mount in an enclosure conforming to requirements in this document. The rack, circuit board and circuit board hardware shall be designed as an integrated system.

C. The rack and enclosure shall provide environmental and EMI shielding necessary to meet the requirements of this Specification.

D. Printed circuit boards shall be positively retained by means of keeper bars or other approved method. The enclosure or rack cover shall not be used to retain the circuit boards.

E. Each circuit board shall be fitted with an ejector or hand grip to assist in board removal. The rack and the edge of each board, or the card ejector, shall be labeled with corresponding numbers to identify board location within the enclosure.

18.30.10 Extenders

Printed circuit board extenders (six sets of each type) shall be provided by the Contractor for test purposes. At least two extenders of each type shall be available for use and evaluation throughout the design conformance and acceptance test programs.

18.31 Auxiliary AC Motors

Motors shall limit starting current to within industry recommended practices and be equipped with NEMA C-frame type sealed bearings that shall not require re-lubrication for the life of the bearing. Bearings shall be sized to provide a minimum life of 6 years. Any motor mounted with the shaft vertical shall have bearings suitable for this type of application. Any motor which is exposed to weather shall be a type specifically designed for the environment. Any motor with a vertical shaft and subject to the weather shall include a moisture seal on the shaft to prevent water from entering the bearings.

18.32 Recyclable Materials

Expendable items that are recyclable shall be identified with the appropriate symbols, as defined by the Society of the Plastics Industry, permanently imbedded in the material.

18.33 Contract Deliverable Requirements List

CDRL #	Title	Car Type
18-001	Material Safety Data Sheet (MSDS)	All
18-002	Joining and Fastening Plan	All
18-003	Dissimilar Metals Report	All
18-004	Mill Reports	All
18-005	Mill Reports	All
18-006	Allowable Stresses	All
18-007	Axles	All
18-008	Wheels	All
18-009	Visual Inspection Criteria for Laminated Glazing	All
18-010	Color and Marbling Variation Tolerances	All
18-011	Honeycomb Panel Test Results	All
18-012	Seat Samples	All
18-013	Countertop/Workstation Surface Color and Pattern Samples	All
18-014	Special Welding Procedures	All
18-015	Exterior Marking Films and Graphics Materials	All
18-016	Additional Locations Requiring Retro-Reflective Material	All
18-017	Paint Coating and Application Document and Paint Schedule	All
18-018	Flammability and Smoke Emissions Test Results	All
18-019	Flammability and Smoke Emissions Matrix	All
18-020	Water Piping and Fittings Sanitizing Procedure	All
18-021	FRP Certificates	All
18-022	Thermoplastic Sheet Certificates	All
18-023	Wiring and Cable Installation Procedure	All
18-024	Wiring Plan	All
18-025	Integrated Schematics Manual with Wire Codes and Device Identification	All
18-026	Proposed Design and Product Line for All Wire Connections	All
18-027	Conduit Arrangement and Installation	All
18-028	Proposed Conduit Fittings and Junction Boxes	All
18-029	Printed Circuit Board Connectors	All

* End of Chapter 18 *

Technical Specification

CTDOT Single-Level Passenger Rail Cars

Chapter 19

Test Requirements

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19.00 Test Requirements

19.01 Overview

A. As part of the production of the cars under this Contract, the Contractor shall be responsible for a comprehensive series of tests to be performed to verify both the suitability of design and workmanship of each car. The Contractor is also responsible to fulfill all requirements called for by the Federal Railroad Administration (FRA) for testing passenger equipment per the applicable requirements of 49 CFR Part 238.111(b) for Tier I equipment, for submission by the Engineer to the FRA. The tests and any required adjustments to be performed are grouped into four classifications: Material Certification, Proof of Design, Production and Acceptance. Whenever test requirements overlap, the more comprehensive shall govern. The Contractor shall perform all tests under Engineer observation, and the FRA may also observe such tests. All contractual tests shall be conducted in accordance with Engineer-approved test procedures. Testing activity scheduled and/or conducted before test procedure approval will be at the Contractor's risk.

B. Material Certification Tests consist of all tests required to certify that the materials used in the manufacture of the rail cars meet the performance and behavior requirements of this contract, the manufacturer's specifications, all applicable industry standards, and Federal requirements. A full listing of the material certification tests shall be included in the Master Test Plan, and the certifications and test results shall be submitted to the Engineer for review and approval. All material samples used for certification testing shall be scrapped upon the conclusion of testing and shall not be used in the manufacture of the cars.

C. Proof of Design Tests are those tests conducted on the systems and components to validate the design of the cars, to confirm that the systems and components function as intended and in accordance with specifications, and to ensure that no unintended or undesirable consequences are encountered during production or operation of the cars. Proof-of-design tests shall be conducted on all major systems and components prior to release of the first cars of each type, and as necessary during production in the event of a design change or component substitution.

D. Production Tests consists of all component, system and car tests to be performed on each production car to ensure that each car meets all functional, operational and workmanship requirements and standards, and that any production errors or nonconforming materials or components are revealed and corrected prior to the vehicle being released from the Contractor's facility. These tests comprise component-level testing at the supplier's facility, and system-level testing at the Contractor's facility during and at the completion of production to demonstrate conformance with Technical Specification and baseline configuration requirements prior to delivery.

E. Acceptance Tests consist of production car tests to be performed on each car by the Contractor after delivery of each car to the Contractor's field site or Engineer's facilities to demonstrate conformance with the Technical Specifications, to ensure that no system functionality was lost during shipment and transit of the vehicle, and as a condition for Acceptance.

19.02 General Requirements

A. The Contractor is required to perform all tests as specified herein. The Contractor and its subcontractors may, at their option, perform additional testing as they deem necessary as part of the quality assurance program. Unless indicated otherwise, all costs associated with any of the tests performed are to be borne by the Contractor. In the event of a failure to meet the Technical Specification requirements in any test, necessary corrections shall be made by the Contractor at its expense, and the failed test shall be rerun in its entirety at the Contractor's expense. If further corrections or modifications affecting the item under test are instituted, the Contractor shall perform

a complete retest at its expense to demonstrate compliance with the Technical Specification requirements. The Contractor shall give at least 45 days' notice to the Engineer prior to the start of any test referred to herein. In the case of pre-revenue service tests per 49 CFR Part 238.111 (b) (2), 45 calendar days' notice shall be given to the Engineer in order to assure timely notification of the FRA.

B. Except as provided herein, the Engineer, at its own discretion, may allow the Contractor to furnish test reports which indicate that equipment furnished under this Contract is identical to equipment which has been previously tested for the same application and/or been successfully in identical service for at least five years and accept this as showing conformance with the requirements of this Technical Specification.

19.03 Test Plans and Reports

19.03.01 Master Test Plan

A. The Contractor shall submit to the Engineer for approval a master test plan covering all tests listed in or otherwise required by this Technical Specification. The master test plan shall be submitted to the Engineer for review and approval no later than 180 calendar days after Notice to Proceed (NTP). This document shall be updated monthly and presented as an attachment to the program meeting minutes. [CDRL 19-001]

B. The master test plan shall include, but is not limited to, all tests as required to be performed by the Contractor and suppliers:

1. Material certification tests;
2. Proof-of-design tests, including all required carshell, truck and suspension and ride quality tests;
3. Production tests; and
4. Acceptance tests.

C. It shall include a detailed schedule showing the sequence in which the test will be performed, and the time and place of each test to be performed. The plan shall be updated periodically, showing the status of each test procedure, test and associated report summarized in a spreadsheet format.

19.03.02 Test Procedures

A. The Contractor shall prepare a detailed test procedure for all tests required by this Specification and for all other tests to be conducted by the Contractor or its suppliers in connection with its own quality assurance program. [CDRL 19-002]

B. Tests procedures shall be submitted for approval in advance of the anticipated test dates as follows:

Supplier Qualification, Proof of Design and Production	No less than 60 days prior to start of testing
Contractor Qualification, Proof of Design Tests	No less than 60 days prior to start of testing
Contractor Production Tests	No less than 45 days prior to start of testing

C. All required testing shall be conducted in accordance with the Engineer-approved master test plan and approved test procedures.

D. The test procedures shall include the following information:

Title/Approval Page:	Includes the name of the test, test number, revision level, date, author, signature of engineer responsible for system, signature of personnel who reviewed and approved the test, etc.
Revision History:	Provides the history of changes made to the document, including description, not merely date.

Table of Contents:

1.0	Purpose	Identifies what the test is to accomplish.
2.0	Application	Identifies which car types/equipment is tested with this procedure.
3.0	References	Identifies any documents used as guidance for the test, such as APTA, FRA, ASTM, etc.
4.0	Definitions	Provides definitions of terms used in the test.
5.0	Prerequisites	Provides requirements of car condition before the test can be conducted, such as which tests must be successfully conducted before this test.
6.0	Equipment	Identifies test equipment and any other special requirements; lists instrument model numbers, calibration dates and serial numbers.
7.0	Initial Conditions	Identifies positions and/or state of all devices, controls and equipment.
8.0	Procedure	This is the actual test sequence. The test procedure shall identify pass/fail (or in some cases, intentional overload) criteria for each step in the procedure. Test data may be recorded within this section, or in a separate data section. The test procedure shall identify the conditions required for the performance of the test, including a sheet where test conditions can be recorded, such as voltage, current, resistance, time, etc. Each test performed shall be signed and dated by the technician performing the test.
9.0	Conclusion	Provides summary of the test findings, including vehicle number, date, test conducted, overall pass/fail, test technician signature, Engineer witness, etc.
10.0	Data Sheets	This is a form in which data is recorded, if it is not recorded within the body of the test. If data is recorded by instruments, such as strip chart format, etc., those results shall be attached here.

E. Each car and system shall be tested in exact accordance with the Engineer-approved revision of the test procedure. All test and inspection instruments shall be properly calibrated.

F. Should a system or component fail a test, the component or system shall be repaired or replaced and the test repeated from the beginning. The test shall not be restarted at the point at which the failure

occurred. The Engineer may, at its sole discretion, determine that portions of the failed test need not be repeated.

G. Each test shall be a separately controlled document and identified by its own number, title and revision. All revisions shall be submitted to the Engineer for approval. A history of test revisions and changes shall be maintained and recorded within the test document. All tests must be written in an instructional form describing the full activity of each test step, and written in duplex-numerical form (similar numbering system as seen in this specification). All special tools and/or equipment to be used must be specified within the test document. A data collection form shall be used with each procedure and shall be fully identified.

H. Each individual test shall be accompanied by a separate sheet where the test results are documented. Each step of the test requiring a specified result or measurement shall be included and identified by the duplex-numeric step number referenced in the test document. Areas shall be provided for recording actual values produced during the test where needed. In addition, acceptance criteria and associated tolerances shall also be shown in parenthesis near the space available for recording the actual value. The test number, revision and page number shall be shown on the header of each page or all test procedures. Areas shall also be allocated for the date, car number, component serial numbers (as applicable), test equipment serial numbers, verification of test equipment calibration, test status (accepted/rejected) and signature areas for the test technician, Contractor Quality Assurance (QA) representative and Engineer representative.

19.03.03 Testing Notification

In the case of pre-revenue service tests per 49 CFR Part 238.111(b)(2), the Contractor shall provide no less than 45 calendar days' notice to the Engineer in order to assure timely notification of the FRA. For other tests, each detailed test procedure shall be submitted to the Engineer for review far enough in advance of the planned test date to allow the Engineer at least 45 days to initially review and comment on, or approve the procedure, and still have sufficient time to allow the Contractor to modify a rejected procedure and resubmit to the Engineer, to have approval a minimum of three working days prior to any testing covered by the procedure. The Engineer shall witness all tests. Under no circumstances will the Engineer accept the results of a test performed without approved procedures.

19.03.04 Test Documentation

A. The Contractor shall be responsible to provide the Engineer with written test reports for all tests performed on the cars and their components, including supplier test reports. [CDRL 19-003]

B. Upon the completion of each test, the Contractor shall submit a written report of each test, including copies of all test data, to the Engineer for approval. In every case, the report shall include a description of the test, all raw data collected in the test, and a summary of the results in a form that can be directly compared to the Technical Specification without further calculations. A test shall not be considered as completed until the Engineer has approved its final written test report.

C. Should the test procedure or reports be inadequate and not meet the requirements of the Technical Specification of the FRA, the Engineer reserves the right to require additional plans, procedures, details, and schedules to satisfy itself that the test program or report is adequate and does meet FRA and Specification requirements. The approval of the Engineer does not in any way relieve the Contractor of responsibility for the adequacy of the test program within the scope of this technical specification.

D. Upon the completion of all required engineering tests associated with the pilot program, all copies of all test procedures, reports and approvals shall be copied and presented to the Engineer in a single volume. [CDRL 19-004]

E. All material certification and proof-of-design test procedures and reports shall be supplied by the Contractor in a separate binder and submitted to the Engineer for review and approval prior to acceptance of the first car of each type. The master test plan shall be included in this binder. Reports on all certification and proof of design tests plus the acceptance tests for the first car of each type shall be submitted and approved by the Engineer prior to acceptance of the first car of each type. [CDRL 19-005]

F. For production tests, which are performed on all cars or all components, a separate volume shall be submitted to the Engineer containing all approved tests applicable to individual cars. In the event a test is revised, the Contractor shall supply a copy of the test reflecting approved changes and the upgraded revision status to replace the existing test within this volume. The test reports required by this specification that are performed on all cars or all components shall be included in the vehicle history books. At the front of the test diction of the vehicle history book there shall be a test log. This test log shall be maintained by the Contractor during the equipment assembly. The test log shall have a place for a technician signature and date and will be signed when each test procedure has been completed. The test log shall be submitted to the Engineer for review before each car shall be released for shipment to the delivery site. [CDRL 19-006]

G. All Contractor and Engineer in process inspection sheets and test data records for that car shall be contained in this test log.

19.03.05 Car Acceptance Testing Facilities

The Contractor shall establish a site where completed cars may be shipped for acceptance testing and inspection. This site shall be within five miles of the Engineer's designated maintenance facility, or at another location as approved by the Engineer. The Contractor shall use this site to prepare cars for acceptance testing, and to perform modification or rework required on cars under its control prior to acceptance, as well as warranty work.

19.04 Material Certification Tests

All materials used in the production of the vehicles shall be tested to verify conformance with all applicable standards, regulations and specifications, and to ensure that the material performs as specified. At a minimum, the following materials shall undergo material certification testing:

A. All exterior glazing shall be certified to conform to 49 CFR Part 223 requirements.

B. All interior materials shall be certified to meet smoke, flame and toxicity requirements.

C. All subfloor panels shall be certified to meet strength and impact resistance requirements.

D. All stainless steel and carbon steel used in production of the carshell shall be certified to meet material strength, composition and performance characteristics.

E. All components used in the manufacture of truck, suspension and coupler assemblies shall be certified to meet all applicable strength, composition and performance requirements.

F. All insulation materials shall be certified to meet applicable insulation performance standards.

G. All interior and exterior emergency signage materials shall be certified to meet FRA emergency exit signage requirements.

H. All emergency power sources shall be certified to meet FRA emergency exit pathway.

I. All emergency equipment shall be certified to conform to all applicable FRA regulations and other requirements as necessary.

J. All exterior graphics components, including paint, decals and hardware, shall be certified to meet all applicable performance requirements including environmental and air quality requirements, durability in accordance with environmental and climatic conditions, and application in a railroad environment.

19.05 Proof-of-Design Tests

19.05.01 General

The Contractor shall develop a series of tests to evaluate the design of the carshell and each car system, subsystem and major component to verify that the performance requirements of the carshell structure, systems and components have been met, that the system and all component parts function as intended and within all specified parameters, and that no unintended or unanticipated functions, problems or non-conformances are discovered during production or operation of the cars. These tests shall validate the design of all systems and components as supplied by the Contractor and subcontractors, and prove that these designs are fully compliant with all applicable specifications, regulations and performance requirements. Proof-of-design tests shall be conducted on systems and components at the facilities of the Contractor or suppliers, or at other facilities as designated by the Contractor. The carshell and its primary structure shall undergo extensive proof-of-design testing to validate the structural strength, dimensional accuracy and performance of the carshell. Proof-of-design tests shall also be conducted on completed cars at the Contractor's facility, to ensure that the individual systems and components have been integrated to function as intended within the completed car or train, without unanticipated or undesirable effect or degradation of performance of other systems or components.

19.05.02 Carbody Structural Tests

A. General

1. Unless otherwise indicated, all references to APTA, FRA and other standards indicate applicability of the current versions of the standards, as of the date of the NTP.

2. The first representative cab carbody shall be tested by the Contractor to confirm that the FEA is sufficiently accurate to ensure that the carbody structure complies with this Specification. If there are no major structural differences between the car shell types and the test results are comparable with the FEA, a report proving such a case shall be submitted, along with the Final Stress Analysis Report, to the Engineer to review and approve only one cab car shell shall be tested. The tests shall be performed at an Engineer-approved facility. To be acceptable, the test facility must have documentation showing calibration of all instrumentation, have qualified personnel with experience in conducting similar tests, and have the necessary equipment, instrumentation and control equipment to conduct the test. The tests shall not begin until the carbody stress and energy absorption analyses have been submitted and approved by the Engineer.

3. The test carshell shall be completely inspected and any non-conformances corrected. All inspection, test, rework, repair and corrective action reports shall be available for review. Particular attention shall be given to recording flatness and straightness.

4. The test carshell shall be structurally complete, including all structural parts but excluding such items as exterior and interior trim, windows, doors, seats, lights, interior lining, or other parts that would obscure any structural member from view, or that would interfere with the performance of the test. The test shell shall have no paint, primer, sound damping coating, or insulation. The weight of under floor and above floor compartment-mounted equipment and

heavy roof-mounted equipment shall be simulated by equivalent weights at their respective CG locations. All structural tests shall be conducted on the same carshell. The carshell shall be weighed and the weight recorded, and the carbody camber test shall be conducted prior to installation of any test equipment. For the tests, the car shall be supported on the trucks or equivalent supports to allow longitudinal movement.

5. It is expected that all gauges and instruments shall have sufficient quality to prevent malfunction or signal loss during the test of record. All gauges and instruments shall be in current calibration and remain so for the duration of the test. The methods of calibration and time periods for recalibration shall be in accordance with the test laboratory's national standard or ISO standards. The laboratory shall have on file a current certification of calibration traceable to the laboratory's national standard or ISO standards.

6. The Contractor may conduct preliminary tests but must follow approved test procedures and make available upon request all preliminary testing results and data. All critical dimensions and flatness shall be verified after the Contractor tests and before the official test begins. The test of record is to be witnessed by the Engineer. A copy of all recorded data shall be given to the Engineer at the conclusion of each test.

7. Where practical, all gauges shall have an electric output suitable for recording on electronic (magnetic) media. A data acquisition system shall be provided to permanently record all gauge outputs at each load step. At the end of each load step, a printout of all strain gauge readings vs. predicted strains, in proper engineering units (micro-strains), and a plot of load vs. gauge reading for critical gauge locations, shall be given to the Engineer for review. The Contractor shall obtain recorded approval of the Engineer after every load step before proceeding with the next step. After reaching the maximum load step for each test, the Contractor shall supply the following in a tabulated format for review by the Engineer before removing the maximum load:

   a. Table of each strain gauge's type, designation number, reading, calculated rosette strain gauge readings, deflection gauge readings, load cell readings

   b. The predicted values for each item listed above

   c. The allowable limits for each item listed above

   d. The utilization for all items listed above

   e. The % difference between the predicted values and the actual values

   f. The table shall highlight which gauges have the highest utilization and the highest % difference

   g. Values for measured dial indicator deflections and % difference to electronic deflection gauges

   h. Date and time of record

   i. The % difference shall be calculated per the following for ease of symmetric graphing

$$IF \quad Actual \geq Predictable \qquad \%\, difference = \frac{Actual - Predicted}{Actual}(100)$$

$$IF \quad Predictable > Actual \qquad \%\, difference = \frac{Predicted - Actual}{Predicted}(100)$$

8. The Contractor shall not break down the test fixtures until the Engineer or his representative has reviewed and accepted all data.

9. The Contractor shall prepare a color photographic record of the test. This record shall include photographs of the car in each test fixture, installation and measure location of each strain gauge, repairs or modifications, deviations from the drawings, and any areas found to be non-compliant. The Contractor shall propose to the Engineer which tests shall be video recorded with a sound-equipped digital video camera or other suitable digital video equipment. At a minimum the coupler compression, end sill compression, and diagonal jacking test shall be proposed. All recordings taken during these tests shall become the property of the Engineer.

10. The Engineer reserves the right to test a second car of each type during the construction period. Should such a test be ordered, it shall be at the expense of the Engineer unless such tests prove the design is non-compliant in any structural area, in which case, the Contractor shall be responsible for the test expense and for all of the Engineer's costs, and the cost of modifications necessary for the car and all other cars to be made compliant with the Specification. The Contractor (at its expense) shall also perform a complete set of structural tests to qualify the modified car.

B. Test procedures

1. A procedure shall be prepared for each test. In addition to meeting the requirements of section 19.3.2, the procedure shall include a description of the test, its purpose, how and with what equipment the specimen is to be loaded and the load increments, the type and location of strain gauges, the location of deflection gauges, a complete description of all fixtures, instruments and gauges, pass/fail criteria, and a detailed description of the data acquisition system. Annotated copies of catalogue cuts may be used to provide parts of the description. An explanation of the accuracy of the instrumentation shall be provided. Drawings and sketches shall be included to detail strain gauge locations, fixture details, test layout with all specimen, tools, and equipment. The test procedure shall provide a step by step instruction describing how the load is to be applied, the load at each step, when data is to be recorded, a space for the date, time, and signature of the test supervisor and a space for recording the authorization to proceed obtained from the Engineer or their representative. Test procedures shall be submitted not less than 60 days in advance of the proposed test date; approvals of the test procedure and final stress analysis report are prerequisites for the start of testing.

2. The test procedure shall include a copy of the current calibration certification for each instrument and gauge to be used for the test. Typical logging sheets, print-outs, plotting forms and examples of any other data sheets for the test or in the final report shall also be submitted as part of the test procedure.

C. Strain gauges

1. A minimum of 200 strain gauges shall be applied to the car structure for each of the compression, vertical load and diagonal jacking tests. Some gauges may be used for more than one test if their location on the structure is appropriate for other tests, but readings from at least 200 strain gauges in locations shall be obtained for each test. The location of the strain gauges shall be based on the Contractor's experience, the stress analysis and the Engineer's recommendations.

2. In order to appraise the stress distribution in the carbody at these cross sections, there shall be no less than three locations where there are a sufficient number of gauges to encircle the carbody. One location shall be outboard of the bolster, one shall be at the quarter-point between the truck centers and one shall be at the center of the car. Gauges shall be placed, for example, on all four sides of the side sill and body sills, on the side framing, along the cant rail, on the cross members, and at the center line of the car.

3. For each post load test, there shall be a minimum of 100 strain gauges applied to the post and car structure in the vicinity of the post. Some of the gauges may be for more than one test if their location on the structure is appropriate for other tests, but readings from at least 100 strain gauges in locations where the stress may be critical shall be obtained for each test.

4. Drawings, sketches, and a 3D model showing the location of each strain gauge shall be prepared by the Contractor and submitted for approval as part of the test procedure. The drawings shall dimension the location of each gauge, showing their orientation, distances from edges, connections, and bends. Their locations on the upper or lower, inner or outer surface shall be noted on these drawings.

5. The strain gauges shall be bonded resistance (SR-4) type or other approved gauges suitable for the application. The gauges shall be calibrated and applied in accordance with the manufacturer's instructions for the material being measured. The gauges shall be compensated for temperature. The strain gauges shall be shunted at the sensor by a precision resistor immediately prior to the commencement of the test of record, at the request of the Engineer, and anytime a gauge is added, removed, or altered.

D. Deflection gauges

1. Vertical deflection of the carbody shall be measured along both side sills at each load step during all tests. At least 11 gauges per side shall be used. Gauges shall be located at the end sills, at the bolsters, and at the mid-point between the bolsters. The remaining gauges shall be evenly spaced between the five locations. Measurements shall be taken to the nearest 0.01 in. (0.25 mm), and the deflections shall be considered as the average of the readings recorded on both sides of the car.

2. To measure the longitudinal deflection of the car during compression testing, additional deflection gauges shall be applied at the end sill, near the ram, and at the opposite end sill, near the reaction.

3. For the diagonal jacking test, additional deflection gauges shall be applied at all four jacking points.

4. During the vertical load test, the change in carbody width due to bending shall be measured and recorded at the belt rail in the center of the car. Two deflection gauges shall be applied in a minimum of one of the side door openings closest to the center of the car and in one of each other unique door openings to measure the change in the diagonal dimensions of the opening during the test.

5. To measure the bending of the collision and corner posts during the post tests, deflection gauges shall be applied at a minimum of seven locations on each post being tested: top, bottom, middle, load application point, between the load application point and the bottom, between the load application point and the center, and between the center and the top. These gauges shall be mounted to measure the deflection of the post in the direction of the applied force.

6. Deflection gauges shall be mounted on rigid stands separate from the carbody and its fixtures. The contact surface on the car shall have a smooth, polished, low- friction surface plate mounted perpendicular to the axis of the deflection gauge. If, during a test, the deflection gauge is struck by a technician or equipment, moves off of this surface plate, or contacts the test carshell or the fixtures, the test shall be terminated. The gauges shall be readjusted, and the test repeated from the beginning.

7. The deflection gauges shall have electrical outputs compatible with the data logging apparatus used with the strain gauges. All deflections shall be recorded simultaneously with the strain gauge recordings.

8. In addition to the above electronic recordings, dial indicators (mechanical) of sufficient stroke shall be employed. Two shall measure the vertical deflection at the center of both side sills during all tests. During the compression tests, dial indicators shall be employed to measure the longitudinal deflection at the end sill next to the ram and next to the reaction at the opposite end of the car. These dial indicators shall be read and manually recorded at the maximum load step. The percentage difference between the electronic gauges and dial indicators shall be calculated and recorded for review by the Engineer. Significant difference may warrant termination of testing for equipment inspection and correction.

9. All deflection gauges shall have sufficient stroke capacity to measure the maximum deflection expected in the test without the need for resetting any gauge during the test.

E. Load cells

1. In order to verify the accuracy of the applied loads and reactions, load cells shall be provided at the appropriate locations for each test. Each load cell shall be calibrated to 1.0% accuracy and certified within one year before commencement of the tests over the full range of 1.5 times the maximum load to which the load cell will be subjected during these tests. The Contractor shall provide records of calibration results prior to commencing these tests. The load cells shall have electrical outputs compatible with the data logging apparatus used with the strain gauges. All loads shall be recorded simultaneously with the strain gauge recordings.

2. Load cells shall be placed at the end of the ram and at the reaction point for the compression test. A load cell shall be placed at each secondary spring location for the vertical test and at each ram if the load is applied hydraulically. A load cell shall be placed at each jack location for the diagonal jacking test. A load cell shall be placed at the end of the ram for each post-test. Load cell readings shall be taken and recorded at each step of load application and removal process.

F. Equipment Validation

In addition to equipment and instrumentation calibrations, the Contractor shall perform the following verifications with the same fixturing, equipment, gauges, and data acquisition systems to be used during the test of record. The tests shall be done within 60 days of the test of record and shall be presented to the Engineer to ensure minimal margin of error within the testing set up.

1. Buff load cell verification

The Contractor shall apply 80% of the buff load directly from the primary buff load cell into the reaction load cell without any structure or fixturing between the two load cells.

2. Strain Gauge and Data Acquisition Setup Verification

The Contractor shall apply a minimum of 9 strain gauges to a simple beam with a cross section resulting in a minimum moment of inertia of 0.1 in^4. A load resulting in 80% of the materials yield strength at one of the strain gauge's location shall be applied and the resultant stress in all strain gauges measured. The results be used to calculate the percentage difference with predicted values from an FEA analysis using the same software and setup as used for the carbody testing.

G. Vertical load test

1. Test description

a. The carbody supported on trucks or simulation thereof, shall be subjected to a vertical load test. The instrumented carshell shall be loaded to simulate ready-to-run weight. A test load, equal to the AW3 loading conditions shall be applied to the car in four equal steps, resulting in a total of five vertical load increments. The test load may be applied by means of weights

or jacks but shall be distributed in proportion to the distribution of weight in the furnished car. The specimen shall be unloaded in the increments in which it was loaded. Strain gauge, deflection and load cell readings shall be taken at each load increment.

b. Post-test, the door diagonal deflection measurements will be jointly reviewed by the car builder and door system supplier to ensure and document that all door systems offers full functionality and performance under these deflected conditions.

c. As an alternate to the above, the Contractor may propose a physical test under which the performance of the door system under loaded conditions (five vertical load increments) can be verified.

2. Test criteria

The car shall be considered compliant with this Specification if all of the following conditions are met:

a. Stresses are in accordance with the requirements of APTA Standard PR-CS-S-034-99 Revision 2.

b. Vertical deflection readings plotted against load do not vary by more than ± 5% from a straight line (linear) deflection curve, with one end point at the origin (no load) and the other at that point which represents the measured deflection for maximum vertical load.

c. Strain readings plotted against load do not vary by more than ± 5% from a straight line (linear) deflection curve, with one end point at the origin (no load) and the other at the point which represents the measured deflection at maximum load.

d. Maximum stresses calculated from strain readings, and calculated stresses from structure only, in any structural element do not exceed the allowable stresses approved prior to starting the test program as part of the stress analysis.

e. Recorded residual vertical deflection between bolsters following removal of the maximum vertical test loading does not exceed 0.04 in. (1 mm).

f. Recorded residual car transverse width and/or opening diagonal dimensions following removal of the maximum vertical test load do not exceed 0.01 in. (0.25 mm).

g. Indicated residual strains at strain gauges on principal structural elements following removal of the maximum vertical loading do not exceed the maximum error resulting from the accuracy of the instrumentation.

h. Carbody deflection, as measured during the vertical load tests under a load equal to the passenger load of AW3, is not more than the design camber in the side sill at any point between the carbody bolsters.

i. Door operation is normal, including normally expected cycle times.

j. There are no permanent deformations, warping fractures, cracks or separations in the car structure. Broken welds resulting from the test are to be inspected jointly by the Contractor and Engineer to determine if the failure is the result of weld quality or stress.

H. End sill compression load test

1. Test description

a. A compression test load as defined in APTA Standard PR-CS-S-034-99 Revision 2 is to be applied to the end sill assembly in the underframe of the test specimen by means of a ram. This load shall be applied horizontally at the horizontal centerline of the carbody.

b. During the compression test, the carshell shall be supported on trucks or simulations thereof to allow free longitudinal movement. The carshell shall be loaded with sufficient dead weight to bring the total body weight of the test specimen to that of an AW0 loaded car. This loading shall be distributed in proportion to the distribution of weight in the finished car.

c. The compression test load shall be applied by means of a controlled hydraulic ram, and the force measured by a means independent of those producing the force. The force shall be measured at the ram and at the reaction at the opposite end of the car. The ram shall be supported at the car end, but shall remain free to move longitudinally with respect to the car end.

2. Test criteria

The car shall be compliant with this Specification if all of the following conditions are met:

a. Stresses are in accordance with the requirements of APTA Standard PR-CS-S-034-99 Revision 2.

b. The vertical deflection of each side of the test structure is within ± 10% of the value determined by the analysis.

c. The force measured at the reaction load cell is within 1.0% of the force applied at the ram.

d. Maximum stresses calculated from strain readings, and calculated stresses from structure only, in any structural element do not exceed the allowable stresses approved prior to starting the test program as part of the stress analysis.

e. Indicated residual strains at strain gauges on principal structural elements following removal of the maximum vertical loading do not exceed the maximum error resulting from the accuracy of the instrumentation.

f. There are no permanent deformations, warping fractures, cracks or separations in the car structure. Broken welds are to be jointly inspected by the Contractor and Engineer to determine if the failure is the result of weld quality or stress.

I. Compression load test at the draft stop

1. Test description

a. A compression test load of 800,000 lbs (363,200 kg) shall be applied to the rear draft stop in the draft gear housing. This load shall be applied at the car transverse centerline and vertically at centerline of shaft. No allowance shall be made for the camber of the carbody.

b. A fixture, which simulates the regular draft gear and carrier, shall be installed. During the compression test, the carshell shall be supported on trucks, or a simulation thereof to allow free longitudinal movement. The carshell shall be loaded with sufficient dead weight to bring the total body weight of the test specimen to that of an AW0 loaded car. This loading shall be distributed in proportion to the distribution of weight in the finished car.

c. The compression test load shall be applied by means of a controlled hydraulic ram, and the force measured by a means independent of those producing the force. The force shall be measured at the ram and at the reaction at the opposite end of the car. The load shall be applied in increments of 25%, 50%, 75%, 87.5% and 100% of full load. After each load

increment is applied, the load shall be reduced to not more than 2% of full load. Strain gauge, deflection and load readings shall be taken at each load increment and at each relaxation of load. The ram may be supported at the car end, but shall remain free to rotate at its contact with the car end.

2. Test criteria

The car shall be compliant with this Specification if all of the following conditions are met:

a. Stresses are in accordance with the requirements of APTA Standard PR-CS-S-034-99 Revision 2.

b. The vertical deflection of each side of the test structure is within ± 10% of the value determined by the analysis.

c. The force measured at the reaction load cell is within 1.0% of the force applied at the ram.

d. Vertical deflection readings plotted against load do not vary by more than ± 5% from a straight line (linear) deflection curve, with one end point at the origin (no load) and the other at the point which represents the measured deflection at maximum load.

e. Strain readings plotted against load do not vary by more than ± 5% from a straight line (linear) deflection curve, with one end point at the origin (no load) and the other at the point, which represents the measured deflection, at maximum load.

f. Maximum stresses calculated from strain readings, and calculated stresses from structure only, in any structural element do not exceed the allowable stresses approved prior to starting the test program as part of the stress analysis.

g. Recorded residual vertical deflection between bolsters following removal of the maximum vertical test load does not exceed 0.04 in. (1 mm).

h. The residual horizontal deflection between ends following removal of the maximum load does not exceed 0.04 in. (1 mm).

i. Indicated residual strains at strain gauges on principal structural elements following removal of the maximum vertical loading do not exceed the maximum error resulting from the accuracy of the instrumentation.

j. There are no permanent deformations, warping fractures, cracks, or separations in the car structure. Broken welds are to be jointly inspected by the Contractor and Engineer to determine if the failure is the result of weld quality or stress.

J. Diagonal jacking test

1. Test description

a. The carshell shall be loaded to its AW0 weight, with trucks, or equivalent weight, hanging from the body bolsters. The carshell shall be supported symmetrically at the jack pads at the four corners of the car. One of the jacks shall be lowered in five equal increments until it is free of the jacking pad. The selection of the jack to be lowered should be based on its relation to the center of gravity of the carshell so that the diagonally opposite jack remains in contact with the jacking pad and carries some car weight. All gauges shall be recorded at each increment of jack position. The procedure shall be reversed until the load on the jack is returned to its original level.

b. The amount of torsional deflection or twist shall be measured.

2. Test criteria

   The car shall be compliant with this Specification if all of the following conditions are met:

   a. Maximum stresses calculated from strain readings in any structural element do not exceed the allowable stresses found in Section 4.4.8.

   b. Strain readings plotted against load do not vary by more than ± 5% from a straight line (linear) deflection curve, with one end point at the origin (no load) and the other at the point that represents the measured deflection at maximum load.

   c. Indicated residual strains at strain gauges following return to original level do not exceed the maximum error resulting from the accuracy of the instrumentation.

   d. There are no permanent deformations, warping, fractures, cracks or separations in the car structure.

   e. Broken welds are to be jointly inspected by the Contractor and Engineer to determine if the failure is the result of weld quality or stress.

K. Collision post elastic test

1. Test description

   a. The ability of the carbody structure to resist the collision post longitudinal loads specified in APTA Standard PR-CS-S-034-99 Revision 2 shall be tested.

   b. During the collision post-test, the carshell shall be supported on trucks or simulations thereof to allow free longitudinal movement. The post-applied load shall be reacted at the coupler. The carshell shall be loaded with sufficient dead weight to bring the total carbody weight of the test specimen to that of an AW0 loaded carbody. This loading shall be distributed in proportion to the distribution of weight in the finished car.

   c. The specimen shall be instrumented as required for the car and collision post per the corresponding test plan. Strain gauges and deflection gauges shall be installed at the same places at some locations so that the structural equivalence of the model to the carbody can be determined.

   d. A longitudinal test load as specified in APTA Standard PR-CS-S-034-99 Revision 2 and not resulting in less than 75% of the material's yield limit as shown through FEA, shall be applied to, and centered on, the collision post at an elevation 18 in. (457 mm) above the top of the underframe. This load shall be distributed over an area not to exceed the width of the collision post by 6 in. (152 mm) in height.

   e. The test load shall be applied by means of a controlled hydraulic ram, and the force measured by a means independent of that producing the force. A fixture and means of cushioning, such as lead sheets, shall be provided to assure uniform bearing and to prevent crippling around the area of force application. This fixture and cushion shall not be attached to the post. The test load shall be applied horizontally parallel to the car longitudinal centerline. The load shall be applied in increments of 25%, 50%, 75%, 87.5% and 100% of full load. The load shall be reduced to not more than 2 percent of full load after each step. Strain gauge and deflection readings shall be taken at each load increment and at each relaxation of load. The ram shall be supported at the car end, but shall remain free to move longitudinally with respect to the car end. The ram shall be safety captured to ensure the ram is not launched from the fixturing in the case of an accident.

2. Test criteria

The car shall be compliant with this Specification if all of the following conditions are met:

a. Deflection readings plotted against load do not vary by more than ± 5% from a straight line (linear) deflection curve, with one end point at the origin (no load) and the other at the point that represents the measured deflection at maximum load.

b. Strain readings plotted against load do not vary by more than ± 5% from a straight line (linear) deflection curve, with one end point at the origin (no load) and the other at the point which represents the measured deflection at maximum load.

c. Maximum stresses calculated from strain readings in any structural element ~ exceed the allowable stresses approved prior to starting the test program as part of the stress analysis.

d. Indicated residual strains at strain gauges on principal structural elements following removal of the maximum loading do not exceed the maximum error resulting from the accuracy of the instrumentation.

e. There is no permanent deformation, warping fractures, cracks or separations in the car structure.

f. Broken welds are to be jointly inspected by the Contractor and Engineer to determine if the failure is the result of weld quality or stress.

L. Corner post longitudinal load test

1. Test description

a. The ability of the carbody structure to resist the primary side corner post longitudinal compressive loads specified in APTA Standard PR-CS-S-034-99 Revision 2 cab cars and trailer cars shall be tested.

b. During the corner post longitudinal test, the carshell shall be supported on trucks or simulations thereof to allow free longitudinal movement. The post applied load shall be reacted at the coupler. The carshell shall be loaded with sufficient dead weight to bring the total carbody weight of the test specimen to that of an AW0 loaded carbody. This loading shall be distributed in proportion to the distribution of weight in the finished car.

c. The specimen shall be instrumented as required for the car and corner post in the corresponding test plan. The strain gauges and deflection gauges shall be installed at the same places at some locations so that the structural equivalence of the model to the carbody can be determined.

d. Longitudinal test loads shall be applied to, and centered on, the corner post at an elevation of 18 in. (457 mm) and 30 in. (762 mm) above the top of the underframe as specified in APTA Standard PR-CS-S-034-99 Revision 2. The magnitudes of the loads shall be limited to values that approach the yield strength of the past as predicted by the approved FEA. These loads shall be distributed over an area not to exceed the width of the collision post and not to exceed 6 in. (152.4 mm) in height.

e. The test load shall be applied by means of a controlled hydraulic ram, and the force measured by a means independent of that producing the force. A fixture and means of cushioning, such as lead sheets, shall be provided to assure uniform bearing and prevent crippling around the area of force application. This fixture and cushion shall not be attached to the post. The test load shall be applied horizontally parallel to the car longitudinal centerline. The load shall be applied in increments of 25%, 50%, 75%, 87.5% and 100% of full load. The load shall be reduced to not more than 2% of full load after each step. Strain

gauge and deflection readings shall be taken at each load increment and at each relaxation of load. The ram shall be supported at the car end but shall remain free to move longitudinally with respect to the car end.

2. Test criteria

The car shall be compliant with this Specification if all of the following conditions are met:

a. Deflection readings plotted against load do not vary by more than ± 5% from a straight line (linear) deflection curve, with one end point at the origin (no load) and the other at the point which represents the measured deflection at maximum load.

b. Strain readings plotted against load do not vary by more than ± 5% from a straight line (linear) deflection curve, with one end point at the origin (no load) and the other at the point which represents the measured deflection at maximum load.

c. Maximum stresses calculated from strain readings in any structural element do not exceed the allowable stresses approved prior to starting the test program as part of the stress analysis.

d. Indicated residual strains at strain gauges on principal structural elements following removal of the maximum loading do not exceed the maximum error resulting from the accuracy of the instrumentation.

e. There is no permanent deformation, warping fractures, cracks or separations in the car structure. Broken welds shall be jointly inspected by the Contractor and the Engineer to determine if the failure is the result of weld quality or stress.

M. Corner post transverse load test

1. Test description

a. The ability of the carbody structure to resist the corner post transverse load specified in APTA Standard PR-CS-S-034-99 Revision 2 SS-C&S-034-99 shall be tested.

b. During the corner post test, the carshell shall be supported on trucks or simulations thereof. Transverse restraint shall be at the lateral stops between the carbody bolsters and truck frame. The carshell shall be loaded with sufficient dead weight to bring the total body weight of the test specimen to that of an AW0 loaded carbody. This loading shall be distributed in proportion to the distribution of weight in the finished car.

c. The specimen shall be instrumented as required for the car and corner post in the corresponding test plan. The strain gauges and deflection gauges shall be installed at the same places at some locations so that the structural equivalence of the model to the carbody can be determined.

d. Longitudinal test loads as specified in APTA Standard PR-CS-S-034-99 Revision 2 shall be applied to and centered on the corner post at an elevation of 18 in. (457 mm) above the top of the underframe. This load shall be distributed over an area not to exceed the width of the corner post and not to exceed 6 in. (152 mm) in height.

e. The test load shall be applied by means of a controlled hydraulic ram, and the force measured by a means independent of that producing the force. A fixture and means of cushioning, such as lead sheets, shall be provided to assure uniform bearing and prevent crippling around the area of force application. This fixture and cushion shall not be attached to the post. The test load shall be applied horizontally perpendicular to the car longitudinal centerline. The load shall be applied in increments of 25%, 50%, 75%, 87.5% and 100% of

full load. The load shall be reduced to not more than 2% of full load after each step. Strain gauge and deflection readings shall be taken at each load increment and at each relaxation of load. The ram shall be supported at the car end but shall remain free to move transversely with respect to the car end.

2. Test criteria

The car shall be compliant with this Specification if all of the following conditions are met:

a. Deflection readings plotted against load do not vary by more than ± 5% percent from a straight line (linear) deflection curve, with one end point at the origin (no load) and the other at the point which represents the measured deflection at maximum load.

b. Strain readings plotted against load do not vary by more than ± 5% from a straight line (linear) deflection curve, with one end point at the origin (no load) and the other at the point which represents the measured deflection at maximum load.

c. Maximum stresses calculated from strain readings in any structural element do not exceed the allowable stresses approved prior to starting the test program as part of the stress analysis.

d. Indicated residual strains at strain gauges on principal structural elements following removal of the maximum loading do not exceed the maximum error resulting from the accuracy of the instrumentation.

e. There are no locations of permanent deformation, warping, fractures, cracks or separations in the car structure. Broken welds are to be jointly inspected by the Contractor and Engineer to determine if the failure is the result of weld quality or stress.

N. Collision post elastic-plastic test

1. Test description

a. The ability of the connections between the collision posts and the carbody structure to withstand a longitudinal load equal to the ultimate load carrying capacity of the post as specified in APTA Standard PR-CS-S-034-99 Revision 2 shall be tested.

b. This test shall also verify the structural energy absorption requirement outlined in APTA Standard PR-CS-S-034-99 Revision 2.

c. The test specimen shall be a full-scale structural model of the cab end of a car. The structural model shall include all structural elements required to support the collision posts including the end underframe and roof between the forward end of the end frame and the bolster. All connections shall be identical to those of production cars. The bolster end of the model shall be attached to a rigid fixture so that the stresses in the post and its supporting structure shall be the same as those in a car subjected to the same load.

d. The specimen shall be instrumented in the same manner in which it was instrumented in the collision post elastic test, except that instruments of greater capacity may be needed for this test. The strain gauges and deflection gauges shall be installed in the same locations so that the structural equivalence of the specimen to the carbody can be determined. Longitudinal test loads shall be applied to and centered on the collision post at an elevation of 30 in. (762 mm) above the top of the underframe. This load shall be distributed over an area not to exceed the width of the collision post and not to exceed by 6 in. (152 mm) in height.

e. The compression test load shall be applied by means of a controlled hydraulic ram, and the force measured by a means independent of that producing the force. A fixture and means of

cushioning, such as lead sheets, shall be provided to assure uniform bearing and prevent crippling around the area of force application. This fixture and cushion shall not be attached to the post. The test load shall be applied horizontally parallel to the car longitudinal centerline.

f. The initial load shall be applied in increments of the same magnitude as those used during the collision post elastic load test. The load shall be reduced to not more than 2% of full load after each step. Strain gauge and deflection readings shall be taken at each load increment and at each relaxation of load.

g. After agreement between the two tests is demonstrated, the collision post shall continue to be loaded in stroke increments of 20% of the full depth of the collision post until the load carrying capacity of the collision post is obtained. At each 20% load increment, all load cell(s), strain gauges and deflection gauges shall be recorded. The load need not be relaxed after each step.

h. The ultimate load carrying capacity of the post shall be defined as the condition where the post cannot support an increased load or the mid-section of the post has deflected more than its full original depth. This deflection shall be measured at the middle of the post from a string connected between the top and bottom of the post.

2. Test criteria

a. The collision post shall be compliant with this Specification if all of the following conditions are met: All strain gauges and deflection gauges have the same readings within ± 5% for the same loads at the same locations as the collision post elastic load test for 0% to 100% as tested in the elastic test.

b. The connections between the collision post and all other structural members are not completely broken.

c. The collision post and supporting structure have absorbed energy as per APTA Standard PR-CS-S-034-99 Revision 2.

19.05.03 Trucks

A. Allowable stresses

For the purposes of truck frame and component load and fatigue testing, the Contractor and/or the truck designer shall determine the maximum allowable stresses that the truck shall be designed to accommodate in order to perform without degradation over the 40-year useful life of the major components of the truck, under AW3 load conditions, all specified track conditions, and the truck's service life cycle as defined in this specification. The allowable stresses shall be determined using industry standard practice, and shall be submitted to the Engineer for approval prior to the start of any truck frame load or fatigue testing.

B. Equalization

1. The truck shall be tested in accordance with APTA Standard PR-M-S-014-06 Revision 1, for car type "G".

2. To verify the equalization provided by the truck design, one truck on the first car at AW0 load shall have one wheel jacked up 2.5 in. (64 mm) and then increasing to 3 in. (76 mm) and suitable instrumentation provided to measure the load carried on the other wheels. The load changes shall be in accordance with the requirements of APTA Standard PR-M-S-014-06 Rev 1. In the event that suitable equalization is not attained as indicated by the tests, the truck design shall

be corrected, the truck retested at the expense of the Contractor, and all trucks installed under the cars shall be modified to be in accordance with the corrected design.

C. Truck frame load tests

1. The truck frame and bolster shall be tested to verify that the maximum allowable stresses established by the Contractor and approved by the Engineer under an AW3 load are not exceeded. This is a static load test, repeated twice with a complete release between applications and shall be performed with the suspension elements replaced by solid blocking (with resilient pads if necessary). The truck shall be tested either as individual load bearing components or as an assembly, as the Contractor elects. If the load bearing components of the truck rather than the complete assembly are tested, provision must be made to apply all input loads described herein and for the member under test to react to these input loads in a manner which is identical to the reactions that would occur when included as part of the assembly. Forces shall enter the parts or truck at the normal application points, and shall be so combined in each case as to produce the maximum unit stresses at the critical points for which the stress estimates were furnished. The tests shall be witnessed by the Engineer.

2. No less than 75 strain gauges shall be applied to the truck near the locations of maximum stress points as agreed to by the Contractor and the Engineer, the Engineer having the power of decision in disagreement. The location of maximum stress points are to be determined by analysis. The loads specified are minimum values. The Contractor shall be responsible for selecting loads that will develop a high level of confidence in the adequacy of the truck design for the intended purpose and application. The critical stress readings of the two applications shall be averaged for comparison with the estimated stresses. The highest vertical load of all car types, as seen at the truck, shall be used for the loadings. The vertical load component shall be 110% of the AW3 loaded carbody weight normally carried by the truck. The lateral component shall be 25% of the vertical component. The longitudinal component shall be 15% of the vertical component.

3. All loads shall be applied simultaneously. At no point shall the average stress exceed the allowable stress as established herein this section. If it does, the Engineer shall have the right to require that the design be corrected to bring the test stresses with the allowable stresses; the truck shall be retested at the expense of the Contractor, and all trucks installed in the cars shall be modified to be in accordance with the corrected design. Testing will not be required on service qualified components which can be shown to have had satisfactory service experience of comparable severity and duration, as determined by the Engineer.

D. Truck frame overload tests

1. To demonstrate that the truck design has adequate strength to sustain a maximum load in the presence of a combination of minor manufacturing defects, a truck frame and bolster shall be overloaded statically. The suspension elements shall be replaced by solid blocking (with resilient pads if required). The loads shall be as follows:

   a. Vertical load = 1.5 x AW3 car weight per truck.

   b. Lateral load = 0.30 g x AW3 car weight per truck applied at the carbody center of gravity (note: this produces additional vertical loads on the truck).

   c. Longitudinal load = 1.00 g) x truck weight.

   d. Brake loads consistent with maximum specified deceleration, split between tread and disc mounting locations according to Chapter 7.

2. All loads shall be applied simultaneously.

a. No less than 75 strain gauges shall be applied to the truck near the locations of maximum stress points as agreed to by the Contractor and the Engineer, the Engineer having the power of decision in case of disagreement. The location of maximum stress is to be determined by analysis. The loads specified are minimum values. The Contractor shall be responsible for selecting loads that will develop a high level of confidence in the adequacy of the truck design for the intended purpose.

b. Unit stresses at critical locations shall be measured before and after the test at representative points on the truck as agreed to between the Contractor and the Engineer, the Engineer having the power of decision in the event of disagreement. Certain before-test and after-test critical characteristic dimensional checks may be agreed upon to supplement strain gauge readings. The Engineer shall be present for the tests. There shall be no permanent deformation as determined from strain gauge readings. If such deformation appears, the design shall be corrected to bring the stress under the test condition within the elastic limit of the material involved, the truck shall be retested at the expense of the Contractor, and all trucks installed in the cars shall be modified to be in accordance with the corrected design. Testing will not be required on service qualified components which can be shown to have had satisfactory service experience of comparable severity and duration, as determined by the Engineer.

E. Truck frame fatigue tests

1. To demonstrate that the truck has adequate fatigue strength under dynamic loading, the truck frame and bolster shall be tested according to the provisions of APTA Recommended Practice PR-M-RP-009-98. The loads specified below are minimum values. The Contractor shall be responsible for selecting loads that will develop a high level of confidence in the adequacy of the truck design for the intended purpose.

2. The truck frame and bolster shall be tested as a unit, with the suspension elements replaced by solid blocking (with resilient pads if necessary). The vertical component shall be plus and minus 0.200 g times the AW1 loaded carbody weight normally carried by the truck with the highest loading. The lateral component shall be plus and minus 0.150 g times the above AW1 load and shall vary with it. The longitudinal component shall be plus and minus 0.150 g times the above AW1 load and shall vary with it. Accessory loads, as determined by the Engineer, shall vary between plus and minus 100% of their maximum steady state or harmonic dynamic conditions. Loads applied to the truck bolster shall include those resulting from the transfer vertically of the applied lateral force from the height of loaded carbody center of gravity to the lateral bumper height. The phasing of loads shall result in maximum combined stresses at the critical locations. The test shall demonstrate that the maximum combined stresses at the critical locations do not exceed those required. Critical locations shall be agreed upon by the Contractor and the Engineer, the Engineer having the power of decision in the event of disagreement.

3. The frequency of the load cycling shall be as proposed by the Contractor for approval by the Engineer. Prior to the test, the Contractor shall provide documentation and/or drawings for all defects that existed in the truck elements as produced, and the repairs made to the parts containing these defects.

4. During the fatigue tests, the truck shall be inspected regularly to detect possible crack initiation and progression. If evidence of progressive cracking or failure is found, the cause shall be assessed by the Engineer and the Contractor after which an appropriate correction shall be established, and the test repeated.

5. At the conclusion of the fatigue test, a magnetic particle or dye penetrate inspection shall be made for cracks in the presence of the Engineer. If any crack is found, or pre-existing cracks have propagated, the design shall be corrected, the truck retested at the expense of the

Contractor and all trucks installed under the cars shall be modified to be in accordance with the corrected design. Testing will not be required on service qualified components which can be shown to have had satisfactory service experience of comparable severity and duration, as determined by the Engineer.

F. Truck primary suspension tests

A load deflection test, including a creep test for rubber or similar components if necessary, shall be performed to demonstrate that the spring rates of the primary suspension system in all axes are within the design limits. This test shall demonstrate that the primary suspension system behaves as predicted and will not result in excessive deflection or a decrease in truck clearance above top of rail to less than the minimums prescribed. If defects are found, the design shall be corrected. The truck, or the primary suspension simulating its installation in the truck, shall be retested at the expense of the Contractor, and all trucks modified to be in accordance with the corrected design.

19.05.04 Couplers

The complete coupler assembly; including draft gear, radial connector, yoke, coupler carrier and uncoupling mechanism, shall be tested to validate conformance to the requirements, including all FRA regulations and applicable APTA standards and recommended practices, range of motion, vertical loading, draft and buff loads and operations.

19.05.05 Brakes

The design and specifications of the friction brake system shall be verified through a series of tests that simulate the environment in which the brake system will function. These tests shall analyze the brake system's performance, reliability and safety under the extreme conditions found in revenue service, including full-service and emergency brake rate measurements, analysis of component fatigue, heat creation and dissipation calculations, handbrake performance, and materials analysis. These tests shall include computer simulations and dynamic testing of brake system components as performed by the brake system supplier, as well as track tests performed by the Contractor using completed cars.

A. Brake pad/shoe force tests

Tests shall be conducted on the first car to verify the actual force produced at the brake pad by the disc brake assembly, and at the brake shoe by the tread brake unit at both a handbrake and a non-handbrake location agree with calculated values. Tests shall be conducted with brake cylinder pneumatic pressures in 5.0 lbs/in.^{2} (0.3 bar) increments, from 0 lbs/in.^{2} (0.09 bar) to the maximum used, and from application of the handbrake.

B. Brake component fatigue tests

A test set-up shall be arranged such that a disc brake assembly, tread brake unit and brake pad and shoe are exposed as nearly as possible to the same conditions as they will encounter in service. The brake pad and shoe shall be loaded by applying air pressure equivalent to a maximum service brake (friction only) application to the disc brake assembly and the tread brake unit, and the forces developed by brake reaction torque shall be applied through the mounting arrangement. The entire brake assembly shall be subjected to 1,000,000 cycles of applications and releases at the working loads predicted for an AW2 loaded car. The direction of the reaction torque shall be reversed every ten brake applications. This test will not be required for hardware that has had satisfactory service experience of comparable severity and duration, as determined by the Engineer.

C. Friction brake system endurance tests

The first complete car set of the friction brake pneumatic control system produced, before mounting on a car, shall be subjected to an endurance test of 1,000,000 cycles of normal applications and releases to demonstrate that the control apparatus has the endurance required for rail service. The system will not be considered acceptable until the test has been performed without a component failure of any kind during 1,000,000 consecutive operating cycles. Half of the cycles should be performed simulating ECP control and half of the cycles should be performed using emulation control. Testing will not be required on service qualified components which can be shown to have had satisfactory service experience of comparable severity and duration, as determined by the Engineer.

D. Brake capacity tests

The first production disc brake assembly, tread brake unit and brake pad and shoe for the car shall be tested using a full-scale dynamometer to verify that the friction brake system design can perform the specified friction brake-only operation. A dynamometer test shall be performed to simulate the proposed revenue speed profile, driven by Engineer-defined train schedule service for speeds up to 125 mph (201 kph). Any elevation grades exceeding 0.2% shall also be taken into account. Wheel and disc temperatures shall be recorded throughout the dynamometer testing, including wear in process. The complete dynamometer procedure, dynamometer facility and test protocol shall be provided by the Contractor and approved by the Engineer. This procedure is an amendment to the qualification of brake shoe and disc brake materials as specified in PRIIA Specification 305-900. All other attributes of friction brake material performance shall be in accordance with PRIIA Specification 305-900. The production brake pads and materials shall be used, and temperature limits specified by the brake and wheel supplier shall not be exceeded. For tread brake and brake shoe dynamic testing, a test wheel shall be provided by the Engineer. The test shall be coordinated according to the planned operating pattern.

E. Handbrake tests

1. Handbrake performance shall be verified for compliance to the specification as well as APTA Standard PR-M-S-006-98 Revision 3 using new and fully worn brake shoes/pads.

2. On the first car a test of the adequacy of the design of the handbrake shall be made (using first new and then fully worn brake shoes) by measuring with a scale the force needed to move the car with the handbrake applied on level tangent track.

3. The "handbrake-applied" indicator light shall also be tested.

19.05.06 Door System

A. The side and sliding end door systems shall be subjected to extensive testing to confirm that the systems and components meet all requirements for:

1. System integrity

2. Safety

3. Functionality and operation across the voltage range of the supply

4. Opening and closing times, and speeds

5. Trainline controls, indicators and interlocks

6. Compliance with regulations, recommendations and standards

7. Reliability

8. Maintainability

9. Sustained and compliant performance under all specified operational and environmental conditions

B. All door system components shall be tested through rigorous multiple-cycle operation that simulates the actual installation, hardware and climatic conditions as specified. A test plan program and the procedures for all tests required shall be submitted to the Engineer for review in accordance with the requirements.

C. Side door system endurance and reliability test

A set of side door panels and operators, fully equipped with all the required equipment as designed, shall be installed in a test fixture at the facilities of the door system supplier, and subjected to a repeated open and close cycle test of no less than 500,000 full cycles, to demonstrate the durability of the operators, hangers, rollers, switches, motors and all other components of the door system. The test fixture shall simulate the actual door opening, threshold and pocket in which the doors will be mounted. Power and control to the doors shall be via the actual wire leads that will connect the door operator to the carbody wiring in a production installation. The door operators shall be monitored for proper function and continued operation. Any failure of the door operators to function or perform according to the specifications, test procedure or performance criteria shall be considered a failure. All failures shall be investigated and analyzed as to cause, and the Contractor or door system supplier shall propose corrective action. Once approved by the Engineer, the door operators shall be modified to conform to the corrective action, and the test shall be started over again. The door system test shall be conducted until both operators function continuously without failure for 500,000 cycles.

D. Side door system vehicle qualification test

1. Once the first car has been completely assembled, and the entire side door system has been installed, the door system shall be functionally tested to verify that the door system design conforms to all applicable safety requirements, including:

   a. Trainline and local control, door summary circuit and zero-speed operation

   b. Obstruction detection recycle operation, door opening and closing times.

   c. Interlocks, isolation and manual locking

   d. Interior, exterior and trainline door status indicators

   e. Manual release (interior and exterior), including the force to activate the manual release, the force to open a door that has been released and the process for resetting the doors to normal operation

   f. Structural integrity of the door panel and glazing signage, and emergency operation. Under no circumstances shall a door be allowed to create an unsafe condition.

2. After the functionality has been verified, the side doors shall be operated for a total of 14,400 continuous trouble-free cycles each.

3. The test shall be configured such that all doors on one side of the car shall operate at high station platform mode, and all doors on the other side of the car shall operate at low station platform mode.

4. After 7,200 continuous trouble-free cycles each, each doorway will be reconfigured to the other station platform height configuration for the remainder of the test.

5. The system shall be monitored to confirm that each door operates through a complete cycle of fully opening and fully closing, and latching for all 14,400 cycles. No adjustments or maintenance will be allowed during the test. Any door or door control failure occurring prior to completion of the test will require that the test be stopped, corrective action be taken to document and resolve the failure and start the test at the beginning for all car doors.

E. Sliding end door endurance and reliability test

1. A sliding end door panel and operator, fully equipped with all required equipment as designed, shall be installed in a test fixture at the facilities of the door system supplier, and subjected to a repeated open and close cycle test of no less than 100,000 full cycles, to demonstrate the durability of the operator, hanger, switches, motor and all other components of the door system. The test fixture shall simulate the actual door opening, threshold and pocket that the door will be mounted in. Power and control to the door shall be via the actual wire leads that will connect the door operator to the carbody wiring in a production installation. The door operator shall be monitored for proper function and continued operation. Any failure of the door operator to function or perform according to the specifications, test procedure or performance criteria shall be considered a failure. All failures shall be investigated and analyzed as to cause, and the Contractor or door system supplier shall propose corrective action. Once approved by the Engineer, the door operator shall be modified to conform to the corrective action, and the test shall be started over again. The end door test shall be conducted until the operator functions continuously without failure for 100,000 cycles.

2. The end door shall also be tested for proper opening, closing and hold-open times, the force required to manually open the door in manual mode, and for proper operation of the obstruction detection system, the normal/manual/open selector switch, the mortise lock and the press plates.

3. A set of end door press plates shall be subjected to a 100,000-cycle test that simulates the use of the press plates to command an end door to open. The press plates shall perform as intended through the 100,000-cycle test without showing signs of wear, abrasion or degradation of the switch, wiring, connectors or seals.

F. Sliding end door vehicle qualification test

Once the sliding end door system has been functionally tested on the first completely assembled car, it shall also be operated for a total of 14,400 continuous trouble-free cycles.

19.05.07 Interior

A. Overhead luggage racks

1. The rack structure and attachment to carbody structure shall have sufficient strength to support a load of 250 lbs (113.4 kgs), applied over 6 in. (152.4 mm) midway between adjacent supports on the inboard edge, with a deflection not to exceed 0.25 in. (6.35 mm) (including rack itself and its attachment to carbody) and without fracture or permanent deformation.

2. The complete and fully-loaded luggage rack and its attachment to the carbody shall also be designed to resist loads, without failure, due to accelerations of 8g longitudinally, 4g laterally, and 4g vertically, acting on the mass of the luggage.

B. Seats

One sample seat of each seat type identical to a production version shall be tested by the manufacturer for all criteria specified in APTA Standard PR-CS-S-016-99 Revision 2 and submitted to the Engineer with a detailed test report. [CDRL 19-007] This test result must be approved by the

Engineer before additional seats can be ordered and assembled into the pilot cars for pre-delivery testing.

C. Seat tests

1. Seat cushions, if applicable, selected twice at random by the Engineer during cushion production shall be tested to verify compliance with section requirements.

2. Seat cushions (both foam and upholstery) shall be tested to verify compliance with requirements.

19.05.08 HVAC

A. Heating and air-conditioning unit tests

1. One complete Heating, Ventilation and Air Conditioning (HVAC) unit and its complete controls shall be given a qualification and capacity test by the air conditioning manufacturer to verify the performance of the unit. This test shall be successfully completed before commencement of the vehicle climate room test. The test shall be conducted in accordance with ANSI/ASHRAE Standard 37. The testing laboratory shall be approved by the Engineer.

2. Testing shall include all tests called for in ASHRAE GPC-23, Guideline for the Design and Application of Heating, Ventilation and Air Conditioning Equipment for Rail Passenger Vehicles.

3. The actual HVAC control system, with actual temperature sensors, shall control all system operations during the test, unless indicated otherwise for specific tests.

4. Tests shall be conducted at nominal voltage and frequency, minimum and maximum voltages and frequencies. Appropriate test log sheets and calculation forms shall be generated and included with the test procedure for approval. They shall become a part of the test report.

5. The accuracy and tolerances of all instrumentation and tests shall comply with the requirements of the ASHRAE Standard 37 Table 4 and all of the required data shall be continuously recorded. Temperature measurements and measurement techniques shall comply with ASHRAE Standard 41.1. An event recorder shall be provided to monitor operation of relays and contactors.

B. System pre-test requirements

1. Prior to any cooling and heating system test, an air balance test, control scan test and a vehicle heat transfer test shall be conducted on each car type. The purpose of these tests is to demonstrate conformance with interior ventilation, air flow and pressurization requirements, to demonstrate that the HVAC control, and thermostats perform as specified, and to demonstrate that the overall car body heat transmission does not exceed the specified limits.

2. The pre-tests shall be satisfactorily completed before continuing to further climate room testing.

C. Air balance test

1. Prior to any cooling and heating tests, an air balance test and a vehicle pressurization test shall be conducted. Any adjustments to air baffle plates, grilles and diffusers shall be documented during this test. All subsequent cars shall utilize permanently set components with settings the match the climate room cars.

2. Each car to be tested shall be measured and the results recorded to verify specification requirements are met for air distribution and balance, including:

   a. Fresh air flow rate

b. Return air flow rate

c. Exhaust air flow rate

d. Air flow rates into cab

e. Car pressurization: cab, car interior, restroom

f. Pressure differential of restroom relative to adjacent car interior

g. Uniformity of supply air flow

h. Interior car noise levels after balancing with blowers on

3. Correct air distribution shall be verified with the fresh air and diversion dampers in each of the nominal positions (e.g. For fresh air dampers, closed, partial, full open positions, etc.). Once the required values are established, the system adjustments and settings shall be recorded to be used as base settings for the remaining cars of that type.

D. Temperature control tests

1. The temperature control components shall be exposed to the specified thermal environments. All points of the approved temperature control schedule referenced in Chapter 10 shall be verified for both the temperature rising and the temperature falling cycles. The temperatures shall be varied as slowly as practical to reflect natural temperature lags as experienced in the actual installation. Demonstration of the pump-down operation, when appropriate, shall be included.

2. Under steady state operation at design conditions, the control voltage shall be varied between the limits allowed by PRIIA Specification 305-912. The system shall operate steadily without malfunction.

E. Refrigerant charge test

The refrigerant charge, by weight, shall be confirmed at the system design conditions. The Contractor shall include the testing criteria in the test procedure which shall be approved by the Engineer. The criteria shall include the following, at a minimum:

1. Level of superheat at the evaporator outlet;

2. Level of superheat at the compressor suction valve;

3. Compressor suction and discharge pressures;

4. Level of liquid refrigerant sub-cooling at condenser outlet;

5. No air bubbles in liquid line sight glass;

6. Compressor(s) working at full load/capacity.

F. Heating and air-conditioning system tests

The first of each type of car shall be tested in an approved climate room test facility capable of maintaining any test temperatures from -30°F (-34°C) to 130°F (54°C) and any relative humidity throughout that range between 25% and 95%. Temperature in the facility shall be uniform throughout. There shall be no more than 5°F (-15°C) variation from 24 in. (610 mm) above top of rail to 24 in. (610 mm) above the vehicle roof and from end to end of the vehicle. Fans may be used to circulate air. Passenger load shall be simulated by means of evenly distributed heaters and humidifiers inside the vehicle; solar loads shall be simulated by means of evenly distributed heaters

inside or outside the vehicles. Humidity introduced into the vehicle shall be calculated and measured to accurately simulate the passengers' latent heat load. The climate room shall have the equipment available to locally raise the condenser temperature to demonstrate the air conditioning system's pressure modulation capability.

1. Data requirements

   a. The Contractor shall record sufficient data at intervals of no more than 5 minutes for each air conditioning and heating test to show that the equipment operates satisfactorily and meets design requirements. The recorded data shall include the following:

   b. Temperatures - °FDB:

      i. Return air at both HVAC units;

      ii. Mixed air at both HVAC units;

      iii. Fresh air at all air intakes (for both HVAC units);

      iv. Distributed air throughout the car;

      v. Condenser air inlet at both units;

      vi. Liquid at the filter-drier outlet on both units

      vii. Suction at evaporator on both units;

      viii. Suction at compressor(s) on both units;

      ix. All temperature sensors and thermostats;

      x. Exterior temperature at 24 in. (610 mm) above the rail at both ends of the car;

      xi. Exterior temperature at 24 in. (610 mm) above the roof at both ends of the vehicle;

      xii. Interior temperature at 14 seats at 6 in. (152 mm) and 48 in. (1,219 mm) above the floor;

      xiii. Interior temperature at 4 aisle positions at 6 in. (152 mm) above the floor and 12 in. (305 mm) below the ceiling;

      xiv. Cab compartment on both sides of the car at 6 in. (152 mm) and 48 in. (1,219 mm) above the floor and 12 in. (305 mm) below the ceiling;

      xv. Toilet room 6 in. (152 mm) and 48 in. (1,219 mm) above the floor and 12 in. (305 mm) below the ceiling;

      xvi. Heater guard temperature at all heater locations;

      xvii. Overheat heater compartment at all overheat protection devices;

      xviii. Wet bulb temperatures at a minimum of two ambient locations next to the fresh air intakes.

2. Pressures:

   a. Compressor(s) discharge on both units;

   b. Compressor(s) suction on both units;

   c. Liquid leaving condenser/sub-cooler outlet on both units;

   d. Suction at evaporator at each evaporator circuit on both units;

   e. Evaporator air pressure drop on both units;

f. Condenser air pressure drop on both units;

g. Vehicle pressurization (inches of water gauge).

3. Electrical Data:

a. Input Voltage;

b. Blower motor current, power, and speed on both units;

c. Compressor(s) motor current, and power on both units;

d. Condenser fan motor current, power, speed on both units.

e. Fresh air damper motor current, power, and position on both units,

f. Supply air diversion damper motor current, power, and position an all dampers.

4. Relative Humidity Data:

Relative Humidity (RH) sensors at 3 aisle positions at 12 in. (305 mm) below the ceiling.

5. For the heating tests all heater circuits and devices shall be continuously monitored to determine all device input voltages, currents and power draw. For all tests, the status of all temperature control modes shall be "event recorded" in parallel with the temperature, pressure and electrical data in a manner which will allow total system functional status to be followed throughout the testing. Coordinating time marks shall be used on all data recording devices.

6. The data acquisition system shall have the capability to add channels, if required.

G. Control scan test

All control switching points for rising and falling temperatures shall be tested, by varying and adjusting the ambient conditions in the climate chamber and the interior loads in the car. All temperatures that affect the control system shall be tested individually. While stabilized within each control mode the interior comfort requirements of Chapter 10, shall be met. Stabilization shall be when the temperature swing at each of the interior car thermocouples, including all spaces such as cab, and toilet room, stay within 3°F (2°C) per hour. In the event of any control failure, appropriate adjustments shall be made and the entire scan test shall be repeated until all system controls performs as intended. If any air flow adjustments are made during the scan test, the airflow balance test shall be repeated. Cooling pump-down cycle and cooling lockout shall also be demonstrated during this test.

H. Vehicle heat transfer test

1. The overall carbody heat transmission, value shall be determined during this test. The fresh air intakes and exhaust openings shall be sealed, the vehicle doors shall remain closed and the car ventilation system shall be shut down during this test. The climate room ambient temperature shall be maintained at a constant ambient temperature below 20°F (-7°C) during this test. Portable heaters and fans shall be evenly distributed throughout the car and shall be used to heat the car until the car interior temperature stabilizes. Once the car interior temperature is stabilized, the overall carbody heat transmission, value can be calculated by dividing the total heat applied in the car by the floor heaters (in BTU per hour) by the stabilized temperature difference between the ambient and interior temperature (in °F). The calculated value must be less than or equal to 1,200 BTU/hr/°F (2,279 kJ/hr/°C).

2. In the event the Heat Transfer test is failed, appropriate changes to the car body insulation system shall be made, and the test shall be repeated.

I. Cooling system tests

1. The air conditioning tests shall demonstrate the performance of the air-conditioning system in cooling the car and maintaining specified car interior temperatures at various designated ambient conditions. Unless otherwise stated, the applied ambient temperatures shall remain constant, within ± 3°F (2°C), during all tests.

2. Pull down and steady state operation at design conditions test

   a. Prior to this test, the car shall be "soaked" at 110°F Dry Bulb (43°C Dry Bulb)/76°F Wet Bulb (24°C Wet Bulb) in the climate chamber for at least 6 hours with all doors closed and maximum solar load applied until the interior temperature has stabilized as described above.

   b. After the completing the "soak" period, all electrical circuits, including car lights, shall be energized and the air conditioning system shall be turned ON with all car doors and windows closed. Fresh air dampers shall operate per control logic.

   c. The time required for the system to reduce the interior air temperature to 74°F (23°C) ± 2°F (1°C) shall be recorded, as well as the time for stabilization. Stabilization shall be when the temperature swing at each of the interior car thermocouples, including all spaces such as cab, and toilet room, stay within ± 3°F (1°C) per hour. Once stabilized conditions have been reached the test operation shall be continued for 30 minutes with temperatures, pressures, electrical and humidity data recorded at one-minute intervals in order to evaluate temperature variations and interior humidity requirement as the controls and equipment cycle. The interior comfort requirements of Chapter 10 shall be met.

   d. The maximum design passenger load shall be introduced into the car, and the temperature of the ambient air entering the condenser units shall be raised locally to 130°F Dry Bulb (54°C Dry Bulb), while maintaining 110°F Dry Bulb (43°C Dry Bulb)/76°F Wet Bulb (24°C Wet Bulb) in the climate chamber. Again, once stabilized conditions have been reached inside the car, the test operation shall be continued for 30 minutes with temperatures, pressures, electrical and humidity data recorded at one-minute intervals in order to evaluate temperature variations and interior humidity requirement as the controls and equipment cycle. The interior comfort requirements of Chapter 10 shall be met.

3. Door cycling test (cooling)

   At the same conditions following the pull down and steady state operation at design conditions test, the doors shall be cycled on one side of the car at a rate of 2 minutes open and 15 minutes closed for two hours. The average car temperature shall recover within 2°F (-17°C) of the required interior car temperature within 3 minutes maximum after each door closing.

4. High ambient temperature test

   a. At the same conditions following the pull down and steady state operation at design conditions Test or upon completion of the door cycling test, the climate chamber's ambient temperature shall slowly be raised to 130°F Dry Bulb (54°C Dry Bulb). After 130°F (54°C) is reached, the system shall operate continuously for one hour. During the entire test, the system shall not shut down from high pressure, circuit breaker trip, compressor motor overload or failure of any device. Cooling shall be provided at a reduced capacity as described in chapter 10 during this test. Temperatures, pressures, electrical and humidity data shall be recorded at one minute intervals during the entire test.

   b. After the one hour operation, the 480VAC power to the car shall be removed for 2 seconds, and then reapplied. The system shall recover from the power interruption and restart with no system or component malfunction.

5. High pressure cut-out test

   Upon completion of the high ambient test, the climate room temperature (or condenser air inlet temperature) shall be further increased until the high pressure devices on both units are actuated, whereby shutting down the cooling. After actuation, both units must restart as directed by the control system. Temperatures, pressures, electrical and humidity data shall recorded at one minute intervals during the entire test.

6. Condensate carry over test

   a. With the Climate Chamber temperature at 80°F Dry Bulb (27°C Dry Bulb)/75°F Wet Bulb (24°C Wet Bulb), operate the air-conditioning system continuously for a period of 4 hours in the cooling mode. The interior passenger load and solar load must be adjusted during this test to maintain system operation in cooling mode. Any adjustments to internal loads must hold the interior sensible heat ratio constant at 50%.

   b. At the end of the test, the heater coil, evaporator blower's compartment, supply-air discharge plenum, air ducts and diffusers shall be examined for the presence of water.

   c. The test shall be considered successful if, during the test, no condensed water drops, runs, or is blown from the evaporator unit casing and/or its drain pan, and carried in the air stream to the heater coil, evaporator blowers, supply-air discharge plenum, air ducts or diffusers. Overhead heater elements must remain dry.

7. Low ambient temperature test

   Upon completion of the condensate carry over test, the climate chamber shall be adjusted to the lowest ambient air temperature at 40% relative humidity that provides the minimum cooling mode with no reheat according to the Contractor's control schedule. The interior passenger load and solar load must be adjusted during this test to maintain system operation in this cooling mode. Any adjustments to internal loads must hold the interior sensible heat ratio constant at 50%. This HVAC system shall operate for 4 hours under these conditions without damage to the equipment, and the evaporator air flow shall not drop more than 15% from the manufacturer's design point. Temperatures, pressures, electrical and humidity data recorded at one-minute intervals in order to evaluate temperature variations and interior humidity requirement as the controls and equipment cycle. The interior must conform to the comfort requirements of Chapter 10. While the unit is still running, examine the evaporator coils for evidence of icing, and verify the oil level at each compressor sight glass.

8. Low ambient temperature test with high internal load

   Upon completion of the low ambient temperature test, the interior loads shall be increased to the maximum design passenger load and full solar load. Operate the system continuously for a period of 4 hours. During the entire test, the system shall operate without damage to the equipment, Temperatures, pressures, electrical and humidity data recorded at one-minute intervals in order to evaluate temperature variations and interior humidity requirement as the controls and equipment cycle. The interior must conform to the comfort requirements of Chapter 10.

J. Heating system tests

1. The heating tests shall demonstrate the heating system's ability to heat the car interior and maintain specified interior car temperatures at various designated ambient conditions. Unless otherwise stated, the applied ambient temperatures shall remain constant, within ± 3ºF (2°C), during all tests.

2. Layover verification test

a. This test begins with the car in a stabilized automatic heating condition with an ambient temperature of 60°F (16°C). The car is then placed in its layover mode and the ambient temperature reduced to -30°F (-34°C) at a rate of change not to exceed 20°F/hour (11°C/hour). This ambient temperature is maintained for a maximum of eight hours. The average interior temperature must remain within the allowed layover temperature range during the eight-hour period.

b. The layover state is continued an additional four hours with reduced applied voltage to its lowest allowable value. Again, the average interior temperature must remain within the allowed layover temperature range during the entire four-hour period.

3. Steady state heating at design conditions test

a. Following the layover verification test, the nominal voltage supply is reapplied and the car is placed in its normal mode, with all car doors and windows closed. Fresh air dampers shall operate per control logic.

b. The time required for the system to raise the interior air temperature to 70°F (21°C) ± 2°F (1°C) shall be recorded, as well as the time for stabilization. Stabilization shall be when the temperature swing at each of the interior car thermocouples, including all spaces such as cab, and toilet room, stay within ± 3°F (-2°C) per hour. Once stabilized conditions have been reached, the test operation shall be continued for 30 minutes with temperatures, pressures, electrical and humidity data recorded at one-minute intervals in order to evaluate temperature variations and interior humidity requirement as the controls and equipment cycle. The interior comfort requirements of Chapter 10 shall be met, and no heater guard temperature shall exceed the specified maximum, 125°F (52°C) during the entire test.

4. Steady state heating (minimum voltage)

Upon completion of the steady state heating at design conditions test, the applied voltage shall be reduced to its lowest allowable value. Again, the system shall stabilize the interior air temperature to 70°F (21°C) ± 2°F (-1°C). Once stabilized conditions have been reached, the test operation shall be continued for 30minutes with temperatures, pressures, electrical and humidity data recorded at one-minute intervals in order to evaluate temperature variations and interior humidity requirement as the controls and equipment cycle. The interior comfort requirements of Chapter 10 shall be met, and no heater guard temperature shall exceed the specified maximum, 125°F (52°C), during the entire test.

5. Door cycling test (heating)

At the same conditions following the steady state heating (minimum voltage) test, the doors shall be cycled on one side of the car at a rate of 2 minutes open and 15 minutes closed for two hours. The average car temperature shall recover within 2°F (-17°C) of the required interior car temperature within three minutes maximum after each door closing.

6. Steady state heating tests

a. Upon completion of the door cycling test, the doors shall be closed, the nominal voltage shall be re-applied and the maximum design passenger load passengers shall be introduced into the car. Again, once stabilized conditions have been reached, the test operation shall be continued for 30 minutes with temperatures, pressures, electrical and humidity data recorded at one-minute intervals in order to evaluate temperature variations and interior humidity requirement as the controls and equipment cycle. The interior comfort requirements of Chapter 10 shall be met, and no heater guard temperature shall exceed the specified maximum, 125°F (52°C), during the entire test.

b. This test shall be repeated at the applied voltage reduced to its lowest allowable value and at the applied voltage increased to its highest allowable value.

c. Upon completion of the steady state heating test (with design passenger load), the nominal voltage shall be re-applied, and the design solar load shall be introduced into the car. The climate chamber ambient temperature shall be raised and maintained at 42°F (6°C). Allow the system to stabilize the interior air temperature to 70°F (21°C) ± 2°F (1°C). Once stabilized conditions have been reached, the test operation shall be continued for 30 minutes with temperatures, pressures, electrical and humidity data recorded at one-minute intervals in order to evaluate temperature variations and interior humidity requirement as the controls and equipment cycle. The interior comfort requirements of Chapter 10 shall be met, and no heater guard temperature shall exceed the specified maximum, 125°F (52°C), during the entire test.

7. Overhead heater safety tests

The overhead heater protection devices shall be tested with restricted and with no airflow. All protection devices and backup protection devices protecting the heaters and housing from overheating shall be tested individually. The tests shall be conducted at nominal voltage supply with an ambient temperature maintained at 40°F (4°C), and then repeated at the applied voltage reduced to its lowest allowable value and at the applied voltage increased to its highest allowable value. The overhead heater shall be activated independently of the normal regulating controls. Temperature measurements at the devices and heater power measurements shall be taken throughout each test. After the functioning of the device, temperature measurement records shall be continued until steady temperature fall is observed. Each test shall be considered satisfactorily completed if the protection device under test has functioned as intended, backup overheat protection devices do not actuate, there is no damage to any equipment or component, and there is no smoke or significant odors detected. When the last level of backup protection device is tested, the test shall be considered satisfactorily completed if the protection device under test functioned as intended, there is no damage to any equipment or component, and there is no smoke or significant odors detected.

8. Freeze protection tests

a. The operation of the door threshold, door pocket, water tank and water drain valve heaters shall be demonstrated in the climate chamber. This test begins with the car in a stabilized automatic heating condition with an ambient temperature of 60°F (16°C). The car is then placed in its layover mode and the ambient temperature reduced to -30°F (-34°C) at a rate of change not to exceed 20°F/hour (11°C/hour), no internal loads and the antifreeze protection circuit energized.

b. With the HVAC system operating in automatic mode, cycle the doors on one side of the car open and closed at the same rate as for the door cycling tests. When the doors are closed, spray water at 33.0°F (0.5°C) onto the lower half of at least one pair of doors and the door threshold.

c. Continue this operation for one hour. The door thresholds must remain free of ice, door pocket drains must drain freely, and doors must open and close smoothly for the entire test period.

d. Repeat the test using an application of simulated snow. Snow may be made prior to test and applied by hand to the threshold when doors are open, closed or both. The snow may be hard packed to simulate tracking in on footwear or may be spread out to simulate natural snowfall.

e. Verify that the freeze protection for the water tanks and water drain valves is working correctly and record the temperature that the systems turned on and verify that no section of the system freezes. Following the Freeze Protection Test, the nominal voltage supply is reapplied, and the car is placed in its normal mode. Verify that the freeze protection systems for the water tanks and water drain valves continue to function as specified.

f. After 2 hours of operation at -30°F (-34°C), remove power from the car and ensure that the automatic drain valves fully drain all pipes and tanks at the correct temperature and protects the system from damage.

9. Cab heating tests

   The operation of the cab heater and cab windshield defroster/defogger system shall be demonstrated in the climate chamber. Cab heater tests shall include overheat protection safety tests.

10. Equipment room heater test

    The operation of the equipment room heater system shall be demonstrated in the climate chamber.

19.05.09 Lighting

A. The function and intensity of all lighting systems shall be tested in the first car of each type to verify compliance with the requirements.

B. Lighting fixture performance

   1. Light level of each fixture shall be measured and compared to the design requirements.

   2. Temperature of surfaces exposed to passengers/crew shall be measured to verify compliance with specification.

C. Ballast qualification

   Performance of all electronic ballasts shall be verified.

D. Independent power sources (for emergency lights)

   Performance shall be verified in all modes of operation. Charge and discharge time shall be measured.

E. Marker light certification

   The marker lights and fixture shall be tested to verify compliance with FRA 49 CFR Part 221.

F. Lighting intensity-interior

   Test shall verify light levels are in accordance with APTA PR-E-RP-012-99 and this specification under all lighting modes as specified.

G. Headlight and Auxiliary light certification

   Test shall verify headlight and auxiliary light levels comply with 49 CFR Part 229.125 and Part 229.133, respectively.

H. Lighting intensity-exterior

All other exterior lights, such as door and brake system indicators, shall be tested in accordance with the requirements as outlined in their respective Chapters.

I. Emergency lighting intensity and duration

The test shall verify light levels and duration of each car type are in accordance with APTA Standard PR-E-S-013-99 Revision 1, 49 CFR Part 238.115 and any additional requirements of the specification. Tests shall be conducted in both Normal and Emergency modes and compete operation of independent power sources, including recharge times.

19.05.10 Communication

A. The communication system shall be tested on the first car of each type to verify that it functions in accordance with the requirements of Chapter 12 of the specification. The diagnostic function of each individual system shall be tested as a separate test or in combination with other functional testing. The PTU shall be used to successfully access all available car subsystems. The capability to modify all password-protected software parameters shall be verified. The interface and functionality of the Vehicle Monitoring System (VMS) and the Train to Wayside Communication (TWC) capabilities shall be tested. Testing shall be conducted to ensure that car faults can be downloaded over the network and that the OTIS/PIS system database can be updated, the VMS and TWC systems shall be fully functionally tested.

B. PA/IC system performance

The performance of the public address and passenger intercom system shall be tested to verify that all aspects of the system perform as intended:

1. System selector switch function and indication
2. PA announcements to the car interior only
3. PA announcements to the car interior and to other cars in the train
4. PA announcements received from other cars in the train via Ethernet Train Backbone and 27-pin COMM trainline
5. PA interface with the CCU and the passenger information system
6. Intercom function between IC stations within the car and between the car and other cars in the train via Ethernet Train Backbone and 27-pin COMM trainline
7. Speaker volume and intelligibility (STIPA), including interior and exterior speakers, quiet mode, and the performance of the automatic noise sensing functionality.

C. Display Signs and Dynamic Advertising System

D. Automatic Passenger Counting System (APC)

The performance of the Automatic Passenger Counting system shall be tested to verify compliance with National Transit Database requirements for accuracy while in revenue service. Tests hall verify operation of the complete system requirements, including data offload, real-time reporting, and data analysis.

E. Video Surveillance System (VSS)

Tests shall verify operation of the entire integrated system hardware and software. They shall show correct interpretation of each input and the amount of data collected and length of retention. Video

focus, resolution, low light performance, and other inputs shall be demonstrated. All modes of downloading shall be demonstrated. Software demonstration shall include validation of inputs and their calibration as a "real time" display as well as data analysis software playback. Operation of self-test and health monitoring functions shall be demonstrated.

F. EMI/EMC

The test plan shall meet the requirements of APTA Standard PR-E-S-010-98, plus any additional requirements of the specification. All modes of operation shall be tested.

G. Wayside equipment tests

1. Each wayside and Control Center component of the communications system installed under this Contract, including the radio system, GPS, OTIS/PIS, the Train to Wayside Communication (TWC) system, and all other communications and interface with the wayside shall be tested to verify that they function in accordance with the requirements. The ability to modify software data files and change parameters for the wayside communications system equipment shall be successfully demonstrated. The interface and functionality of the car VMS and OTIS/PIS with the TWC system and wayside server system shall be fully tested. Testing shall be conducted to ensure that car faults can be downloaded over the LAN and that the OTIS/PIS system database can be updated.

2. Each component of the communications system, including the GPS, OTIS/PIS, and TWC, shall be tested to verify that they function in accordance with the requirements. Wayside simulations shall be performed as approved by the Engineer to fully verify all functions. All equipment which is installed under the Contract on the Engineer wayside or the Engineer Control Center shall also be tested to verify compliance. The ability to modify software data files and change parameters for the communications system equipment shall be successfully demonstrated.

19.05.11 Electrical

A. Electrical load/phase balance/power factor

One completed car of each type shall be tested to determine the actual electrical loads, their phase balance and power factor. This shall be done under at least three different conditions: maximum heating load, maximum cooling electrical load and ventilation. These values shall be used to verify specification compliance.

B. Trainline tests

1. Trainline tests shall be conducted at both ends of the first cars of each type. All receptacles for the HEP, MU and COMM trainline circuits shall be tested for proper functionality using a trainline test unit.

2. The first two cars shall be coupled together on the Contractor's test track, and all trainline functions, including coupling and uncoupling and diagnostic messages, shall be tested to verify correct operation.

C. Battery and battery charger tests

1. Tests of battery capacity and the battery charger shall be made to show compliance with their requirements. The ability to charge the batteries and support other low voltage loads shall be verified. The capacity of the battery to support essential loads for the required time upon loss of HEP output shall also be verified. The ability to check the battery fluid levels and refilling shall be demonstrated.

2. Battery capacity

Battery on each car type shall be tested to demonstrate specification compliance.

3. Battery/battery charger performance

   The battery and battery charger shall be tested to measure charge/discharge characteristics of the overall system. This shall include: 24-hour charge with DC loads active; discharge to load shed; recharge for 24 hours. Strip chart or Data Acquisition system- type instrumentation shall monitor battery voltage and load and battery current over the entire interval. The system shall be tested to verify fault coordination between battery charger, battery and main DC circuit breakers and the ability to support large step loads on car, such as door operators cycling.

4. Battery tilt and shock

   Verify each battery type complies with the 45-degree tilt and 8g/4g/4g acceleration requirements of 49 CFR Part 238.115.

D. Ethernet Train Backbone and Ethernet Car Network Integration Tests

1. The Contractor shall perform Network Interface Card (NIC) test of each end station and switch connected to the Ethernet Train Backbone or Ethernet Car Network to verify compliance to IEEE standards.

2. The Contractor shall perform a complete network integration test of all train subsystems, including transmission through the ETB jumper to determine the network noise limits, and to pre-qualify the proposed architecture of the networks before vehicle implementation. The test shall consist of a simulated 1 car train with all train switches, actual cable and cable length, jumper assemblies and connectors that will be used on the vehicles. All intelligent system controls connected to the Ethernet Car Network shall be the actual units in one cab car and one trailer car, the other cars may use simulated traffic generators. The tests shall verify that the protocols, datasets, and messages used on all networks correspond to the Network Interface Control Document, and that the specific signal, message and dataset documentation has been provided for each network. At the time of the integration tests, the Contractor shall also demonstrate fault tolerance of all networks by simulating all possible faults. The Engineer shall have the option of witnessing the tests. The test procedures and test results shall be submitted to the Engineer for review and approval.

E. Vehicle Monitoring System Integration Tests

1. The VMS shall be subject to performance, qualification, factory acceptance, and reliability testing per procedures generated by the Contractor and submitted to the Engineer for review and approval.

2. A combined factory level system test shall be conducted on one complete set of VMS equipment and subsystem control units networked over the Ethernet Car Network to simulate an 8-car train prior to the VMS first article inspection. The combined factory level test shall include a Fault Management Qualification test, network and VMS capacity test, PTU operational verification test, VMS performance test, and an integration test of the completed VMS. The test shall include subsystem reporting to the VMS, Fault Display, PTU operation and snapshot configuration and retrieval, and other VMS functions as defined by the specification. The test shall verify reporting within a single car, as well as fault reporting, display, and controls over the Ethernet Trian Backbone. The test shall include verification that the display status, help, and maintenance screen perform as specified. The combined test shall also verify proper display of train composition and display of failed cars. The combined factory level test procedure and report shall be submitted to the Engineer for review and approval.

3. The Contractor shall develop and conduct a functional test of an installed VMS on the pilot cars to verify all features and components are in compliance with the requirements.

19.05.12 Water and Waste

A. Water and waste system performance

1. A set of equipment that simulates the fresh water distribution and waste retention systems on a car shall be assembled and connected to operate. The system shall be piped to simulate actual car piping.

2. The proper operation of the following shall be verified:

   a. Performance of all system components and controls in normal and standby mode

   b. System pressures, temperatures and flow rates

   c. Safety controls

   d. Backflow prevention devices

   e. Tank level indications

   f. Vacuum levels attained and maintained

   g. Flush valve life cycle

B. Water and Waste Qualification Test

One of the first cars shall be qualification tested to ensure compliance with this specification and proper functionality of the system. The test procedure shall be submitted for review and approval by the Engineer. It shall include a full range of testing, including the following minimum requirements:

1. Full and complete flushing of toilet bowl

2. Water and waste tank level requirements, including indicators of tank level and disabling of the system when the water tank is empty or the waste tank is full

3. Full/complete emptying of waste tank demonstration

4. Water tank filling demonstration

5. Water and waste tank removal demonstration.

6. Verification of proper mixing of hot and cold water at sink.

7. Verification of proper pressure at sink.

8. Full and complete collection of gray water in the waste tank.

9. System pressure and vacuum level adjusting/fine tuning.

10. Noise levels in compliance with this specification

C. Water and Waste Cold Condition Qualification Testing

During the HVAC system climate room test, the freeze protection system shall be proven to function correctly at the lowest ambient temperatures listed in this specification.

1. The system shall maintain all components and pipe runs containing liquid and the dump valve above at no less than 40°F (4.4°C).

2. Heating equipment shall be verified to cycle on/off as required.

3. The system shall be given a complete functional test at these conditions.

4. Power shall be removed from the vehicle and the dump valve protection shall be tested. All liquid shall drain from the system. Verification that no remaining liquid remains in the system shall be demonstrated.

19.05.13 Cab and Controls

A. Train control, event recorder, train data system and video camera

The train control system, event recorder, train data system and associated components shall be subjected to qualification tests to verify that they comply with the requirements. As a minimum, these tests shall include complete functional tests before and after the equipment is subjected to the simulated environmental conditions such as appropriate extremes of temperature, vibration and shock. Tests shall also confirm resistance to interference limits as specified. Equipment so tested shall conform to the manufacturing drawings. All modes of operation shall be verified for the equipment such as low light performance of cameras and ECP data recording in ECP mode as necessary.

B. Operation of positive train control

1. The Contractor shall develop proof-of-design test procedures that validate all systemic, operational and programming designs, functions and requirements for the Positive Train Control (PTC) system, including component performance, integrity of system architecture, data collection and retention functions, and train status evaluation. These procedures shall be developed in accordance with system requirements as established by the system manufacturer, the FRA and railroads, and shall include evaluation and verification of compliance with requirements for:

   a. Accurate determination of train location, speed, direction of travel and status of all operating systems;

   b. Communication to wayside signal systems and railroad data centers;

   c. System monitoring of train performance;

   d. Display of graphic data as received from the railroad;

   e. Initiation of service or penalty brake applications and locomotive PKO functions;

   f. Interface between the PTC system and on-board systems, including event recorders, train monitoring systems and others;

   g. Data recording, security and download requirements; and

   h. Compliance with all applicable regulations, standards and system requirements.

2. Additional railroad-specific data transfer and uploading to the system may occur after the cars have been delivered to the Engineer if necessary. The PTC system as designed and installed shall be subject to review and approval by the Engineer, the FRA, Amtrak and representatives of the host railroads over which the cars will operate.

C. Cab audio alarm levels performance

The audio level of all cab alarms: loco failure, wheelslip/brake warning, alerter, overspeed, PTC and conductor signal shall be tested to verify suitable loudness.

D. Event recorder (FRA) performance

Tests shall verify proper operation of the entire integrated system hardware and software. They shall show correct interpretation of each input, including combinations (such as throttle) through the use of the verifier function on a laptop. Resolution, set point and calibration of all analog inputs shall be shown at zero, midscale and maximum values, which will include applying pneumatic pressure to those inputs by manipulating the brake system and agreed ECP message data. All modes of downloading shall be demonstrated. After downloading, graphic and tabular readings shall be compared in detail to verify all channels show activity consistent with the test code and that graphic and tabular values of analog functions match: speed, brake pipe, brake cylinder pressures at zero, full scale and mid-scale values. Operation of self-test and health monitoring functions shall be demonstrated. An electronic download, labeled for car number and date, shall be provided for each car.

E. Horn and bell performance

1. The horn shall be tested to verify compliance with FRA 49 CFR Part 229 loudness requirement.

2. The bell shall be tested to measure loudness and proper continued operation.

19.05.14 Pilot Car and Pilot Train Testing

A. Roll angle tests

The first pilot car, simulated to be at AW3 load, shall be placed upon a super elevated track to determine compliance with the clearance requirements by verifying the Contractor's clearance diagram despite any body roll and lateral shifting of the car body. The static lean allowance shall also be tested at both AW0 and AW1 load to verify compliance under all specified suspension conditions. In addition, tests shall be performed at AW0 load on a superelevation of both 5 in. (127 mm) and 6 in. (152 mm) to measure body roll and wheel unloading to verify compliance with 49 CFR Part 213.57(d). The Contractor shall provide a test report providing all data required by 49 CFR Part 213.57, and shall fully support Engineer’s submission to the FRA with additional information as requested by the FRA.

B. Pilot cars

1. Pilot car testing refers to the test of the first four cars (one cab and three trailers) at the Contractor's final assembly facility prior to shipment. To implement pre-delivery testing of the pilot cars, the Contractor shall provide at its assembly facility a test site on which the specified tests can be conducted. In addition, this site shall be equipped with locomotive HEP power simulation with which it shall be possible to test performance.

2. Pilot train testing

   a. After the pilot cars have undergone and passed all applicable proof-of-design and production testing requirements, the four cars shall be combined to form the pilot train for car-to-car operational, compatibility and coupler tests.

   b. All trainline functions shall be tested and verified, including:

      i. Door control, door system status and traction inhibit

      ii. End of train identification

      iii. Locomotive control

      iv. PA, IC and PIS communications and data transfer

v. HEP and power distribution

vi. Air brake application and release in ECP and Emulation Modes

c. The pilot train shall be tested to confirm compliance with track geometry requirements, including curve and crossover negotiation. All car-to-car connections shall be verified as performing in compliance with the track geometry requirements, including:

i. Carbody clearance

ii. Truck swing

iii. Coupler swing

iv. MU, COMM and HEP cables

v. Brake pipe and main reservoir air hoses

vi. Diaphragms, buffer plates and diaphragm curtains

d. The clearances between the carbody and the trucks, between the carbody and the couplers, and between cars shall be checked on all pilot cars by methods which place the relevant components in the correct angular relationship corresponding to the worst case conditions to be incurred by operation in the static car envelope. In addition to demonstrating adequate mechanical clearance of the major elements involved, this test shall demonstrate that no interferences or potentially damaging contacts or stress conditions occur between or to any parts of the car, including stops, wires, cables, or enclosures. Trainline cables shall not droop when under slack conditions such that they can potentially contact the ground, the top of rail, or other obstructions below the car's operating envelope.

e. The cars, with springs loaded statically to AW0 and AW3 conditions, shall be demonstrated by either testing (measured against a template, plumb line or other approved method) or analysis to confirm that the car conforms to the Contractor's designs and that all the specified clearances and static car envelope requirements have been met, both to wayside and rail. This test shall be performed successfully with each end of each car coupled to another car. Test results must verify compliance with the Contractor's clearance calculations and diagrams for a train of cars under all operating conditions. Test car(s) shall be selected so that all variations of car end configuration can be covered.

3. Pilot train compatibility testing

a. After the four pilot cars have undergone and passed the above, an existing single-level car will be coupled between two of the pilot cars. The single-level car from the Engineer's existing operational fleet will be provided at CTDOT for testing.

b. All trainline functions shall be tested and verified, including:

i. Door control, door system status and traction inhibit

ii. End of train identification

iii. Locomotive control PA, IC

iv. HEP and power distribution

v. Air brake application and release in Emulation Mode

c. The compatibility test train shall be tested to confirm compliance with track geometry requirements, including curve and crossover negotiation. All car-to-car connections shall be verified as performing in compliance with the track geometry requirements, including:

i. Carbody clearance

ii. Truck swing

iii. Coupler swing

iv. MU, COMM and HEP cables

v. Brake pipe and main reservoir air hoses

vi. Diaphragms, buffer plates and diaphragm curtains

d. The clearances between the carbody and the trucks, between the carbody and the couplers, and between cars shall be checked on the pilot cars and existing single-level by methods which place the relevant components in the correct angular relationship corresponding to the worst case conditions to be incurred by operation in the static car envelope. In addition to demonstrating adequate mechanical clearance of the major elements involved, this test shall demonstrate that no interferences or potentially damaging contacts or stress conditions occur between or to any parts of the car, including stops, wires, cables or enclosures. Trainline cables shall not droop when under slack conditions such that they can potentially contact the ground, the top of rail or other obstructions below the car's operating envelope. After completion of these tests, the existing single-level car can be removed from the test train.

4. High-speed testing

The Pilot Train shall be tested in accordance with the applicable requirements of 49 CFR Part 213.345 for vehicle testing on the track of a qualified test facility to be selected by the Contractor and approved by the Engineer. Testing shall begin at a speed of up to 50 mph (81 kph) and test speeds will be incrementally increased as described below. Test results shall be made available on the pilot train immediately after the completion of each test trip, and will be reviewed by the Engineer before the decision is made to proceed to the next higher speed increment. The maximum test speed shall be per 49 CFR Part 213.345 using the Pilot Train with a minimum of one instrumented car of each car type to be tested. Vehicles with minor variations in their physical properties that do not result in significant changes to their dynamic characteristics are considered to be of the same type for testing purposes.

5. Test instrumentation

a. Test instrumentation shall be provided by the Contractor to record all data necessary to demonstrate compliance with the acceleration limits identified in 49 CFR Part 213.345. Each of the instrumented cars on the Pilot Train shall be provided with one truck equipped with two Instrumented Wheelset (IWS) axles. The IWS-equipped truck shall be located at the cab end of the car and shall be located in the test train such that it is either the leading truck or trailing truck of the train, depending on the direction of movement. For orders with no cab cars, the instrumented car will be placed on the trailing end of the train. The IWS-equipped truck shall be the training truck of the test train. Tests shall be conducted in the trailing direction of movement only. Friction brakes on the IWS-equipped truck shall be cutout for the duration of testing.

b. Each truck on each instrumented car shall be equipped with two lateral accelerometers, mounted on the truck frame at diagonally opposite locations along the vertical line passing through the center of the journal bearing. All instrumented cars shall also be equipped with three carbody lateral and vertical accelerometers. They shall be located on the interior floor, on the car longitudinal centerline, above each carbody bolster and at the middle of the car.

c. A GPS location system shall be used during testing to accurately report the location of the IWS trucks. This may be done by use of the existing destination sign system GPS, or by a separate GPS system for testing, in which case the GPS antenna shall be located on the roof of the IWS-equipped car. An accurate speed signal shall be provided in the data. This signal may be provided by the locomotive or cab car speed measurement system or by separate

test instrumentation. The speed signal data and the cab speedometer display shall agree to within 1 percent across the entire speed range.

6. Data collection and reporting

   a. The Contractor shall provide carborne test equipment capable of recording all data required, analyzing these data for compliance with FRA criteria and reporting results to test train personnel in graphical form. Results will be reviewed on the test train for acceptability by the Engineer before the decision is made to move to the next higher test speed. Reports for a given test trip may be generated as a series of data packages, each covering a distance of approximately 2 miles (3 km) to 5 miles (8 km).

   b. The reporting software shall be capable of generating the following for each data package:

      i. A time and date stamp.

      ii. A graphical depiction of train location and speed by railroad milepost.

      iii. A graphical depiction of the various wheel/rail force signals and the truck acceleration and carbody acceleration signals. It shall be possible to directly correlate these signals with the location, speed and time/date data. The location of the worst-case data in each data set shall be indicated.

      iv. A summary report of the worst-case values recorded for the IWS wheel/rail force criteria, and the truck acceleration and carbody acceleration data. Any values which are in excess of those allowed by FRA shall be flagged as exceptions.

   c. Exception reports shall be provided for all events flagged as exceptions. These reports shall include the values recorded plus a close-up view of the data signal associated with each exception.

   d. Data packages shall be available within 10 minutes after collection of test data. Simultaneous data collection and report generation shall be required. All necessary calibration data, sign conventions, sampling rates, headers, etc. required to process the data shall be included in the report. Data shall be provided to the Engineer in both paper and electronic media which shall include all software required to format, process and graphically view the test data.

7. Test reports

   The Contractor shall prepare the required final test reports for submission to the FRA by Engineer. This shall include the track geometry data for the test zones, which accurately reflects the state of the track condition at the time of test. The Engineer reserves the right to require additional vehicle modeling, instrumentation and/or testing if test results show failure to comply with the FRA requirements for operation at any speed below 125 mph (201 kph), or if additional dynamic behavior which may present a safety issue is observed.

8. Noise and vibration tests

   a. The interior and exterior noise levels and vibration levels of the pilot cars shall be measured to prove compliance with all specification requirements. Interior noise measurements shall be made with all car systems operational while operating on level tangent track from standstill to 125 mph (201 kph) and back to zero speed using service braking to demonstrate conformance to the requirements in Section 9.9.1, Interior Noise Levels (Passenger Areas) and Section 19.5.14.2.7, Noise and Vibration Tests. The sound level meter shall conform, as a minimum, to the requirements of ANSI Standard S1.4, Type 2, and set to an A-weighted slow response or with an audio dosimeter of equivalent accuracy and precision.

b. In conducting interior sound level measurements with a sound level meter, the microphone shall be oriented vertically and positioned to simulate the location of a seated passenger or Operator's ear. Measurements with an audio dosimeter shall be conducted in accordance with manufacturer's procedures as to microphone placement and orientation.

c. Measurement of the sound level of the horn shall be made using a sound level meter conforming, at a minimum, to the requirements of ANSI Standard S1.4, Type 2, and set to an A-weighted slow response. While the car is on level tangent track, the microphone shall be positioned 4 ft (1219 mm) above the ground at the center line of the track and shall be oriented with respect to the sound source in accordance with the manufacturer's recommendations. A 4 dB(A) measurement tolerance is allowable for a given measurement.

d. Vibration tests shall be made with all car subsystems operating, with the car stationary.

9. Friction brake performance tests

The friction brake system on one of the pilot cars shall be tested to demonstrate that it meets the requirements. The brake disc, brake pad, brake shoe and wheel temperature shall not exceed the supplier's working range, defined as that within which the material is capable of meeting the specified performance and tolerances. Successful completion of all of the preceding tests and acceptance of the test results by the Engineer will be required for final approval of the friction brake system.

10. Ride quality tests

a. To verify conformance to the ride quality requirements, one of the first pilot cars shall be subjected to ride quality road tests. At a minimum, the ride quality tests shall consist of testing of one or more cars on minimally compliant track that conforms with all FRA track standards for the classes of track over which the cars are designed to operate. The car or cars shall also be tested on a major segment of track over which the cars are intended to operate in revenue service, making all local stops while operating at normal scheduled speed, under AW0 and AW1 load conditions. The Contractor shall prepare a ride quality testing plan for submittal to the Engineer for review and approval, specifying the start and end points, speeds, test methodology, measurement parameters and criteria, and method of instrumentation for the ride quality tests. Results from previous ride quality tests that closely simulate the Engineer’s revenue service environment may, at the sole discretion of the Engineer, be accepted in lieu of additional ride quality testing.

b. The results of these tests shall be compared to the results from the modeling performed as specified in Chapter 5.

c. Instrumentation capable of measuring and charting (for permanent record) the magnitude and frequency of the vertical and lateral shocks expected, up to 1.00 g and 0.5 to 50 Hertz, shall be provided and operated by the Contractor, who shall reduce the raw data for presentation to the Engineer. Sensing units shall be located on the car floor above the intersection of the car longitudinal center line and each truck transverse center line. Weights used in simulating the AW1 load, as well as their loading and unloading, shall be provided by the Contractor.

d. In the event that the dynamic behavior of the cars is non-compliant in any respect with the requirements, the Contractor shall submit to the Engineer, within 60 calendar days, a program containing mathematical analysis of the problem and a course of action for its correction. If the Engineer approves the analysis and corrective measures, those corrective measures shall be made effective on the pilot cars within 90 calendar days at the expense of the Contractor, the car shall be retested, and if the measures are successful, they shall be

applied to all the cars. If not, the analysis and correction steps shall be repeated, resubmitted and retested until success is attained.

19.06 Production Tests

19.06.01 General

A. As a minimum, the tests listed in this section shall be performed on each car (including all pilot cars) prior to the issuance of a release for shipment document by the Engineer. The Contractor's production conformance test shall include all tests and adjustments which can be made prior to delivery in order to keep car acceptance testing and adjustments at Engineer to a minimum.

B. After completion of each car, the Contractor shall demonstrate that each car subsystem is operational and that each car and cab can properly control a train. The Contractor shall also demonstrate that all cab controls and cut-outs and bypass switches function correctly. The following static tests where power is required on the car shall be conducted by applying a supply voltage to the trainline cables to the car and functionally testing all car systems.

C. The test procedure shall include and use a check-off list that shall become a record that all systems have been actuated and have functioned as required. This is particularly required for all protective and safety related devices. All equipment final adjustments shall be made prior to car shipment. After completion of each car, the Contractor shall demonstrate that all discrepancies logged against the car during its construction and test period, by either the Contractor’s own inspection forces or Engineer’s inspectors, have been suitably resolved to the Engineer’s satisfaction.

D. After the installation, connection and cleaning of all piping as specified, the piping shall be pressure tested in accordance with the latest edition of the Code for Pressure Piping, ANSI B31.1. All leaks which appear during pressure testing shall be repaired, after which the system shall be retested until leak-free.

E. All air, water, waste system and HVAC pipework, hoses and fittings shall be properly cleaned, purged checked for leaks with all systems in operation and any faults rectified.

F. All equipment on each car (including all pilot cars) shall be given tests for proper operation and conformance, at the manufacturer's facility prior to shipment to the Contractor. All equipment shall also be given a functional test (pre-delivery) on the completed car to test for proper operation, by the Contractor prior to issuance of a release for shipment document by the Engineer. The test to be performed by each manufacturer and the Contractor on each car component or subsystem shall be in accordance with the applicable industry standards listed in this Technical Specification and the approved test plan. The following tests in this Section list some but not all of these tests to be performed; all Technical Specification requirements must be achieved in any case. The test reports of all tests shall become the property of Engineer and be included in each vehicle history book as specified. This is in addition to, and is not to replace, the Contractor's and suppliers' QA plans.

19.06.02 Carbody

Watertightness tests

A. Each car shall be tested for watertightness in both the completed shell and assembled car stages prior to pre-shipment.

B. Water shall be sprayed from nozzles which are spaced no more than 3.0 ft (914mm) from, and aimed directly at, the roof and sides of the car, with the side wall nozzles continuing in a vertical plane to 1.0 ft (305 mm) above top of rail. Not less than 0.63 gpm (2.37 L/min) shall be delivered to each

square foot of surface being tested, and the nozzle velocity of the water shall not be less than 150 ft/sec (46 m/sec). All spray applications shall run for 10 minutes before the inspection for leaks and shall run continuously during the inspection.

C. During the shell watertightness test, all areas of the sides, ends and roof of each car shall be given a complete test for watertightness. The tests shall be made before installation of sound deadening material, thermal insulation and interior finish.

D. Water spray - bare car shell (watertightness test)

Each car shell shall be sprayed with water, simulating the conditions at the rated speed of the car, to verify there are no leaks in the joints. All surfaces shall be sprayed. This shall be done before the application of any sound deadening material or thermal insulation. Openings, such as doors, windows, etc, shall be closed off by suitable means, such as blanking plates, during testing. All spray applications shall run ten minutes before and continuously during the inspection. Test arrangement is subject to Engineer approval.

E. Water spray - completed car

Each completed car shall be sprayed with water, simulating the conditions at the rated speed of the car, to verify there are no leaks. Of special interest are the door and window openings and any roof penetrations, such as those for antennae. Water shall be directed at the F-end to verify there are no leaks there, especially at the end door. All spray applications shall run ten minutes before and continuously during the inspection.

19.06.03 Truck Tests

A. All trucks

1. Trucks (including the frame, bolster and any primary structural members) shall have their fabrication techniques qualified by means of a complete radiographic inspection of the entire structure. If determined by the Contractor and agreed to by the Engineer that radiographic methods are not practical for some areas, then the inspection in these areas shall be performed using both ultrasonic and magnetic particle inspection methods approved by the Engineer. Castings shall be radiographed in accordance with requirements. Radiographs shall be made in accordance with either AWS Standard D1.1 or ASTM Standard E94-04. The radiographic inspection quality level shall be selected by the truck manufacturer to be consistent with the truck design but shall not be of lesser quality than that required by Appendix F of AWS Standard D1.1. If the first truck fails the radiographic/ultrasonic inspection, then the second shall be inspected, and this process shall continue until a truck passes the inspection. The production variables for the succeeding trucks shall duplicate those for the truck which passes the above inspection.

2. After qualification in accordance with the preceding, all exposed welds and entire castings of all steel castings used for succeeding trucks shall be subjected to magnetic particle or dye penetrant inspection. Magnaflux shall use a no-yoke probe only. All critical welds, and critical areas of the sampled castings shall also be inspected by radiographic methods using a sampling frequency proposed by the Contractor and submitted to the Engineer for approval (for castings, typically one casting out of each 25 produced shall be inspected) [CDRL 19-008]. If determined by the Engineer that radiographic methods are not practical for inspection, then critical welds, and critical areas on sampled structural elements shall be inspected using ultrasonic and/or magnetic particle inspection techniques. Magnetic particle inspection shall be in accordance with ASTM Standard E709-08 or approved equal. Dye penetrant inspection shall be in accordance with ASTM Standard E165-02 or approved equal. Critical welds shall be as identified by the truck manufacturer and approved by the Engineer, and shall include, as a minimum, all assembly welds and welds or portions of welds which, based on the results of the stress analysis and/or truck

tests, are expected to be critical in fatigue. Critical areas of castings shall be identified in a similar fashion. Critical areas of each truck frame and truck bolster shall be inspected as required.

B. Truck weight

Each completed truck assembly shall be weighed, and the weight of the truck assembly recorded on a truck weight certificate, prior to installation of the trucks under the carbody. The completed truck shall include all truck-mounted equipment, including handbrake linkage if so equipped, but shall not include secondary suspension components or truck-to-carbody air hoses. The serial number of the truck frame shall be included on the truck weight certificate.

C. Carbody leveling and floor height

1. Each completed car shall be leveled and measured to verify correct truck setup adjustments, that the car is level, has the correct floor and diaphragm buffer plate heights and diaphragm curtain heights. Measurements shall be taken with the car on calibrated track.

2. Truck attachment, leveling and coupler height tests

   a. All mechanical, electrical, pneumatic and hydraulic connections between the trucks and the carbody shall be checked. The AW0 car floor height/car level and the coupler height shall also be verified.

   b. The height of each corner of the carbody shall be measured from the top of rail on a level section of track to check for proper carbody level with all suspension components at proper design height. Side-to-side differences in height shall not exceed 0.25 in. (6.35 mm). End-to-end differences in height shall not exceed 0.5 in. (12.7 mm).

19.06.04 Couplers

Coupler height and operation of each car shall be verified, including clearance and operation of the uncoupling rods and full opening of the knuckle by the uncoupling rods.

19.06.05 Brakes

A. Single car brake and pneumatic system operation

1. The brake system and auxiliary air system of each car shall be tested for leaks. The AAR S471 Ball Test shall be conducted on the Brake Pipe. A functional test that exercises each function of all brake system valves and components shall be conducted in accordance with the OEM recommendations. Pneumatic brake applied indicators and the brake applied/released indicators shall be tested. Tests shall include auxiliary air system functions, such as the governor and regulator for water rising (if equipped). In addition, all requirements of APTA Standard PR-M-S-005-98 Revision 4 (current revision on date of test) shall be met, including ECP trainline functionality.

2. The Contractor shall perform on its test track a complete functional test of the friction brake system prior to shipment of each car. This shall include, as a minimum, a single-car air test, in compliance with FRA requirements, as well as, a test of brake cylinder pressure settings, control and indicator checks, leakage tests and handbrake test.

B. Hand brake operation

The hand brake of each car shall be tested to verify that, when applied, the brake shoe is in contact with the wheel and that the hand brake indicator properly displays the hand brake status.

C. Wheelslide control system operation

The wheelslide control system shall be tested on each car to verify correct speed sensor air gaps, correct end-for-end wiring of sensors and dump valves, and self-test functions of the controller, with the car on air to actually exercise the brakes. Speed signal interfaces for the door system shall also be tested.

19.06.06 Door System Tests

A. All door equipment and their operating systems shall be completely functionally tested before shipment from the door supplier, and a complete functional test of the entire door system shall be performed after final car assembly.

B. The doors shall be checked and adjusted on all cars to ensure smooth functioning, proper fit, attainment of the specified speed of operation and proper functioning of controls, signals and interlocks. All power operated side doors and sliding end doors shall be operated a minimum of 800 consecutive, separate successful cycles. Initiation of the cycling shall be through the trainline external from the car. Proper adjustments for opening and closing shall be checked on every door before and after the above test. Improper adjustment at the end of a test shall require the test to be repeated. Any door or door control failure occurring prior to completion of the test will nullify the test, requiring that it be repeated from the beginning following correction and documentation of the failure.

C. Door safety systems

All doors shall be individually tested to confirm correct operation, including all indicators, audible signals and interlocks, from the cab, from the individual local door pushbuttons and when obstructions are placed in the door. Tests shall also be performed to confirm correct operation of all interior and exterior manual door opening/passenger emergency facilities, interlock bypass switches and crew door switches.

19.06.07 Interior

Interior doors and hardware

A. All interior doors and hatches shall be functionally checked on each car to verify: smooth movement, latching, locking, unlocking from external side of door, correct latch engagement/release, proper operation of detente, non-interference, freedom from sticking or excessive looseness (rattles) and proper switch activation. Force to overcome the detente used on sliding toilet room doors shall be measured.

B. Proper engagement of the ceiling hatch safety catches shall be checked.

19.06.08 HVAC

A. Heater circuit tests

Each heater circuit shall be high potential tested in accordance with IEEE Standard number 16.

B. Heating tests

1. The heating system, including cab, doorway and protective heaters, shall be functionally tested in all cars. The operation of the thermostatic control system and layover heating shall be demonstrated by test. Controls shall be checked and adjusted for even distribution and proper volume of heat.

2. Duct heater operation

Duct heat of each car shall be verified for function, uniform temperature distribution and correct current draw.

3. Duct heater shunt trip operation

   Proper operation of each safety interlock of the duct heat control system shall be verified on each car. In addition, operation of the shunt trip feature of the circuit breaker shall be exercised by applying heat directly to the high limit thermostat of each heater assembly.

4. Floor heat operation

   Floor heat of each car shall be verified for function, uniform temperature distribution and correct current draw.

C. Air conditioning unit tests

Each refrigerant compressor shall be given an air pressure test. Each evaporator and condenser coil shall be proof pressure tested and each complete unit shall be vacuum tested, leak checked with an electronic sniffer, and pressure tested to the requirements. All pressure vessels shall have ASME certificates. Compliance to the random starting timing requirements in Chapter 10 shall be verified.

D. Air conditioning system tests

1. The air conditioning system shall be functionally tested in all cars. The thermostatic control system operation shall be demonstrated by test. All controls and dampers shall be checked and adjusted for even distribution and proper circulation of air. Refrigerant charge and compressor oil levels shall be verified. The initial fine mesh liquid line strainer shall be replaced with the proper mesh at the conclusion of testing.

2. Air conditioning system operation

   The air conditioning equipment on each car shall undergo an evacuation and leak test. For package units, this may be done at the supplier plant; however, a "sniff" type leak test shall be done on the car to verify no leaks have occurred as a result of shipping damage. The equipment on each car shall be checked to verify proper control response and function for all operational modes (partial cool, full cool, partial heat, full heat, etc.). In addition, motor currents shall be recorded for:

   a. Blower fan

   b. Condenser fan(s)

   c. Compressor

   d. Exhaust fan(s)

19.06.09 Lighting

A. Lighting operation

Proper function of all interior and exterior lighting fixtures and all their controls shall be verified on each car, unless those lights are tested as part of another subsystem, such as doors or brakes. This shall include operation in each lighting mode: normal, quiet car, standby, load shed and emergency modes as well as night. Adjustment of all limit switches controlling lighting shall be included. Test shall include verification operation of Independent Power Source functions.

B. Marker lights

Proper operation and aiming of marker lights shall be verified.

C. Headlights and Auxiliary Lights

Proper operation and aiming of headlights and auxiliary lights shall be verified.

19.06.10 Communication

A. The communication system tests shall be performed both on an individual car and while coupled to another car in consist.

B. Communications system tests

The entire communications system and components shall be tested for proper operation. During the testing all functions of the PA, Intercom (IC), PEI, APC, OTIS, Video Surveillance and all other communications equipment shall be exercised. The Contractor shall provide as approved by the Engineer a suitable simulation of the wayside as necessary to test all communications systems.

C. PA and IC system operation

The proper operation of the PA and IC system on each car shall be verified, including system selector switches and indicators, PA speaker volume and IC communication between stations and trainline communications into and out of the car.

D. PEI system operation

The proper operation of the PEI system on each car shall be verified.

E. OTIS / Destination sign operation

All modes of trainline operation shall be demonstrated, as well as interaction with the PA/IC system. The function used to advance the sign reading to the next message shall be demonstrated, using the actual input message to the system. Trainline functions of this system shall be verified.

19.06.11 Electrical

A. Electrical apparatus tests

Each component that is separately assembled, housed and wired into a package unit prior to installation shall be tested at its point of manufacture and a certified test report, signed by the responsible Quality Assurance representative of the manufacturer, shall be furnished to the Contractor with a copy to the Engineer. Tests shall be in accordance with IEEE Standard 16 for control apparatus as appropriate.

B. Battery tests

1. Battery and battery charger operation

   The overall DC power system of each car shall be tested to verify correct operation. This shall include battery charger self-test, verifying correct charge voltage and current of the charger, operation of the temperature sensor, load shed and all external indicators. The test shall include operation in which the battery supports the car loads for a minimum time, (i.e. 30 minutes)

2. Battery capacity

   Verify battery meets 5 hour name-plate rating.

3. Battery/battery charger performance

   a. The performance of the battery charger connected to the battery and a simulated car load, shall be tested to verify correct operation. This shall include battery charger self-test, verifying correct voltage control and current control modes of the charger, operation of the temperature sensor, load shed and drive to any external indicators. This shall include: 24 hour charge with DC loads active; discharge to load shed; recharge for 24 hours. Strip chart or Data Acquisition system type instrumentation shall monitor battery voltage and car load and battery current over the entire interval. The test shall also verify proper operation of the equipment during:

      i. Sustained low input voltage

      ii. Loss of input phase

      iii. Reversed phase rotation

      iv. Overload or shorted battery charger output

      v. Battery ground fault

      vi. Temperature sensor fault

      vii. Reversed battery connections

      viii. System overload

      ix. Fault coordination between battery charger system, battery and main DC circuit breakers

      x. Ability to support large step loads on car, such as door operators cycling

   b. Each battery shall be given a capacity test at the point of manufacture in accordance with APTA Standard PR-E-RP-007-98.

4. Battery and battery charger operation

   The overall DC power system of each car shall be tested to verify correct operation. This shall include battery charger self-test, verifying correct charge voltage and current of the charger, operation of the temperature sensor, load shed and all external indicators. The test shall include operation in which the battery supports the car loads for a minimum time, (i.e. 30 minutes).

C. Car wiring tests

1. Continuity

   On each car, all wiring shall undergo a continuity test in which wire labeling, continuity of conductor and proper connection points are verified.

2. Power distribution

   Power distribution of each car shall be tested including phase rotation, correct voltage of each transformer-derived voltage, polarity of DC at the load and correct feed by the respective bus.

3. Electrical insulation testing

   Electrical insulation tests shall be conducted on all applicable electrical components to verify the state of the insulation to the case, between wiring of different voltage classes, and between the input and output circuit of high voltage line switches and circuit breakers. Semiconductor devices may be protected against the test voltage by means of shorting jumpers if they are not inherently protected by the circuit in which they are used.

D. Insulation testing

1. All wiring on each car shall undergo a Megger and high potential test, in accordance with APTA Standard PR-E-S-001-98.

2. Insulation resistance tests shall be conducted before high potential tests are conducted.

3. On items with double insulation, such as grid resistors or heating elements mounted on an insulated frame or stand-off, each set of insulation shall be individually tested. (i.e., resistors to frame and frame to carbody.)

E. Trainline tests

1. The Contractor shall verify the accuracy of the trainline connections by use of a test panel which is connected to the trainline connectors at each end of each car. The test panel shall use the illumination of lights or other appropriate means to confirm that only the proper trainline wires are energized when the various car controls (public address system, doors, etc.) are operated, and that there are no shorted, crossed, incorrect or open circuits. This test shall exercise the controls in the cab cars, as well as all door control panels, PA controls, etc. All spare trainline circuits shall also be tested.

2. 480V HEP trainline

   The 480V trainline wiring shall be tested on each car to verify continuity of each power and control conductor and grounding of control contacts.

3. 27-Point communication trainline

   Through the use of a test fixture, the 27-point communication trainline shall be tested on each car to verify continuity of each conductor, freedom from unintended cross-connections and shorts. Proper operation of any device which interrupts a circuit, such as pressure switches or relays, shall be demonstrated. Operation of end-of-train relays shall be verified. Transmit/receive functions of equipment that is controlled by the trainline, such as side doors, shall be demonstrated by the respective system test.

4. 27-Point MU trainline

   Through the use of a test fixture, the 27-point MU trainline shall be tested on each car to verify continuity of each conductor and check for unintended cross-connections and shorts. Transmit/receive functions of equipment which is controlled by the trainline shall be demonstrated by the cab system test.

F. Convenience outlets

All 120VAC receptacles shall be tested for proper polarity, grounding and the trip action of any associated GFCI devices on each car. Operation of DC receptacles shall likewise be verified if applied.

G. Auxiliary circuits and equipment tests

All auxiliary circuits and equipment shall be tested for proper operation, and adjusted or corrected as required.

H. VMS and network tests

All VMS equipment and all on-board networks, including Ethernet Car Network and Ethernet Train Backbone shall be tested for functionality. All discrete inputs to any monitoring equipment shall be individually tested. Each Ethernet link shall be tested with a certified cable tester according to the appropriate standard for the installed cable (Category 7, Category 6A, or Category 5E). Test results for each connection shall be recorded in the Car History Book.

19.06.12 Water and Waste

A. Water piping

All car water piping shall be pressure tested for leaks on all cars. Testing may be done in sections if desired. Movement of all valves and freedom from interference shall be checked. All faucets shall be tested for correct temperature adjustment range, water flow rate and freedom from splashing. All sinks shall be tested for proper operation.

B. Water raising and distribution operation

The water raising system of each car shall be tested, including the correct operation pressure of each regulator in the distribution system.

C. Water heater operation

Correct operation of each water heater shall be verified, including thermostat and hot water delivery temperature. If a mixing valve is used, correct adjustment shall be verified with input supply water at two different temperatures. Poly phase water heaters shall have the correct current value of each phase verified.

D. Toilet operation

Correct operation shall be verified on each toilet of each car. This shall include verification that each control device is calibrated and operates correctly: pressure switches, level controls, switches, water and air pressure regulators, solenoid valves and indicators. Timing of each step of the flush sequence shall be checked. Operation of the collection tank controls, including drain and rinse cycles shall be tested. Freedom from vacuum leaks shall be verified to OEM recommendations.

19.06.13 Cab and Controls

A. Alerter performance

Tests shall verify proper timing, operation of each input and output, including at various simulated vehicle speeds. They shall demonstrate all modes of operation, including self-test.

B. Speedometer/overspeed performance

Tests shall verify all modes of operation, including self-test. Each input and output shall be demonstrated. Calibration at zero, mid-scale and maximum speed shall be shown. Calibration and action at each overspeed set point shall be verified.

C. Event recorder performance

Tests shall verify operation of the entire integrated system hardware and software. They shall show correct interpretation of each input, including combinations (such as throttle). Resolution, set point and calibration of all analogue inputs shall be shown at zero, midscale and maximum values, which will include applying pneumatic pressure to those inputs. All modes of downloading shall be demonstrated. Software demonstration shall include validation of inputs and their calibration as a "real time" display as well as data analysis software playback, both graphic and tabular. Comparison of the graphic and tabular values must be included. Operation of self-test and health monitoring functions shall be demonstrated.

D. Train control system

Perform a test of the PTC system in accordance with manufacturer and railroad requirements. Tests shall verify all modes of operation, including self-test. Each input and output shall be demonstrated. Calibration of pickup and drop out of each parameter of the carrier shall be demonstrated. Interaction with the brake system to produce a penalty brake application, with associated PCS shall be demonstrated, along with the inability to suppress it. Overspeed, failure to acknowledge and overspeed with failure to acknowledge shall all be demonstrated. Permanent suppression shall be demonstrated. Diagnostics and data-logger shall be demonstrated.

E. Locomotive and air brake control

Tests shall verify performance of the integrated system of cab controls, including traction and braking. They shall include complete demonstration of all interface signals between the brake equipment and other vehicle equipment. All inputs and outputs shall be exercised. Calibration and resolution of all analog signals at zero, midrange and maximum values shall be demonstrated.

F. Brake control operation

Note: All compressed air which is connected to the car or its air components shall meet the air quality requirements of APTA Standard PR-M-S-011-99 Revision 2.

1. Calibration of air pressure gauges shall be verified and values recorded
2. Verify operation of each mode of operation shall be demonstrated, in accordance with OEM brake supplier test code, including but not limited to:
3. Passenger mode, freight mode, cutout, test (if equipped)
4. Holding brake, including effect of cutting out automatic brake and penalty brake
5. Calibration of brake valve settings of release, min, suppression, full service and Emergency measured on brake pipe and brake cylinder. Values shall be recorded.
6. Penalty application; non-suppressible and suppressible
7. Emergency application; local and remote (all sites on car + remote in consist)
8. PCS function
9. Operation of pressure switches
10. Operation of ECP Controls

G. Cab indicator operation

The test shall verify proper operation of all indicator lights and audio alarms.

H. MU and COMM trainline function operation

The test shall verify the correct transmit/receive function, including controls, indicators and alarms of each trainline wire. Interaction of PCS/PCR shall also be included.

I. Windshield wipers operation

The test shall verify proper operation of each wiper unit, including: smooth movement, sweep over the required area of the windshield, speed control, parking position, and noise. Also test proper operation of washer and freedom from air leaks, if pneumatic.

J. Defroster/heated windshield operation

Proper function of the defroster and heated windshield, their controls and indicators shall be verified.

K. Horn and bell operation

The test shall verify proper operation of devices and all controls, including automatic sequencer and speed input to it.

L. Cab radio tests

Each cab radio shall be tested and adjusted to meet all technical parameters, and the proper certificates supplied in the vehicle history book. Additionally, the antenna shall be verified for conformance with its specified radiation pattern.

M. Headlight and crossing light tests

The headlights and crossing lights on each cab car shall be tested and adjusted in accordance with 49 CFR Part 229.125 for proper illumination, orientation, aim and operation.

19.06.14 Completed Car

A. Weighing

1. The Contractor shall weigh each car at the time of shipment. All cars shall be measured empty and dry, with no fresh water, waste or consumables, and with no leftover tools or materials from the production process. All parts shall be properly installed on each car prior to weighing. Each car shall be weighed by measuring the weight on each of the car's eight wheels. A weighing device which provides a permanent printed record of the weight shall be used, and the weight tickets shall be submitted to the Engineer and copies thereof included in the vehicle history book.

2. The weighing device shall be maintained within an accuracy of 0.2%. If the weighing device is electronic, it shall be calibrated at intervals of no more than 60 days. If mechanical, it shall be calibrated immediately prior to weighing the first car and annually thereafter.

3. Any total car weight deviation of greater than 300 lbs (136 kg) from the weight of the pilot car of similar configurations, any car weight in excess of the maximum allowable weight specified in Chapter 4, or any car with a weight distribution not in compliance with the provisions of Chapter 4 must be documented on a nonconformance report and explained to the satisfaction of the Engineer prior to shipment. The Engineer may require that the Contractor reduce the weight of any cars exceeding the overall weight or weight distribution limits.

B. Clearance tests

Each car shall be measured to prove compliance with the Contractor's approved clearance diagram for the as-built car configuration, to verify that the car clearances while in operation will meet the requirements. In addition, the centering of the carbody with respect to the trucks shall be measured, and corrected if necessary. The completely assembled truck shall not exceed the clearance limits specified between the truck and the carbody, and the limits between the truck and the rail.

19.07 Acceptance Tests

19.07.01 Car Acceptance Tests

A. The tests specified in this section are to be performed by the Contractor on CTDOT, or as otherwise designated by the Engineer. The tests shall be satisfactorily completed as a condition of acceptance. All tests shall be performed on all cars (including the pilot cars) unless otherwise specified by the Engineer.

B. After receipt of each car at CTDOT and before it is operated, it shall be carefully inspected jointly by the Engineer and the Contractor, and any part, device or apparatus which requires adjustments, repair or replacement shall be noted by the Contractor who shall make such adjustment, repair or replacement before acceptance testing is begun. All expenses and costs incurred in any necessary removal of cars from the designated delivery point and their return there for correction of defects shall be borne by the Contractor.

19.07.02 Functional Tests

A complete, orderly and comprehensive check of each and every vehicle system shall be made to verify its proper operation before commencement of revenue operation. A set of diagnostic test equipment owned by the Contractor of the same design provided to the Engineer shall be used for these tests to the extent possible, but devices bypassed by the use of the DTE's (door open and door close buttons for example) shall also be checked. All aspects of wayside communications shall be tested for proper operation. All software files required for the destination sign system, automatic vehicle location system, GPS and other communications systems shall be loaded and verified for proper operation.

19.08 Post-delivery Testing of Pilot Train with Other Equipment

A. After the pilot cars have been delivered to the Engineer’s facility and have undergone and passed all applicable acceptance inspections and tests, the four cars shall be combined with other rail equipment as designated by the Engineer to verify car-to-car operational, compatibility and coupler tests with other car types that may constitute part of the Engineer’s existing rail service.

B. All trainline functions shall be tested and verified, including:

   1. Door control, door system status and traction inhibit
   2. Locomotive control
   3. PA, IC, PEI and PIS communications and data transfer
   4. HEP and power distribution
   5. Air brake application and release, in ECP and Emulation Modes

C. The Pilot Train, combined with the other rail equipment as specified, shall be tested to confirm compliance with track geometry requirements, including curve and crossover negotiation. All car-to-car connections shall be verified as performing in compliance with the track geometry requirements, including:

   1. Carbody clearance
   2. Truck swing

3. Coupler swing
4. MU, COMM and HEP cables
5. Brake pipe and main reservoir air hoses
6. Diaphragms and diaphragm curtains

D. Requirements for successful completion of the testing between the Pilot Cars and the other rail equipment shall be the same as those specified for car-to-car testing of the Pilot Train.

19.09 Reliability and Post-Delivery Tests

A. The complete operational car fleet shall be monitored by the Contractor to demonstrate conformance with the reliability requirements. This test shall begin when five cars are in service and shall continue until the last full month during which four operating cars or more remain under the two-year car warranty. All cars in the increasingly large fleet with greater than 5,000 miles (8,050 km) of service shall be included in the data collection activity.

B. On a monthly basis, the Contractor shall issue a report detailing the performance of the car fleet and its equipment with regard to maintenance actions (which shall be detailed in an appendix by type) and the calculated period and cumulative Mean Distance Between Failures (MDBFs) and Mean Time Between Failures (MTBFs) as appropriate. Any component(s) or system(s) and/or related subsystem and/or whole car found to be causing the MDBF/MTBF to fall below the required performance level shall be subject to redesign and modification. During the period such efforts are carried out, failures due to these component failures shall not be counted. However, upon completion, the modified car and/or subsystem shall be monitored for a period of no less than an additional 6 months or the remaining base period, whichever is greater, and the MDBF/MTBF shall be acquired. If the use or failure of the component or system is weather or temperature related, the 6-month period shall include those calendar months during which such use or failure is incurred. It shall be understood that the total test time period shall not be assumed to be 365 consecutive calendar days in the event that modification is required. [CDRL 19-009]

C. Following a satisfactory completion of the test for all subsystems, the Contractor shall issue a final report summarizing the results and with all interim reports appended for completeness. If a satisfactory completion cannot be obtained before the end of the specified warranty period, the Contractor and the Engineer shall resolve any outstanding issues in accordance with the Contract terms and conditions. [CDRL 19-010]

19.10 Contract Deliverable Requirements List

CDRL #	Title	Car Type
19-001	Master Test Plan	All
19-002	Test Procedures	All
19-003	Test Reports	All
19-004	Pilot Test Binder	All
19-005	Material Certification and Proof-of-Design Test Binder	All
19-006	Production Test Binder	All
19-007	Sample Seat Tests	All
19-008	Sampling Frequency for Critical Welds and Areas of Sampled Castings	All
19-009	Monthly Reliability Report	All
19-010	Final Reliability Report	All

* End of Chapter 19 *

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Chapter 20

Tools, Consumables and Spare Parts

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20.00 Tools, Consumables and Spare Parts

20.01 Overview

A. This chapter details the requirements for the Contractor to identify and provide the specialized tools, spare parts and consumables that will be needed to operate, maintain, troubleshoot and repair the vehicles to be delivered to the Engineer.

B. All information required in this chapter shall also be included in the appropriate operating and maintenance documentation as identified in Chapter 22, including:

1. Operator's Manual
2. Running Maintenance Manual
3. Heavy Maintenance Manual
4. Illustrated Parts Catalogue
5. Troubleshooting Guide
6. Service and Inspection Manual
7. Integrated Schematic Manual
8. Interactive Electronic Manuals

20.02 Specialized Tools

A. The Contractor shall provide to the Engineer four sets of all specialized tools, gauges, meters, diagnostic equipment (including laptop computers), etc. that will be necessary to operate, maintain, inspect, test, troubleshoot and repair all configurations of the vehicles throughout their design life. These tools and equipment shall be delivered to a location specified by the Engineer and shall be delivered to the Engineer prior to the acceptance of the first car. All specialized tools shall be included in the base warranty as specified. [CDRL 20-001]

B. The diagnostic equipment is defined as the equipment required to perform all testing necessary to verify proper operation of and diagnosis of failures for all car systems, such as Portable Test Equipment (PTE) and two sets of Bench Test Equipment (BTE). The diagnostic equipment shall be designed to efficiently isolate defects to the lowest replaceable component level. The diagnostic equipment shall require minimal setup and test time.

C. All diagnostic and programming software shall be provided in Windows operating system format with no use restrictions so that the Engineer can install the software on additional computers as needed.

D. For custom software that is resident in test computers, the Engineer shall be given a license for unlimited use of the software for the approved purposes of this Contract. Licenses shall not be linked to specific hardware serial numbers.

E. The detailed functions of all diagnostic equipment shall be presented during the associated system's design review. [CDRL 20-002]

F. If at any time during the project, including the warranty period, it is determined that the diagnostic equipment does not properly log or isolate faults, or fails to perform any of its intended functions, the Contractor shall reprogram or modify the equipment as necessary. The Contractor shall make all modifications to the diagnostic equipment which are required due to changes and modifications made to the vehicle or any of its subsystems.

G. The PTE shall consist of a ruggedized portable laptop computer with the latest version of Windows or another approved operating system. Each PTE shall have the software and hardware to access all intelligent microprocessor-based subsystems via Wi-Fi or directly from the subsystem's local ethernet port.

H. BTE shall be provided for both intelligent and non-intelligent systems. Separate BTEs shall be provided for different subsystems. The BTE shall be provided with all necessary power supplies and shall provide all necessary inputs to fully test the LRU. [CDRL 20-003]

I. The BTE shall provide the necessary inputs and probes to isolate repairable printed circuit board failures to the component or group level and to support off-vehicle repair and maintenance activities.

J. The BTE shall include all necessary computers and software for full operation. The BTE computers shall be a rack mount industrial design.

K. For subsystems for which the LRU is an assembly greater than a printed circuit board, the BTE shall be provided with custom test interface fixtures and cables to allow GO/NO-GO test of the LRU and guided probe isolation of the failed board or subassembly.

L. During the design review process, the Contractor shall submit a list of specialized tools and diagnostic equipment which shall include [CDRL 20-004]:

1. Specialized tools for inspecting, repairing, removing, installing, maintaining or measuring components and systems on the cars;
2. Diagnostic equipment to troubleshoot problems, determine component or system status or condition, or interpret diagnostic information;
3. Portable computer equipment required to view, change or monitor the operating parameters, downloadable recorded data, service history or digital programming for computerized or microprocessor-controlled components or systems; and
4. All cables, connectors, software, power supplies, carrying cases and peripherals as required for use with the portable computers.

M. The Contractor shall provide a manual and drawings for each special tool. The manual shall explain the use of the tool and detail the tool's maintenance requirements. The drawings shall include all dimensions, materials and parts lists for the special tool. [CDRL 20-005]

N. The Contractor shall also provide any necessary adapters or fixtures required to interface with the Engineer's existing general-purpose shop equipment, such as cranes, forklifts, axle presses, etc. The Contractor shall provide schematics, specifications, part numbers and prices for all special tools and maintenance equipment to enable the Engineer to purchase additional quantities.

O. All systems employing intelligent components shall supply programs for logging, viewing, and troubleshooting faults and downloading the system history and PTE test reports without erasing the data. All such systems shall reside on a common laptop computer. The systems shall open and operate in the same manner. The ability to temporarily change parameters to test shall be available to all users. Permanent changes to parameters and installation of new versions of software shall be accessed by authorized technicians via password protected programs. BTE shall have this same set of software controls installed. Automated tests of the system shall be programed into the PTE programs. All necessary connectors and auxiliary testing devices shall be supplied in the same quantities as PTEs and BTE.

20.03 Consumables

A. The Contractor shall provide a list of all service consumables needed to support the vehicle throughout its service design life. Consumables are identified as those items replaced as a function of normal operation, whether the replacement is on a periodic basis or as they wear out. This list shall be provided as a component of the final design review. [CDRL 20-006]

B. This list should include items such as:

1. Brake pads
2. Filters - Heating, Ventilation and Air Conditioning (HVAC), air, water
3. Windshield wiper blades
4. Lamps/Light Emitting Diodes (LEDs) Fuses, Diodes and Resistors
5. Air hoses
6. Rubber seals and Gaskets

C. This list shall include the following information as it relates to these parts:

1. Contractor part number
2. Part description
3. Manufacturer name
4. Manufacturer part number
5. Quantity required by car type
6. Frequency of replacement
7. Unit price for individual parts
8. Extended price based on recommended quantities

20.04 Spare Parts

A. During final design review, the Contractor shall provide to the Engineer a list of strategic spare parts which shall include recommended quantities of replacement parts, repair parts and maintenance parts that the Engineer should acquire and maintain to support the fleet of equipment after the end of the warranty period. [CDRL 20-007]

B. The Contractor shall provide all spare parts to be used during the warranty period. [CDRL 20-008]

C. Replacement parts are defined as parts that are typically replaced on a regular basis and which can be expected to fail randomly.

D. Repair parts are defined as parts that are not expected to fail but may reasonably be expected to require replacement on occasion due to accidents, debris strikes or vandalism.

E. Maintenance parts are defined as parts that are typically replaced on a scheduled inspection basis for any system or subsystem.

F. This list shall include, but is not limited to the following:

1. Parts that are critical to the safe operation of the equipment;

2. Parts with a high failure rate, based on the Contractor's reliability analysis (see Chapter 19);
3. Parts located on the vehicle exterior and therefore subject to damage from debris strikes or accidents;
4. Parts installed in a high-wear environment; and
5. Parts that require troubleshooting and repair off of the car, such as electronic components.

G. This list shall include the following information as it relates to these parts:

1. Contractor part number
2. Part description
3. Manufacturer name
4. Manufacturer part number
5. Quantity required by car type
6. Shelf life/maximum storage period
7. Recommended quantity to have on hand
8. Lead time to receive spare parts

H. The Contractor shall also provide maintenance part kits for each system or subsystem. [CDRL 20-009]

I. The Contractor shall be responsible to provide replacement parts for those failing under the terms of the warranty. The Engineer shall not be responsible to supply replacement parts to the Contractor for the purposes of fulfilling warranty provisions.

J. All spare parts shall be configured to the latest revision during the warranty period. If a revision change is made to a part, then the Contractor shall replenish the Engineer's spare parts stock with the current revision of parts.

K. The Contractor shall make all reasonable efforts to ensure the availability of replacement parts for the vehicles for a minimum of fifteen years after the date of acceptance. Should a part not be available through the Contractor for which there is no competitive equivalent available in the marketplace, the Contractor agrees to assist the Engineer with drawings and specifications to facilitate component procurement.

L. All assemblies, subassemblies and components shall have an identification label, which contains a part number, serial number and a vendor identification.

20.05 Contract Deliverable Requirements List

CDRL #	Title	Car Type
20-001	Specialized Tools	All
20-002	Diagnostic Equipment Functions Details	All
20-003	Bench Test Equipment	All
20-004	Specialized Tools and Diagnostic Equipment	All
20-005	Special Tools Manuals and Drawings	All
20-006	Service Consumables List	All
20-007	Strategic Spare Lists	All
20-008	Warranty Spare Parts	All
20-009	Maintenance Part Kits	All

* End of Chapter 20 *

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Chapter 21

Shipping Preparation

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21.00 Shipping Preparation

21.01 Overview

A. This chapter describes the requirements for preparing completed vehicles for shipment to the Contractor's field site where vehicle acceptance will take place.

B. All vehicles must receive approval for shipment from the Engineer before they can be shipped to the field site.

C. The Contractor is responsible for all costs and arrangements associated with the shipment of the completed vehicles to the Contractor's field site.

21.02 Requirements for Shipping Vehicles

A. All completed vehicles shall be prepared for shipping as follows:

1. All hoses and inter-car cables required to move the rail cars shall be connected between vehicles, if more than one car is shipped at a time. Those not required for movement shall be stored in the rail cars.
2. Brake control valve selector plate shall be set to graduated release if being moved in passenger service (see Chapter 7).
3. Cab car brake valve shall be in the cutout position (see Chapter 16).
4. A single car air test shall be successfully conducted within 30 days of shipment.
5. Automatic Equipment Identification (AEI) tags shall be properly programmed and installed. The Contractor is responsible for ensuring that the car's technical data is entered into the Umler/EMIS (Equipment Maintenance Information System) system prior to the release of the car (see Chapter 4).
6. Shipping labels and warning signs shall be applied as needed (such as DO NOT HUMP, DO NOT COUPLE TO SHELF COUPLERS, instructions for operation of parking brake, etc.).
7. New air filters shall be installed in Heating, Ventilation and Air Conditioning (HVAC) system (see Chapter 10).
8. All required inspections must be complete, including inspections and approvals from the FRA and CTDOT. The following documents must be completed and signed, and be installed in the document holders in each car and in the cab of each cab car as applicable (see Chapter 16):
    a. Amtrak MAP 816/FRA F6180-49, Locomotive Inspection and Repair Record ("Blue Card")
    b. Amtrak MAP 100, Equipment Condition Report
    c. Amtrak MAP 101, FRA Rule No. 229 Inspection Record
    d. Amtrak MAP 1173, Class 1 Brake/Calendar Day Test
    e. Amtrak MAP 10C, Passenger Car Daily Inspection
9. The Contractor shall comply with the requirements of the Association of American Railroads (AAR) Specification M-1006 and Recommended Practices RP-2001 and RP-2002 regarding railroad shipping information and shall be considered the point of contact for additional information.
10. Waste system shall be drained (see Chapter 15) and winterized unless it is verified that the car will be kept on HEP during the entire delivery.
11. All doors and windows shall be closed and locked.

12. Car clearance shall be verified with all involved railroads for the delivery routing.
13. The Contractor shall perform other shipping-related tasks as required by the Engineer.

B. The following shall be set up at the discretion of each Engineer in accordance with the requirements for each shipment of cars:

1. Fresh water may be supplied from the potable water tank for use of the toilet system while in transit. If no water is needed, the tank shall be drained and all water supply lines shall be blown dry and tagged.
2. ON/OFF setting for all circuit breakers and the main 480VAC Head End Power (HEP) breaker shall be made appropriately for the type of transportation selected.
3. Diaphragms shall be removed if necessary. If removed, diaphragms shall be properly prepared for shipment by the Contractor to the Contactor's field site, where they will be reinstalled by the Contractor prior to Engineer acceptance of the car.

21.03 Contract Deliverable Requirements List

CDRL #	Title	Car Type
N/A	N/A	N/A

*End of Chapter 21 *

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Chapter 22

Training and Documentation

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22.00 Training and Documentation

22.01 Overview

A. This chapter describes the requirements for the development and delivery of project documentation, including manuals, drawings and photographs, and for the implementation of a post-delivery training program to familiarize operating, mechanical, supervisory and administrative personnel with all aspects of the operation, inspection, maintenance, repair and supply of parts for the fleet of cars.

B. The Contractor shall be fully responsible for the completeness, accuracy and readability of the manuals, drawings and schematics, and to ensure that these documents meet the requirements for all systems, subsystems, components and operations to perform as intended for the duration specified.

C. The Contractor shall develop and provide a training program that accurately and completely reflects the requirements of the manuals, and be structured and implemented so that the Engineer and its designated maintenance and operations provider have access to all necessary resources to properly and successfully operate, maintain, repair and administer the vehicles as required by the Contractor, the FRA, CTDOT and others.

22.02 General Requirements

22.02.01 General

A. The material in the maintenance manuals and the illustrated parts catalog shall be organized and sequenced with a standard numbering system or alternative numbering system as approved by the Engineer. Sharp, clear drawings shall be used throughout the documents for illustration. Photographs may be used only where explicitly approved by the Engineer. The operator's manual binder shall be lightweight plastic, which can be easily opened for page revisions. The operator's manual shall use a page size of 6.75 in. tall by 3.875 in. wide (171 mm tall by 99 mm wide), vertical format. All other documents shall be 8.5 in. wide by 11 in. high (216 mm wide by 279 mm high), vertical format, unless specified otherwise. A complete table of contents shall be given at the beginning of each publication, and a complete page-numbered index at the end. With the exception of the Operator's Manual, plastic coated tabs shall be used to segregate sections within each publication.

B. All publications must be reviewed in detail by the Contractor to ensure completeness and accuracy of information and quality prior to any submittal to the Engineer for approval. All manual submittals shall include sign-off sheets with engineering and validation confirmations from the Contractor. Validations shall be Contractor-signed documents certifying that each procedure has been validated on the vehicle and any discrepancies and changes have been addressed in the submitted material. Submittals without the completed validation sheets shall not be accepted by the Engineer for review. Submittals shall not be labeled or considered "Final" until the final copy has been reviewed and approved for printing by the Engineer. Draft submittals shall undergo a validation and revision process prior to delivery of the draft manual, also described here. Chapter numbers shall be consistent for all documents.

C. Manual information shall be kept up-to-date to the car configuration and operation during the full period of the Contract. As information becomes available and changes occur, the Contractor shall incorporate the changes and supply the information in updated electronic editable and Portable Document Format (PDF) files in an organized, timely manner based on a regular schedule to be approved by the Engineer. Each updated information submittal shall be accompanied by a file containing a revised list of effected pages for the manual set being changed.

D. Engineering changes that affect any potential safety issue, or may significantly affect car operation in scheduled service, shall be published in the form of an Engineering Change Service Bulletin (ECSB). ECSBs shall be used in the interim until the official changes in the maintenance manual and illustrated parts catalog have taken place. The creation of ECSBs shall be included within the Contractor's

engineering change procedures and engineering change proposal system. ECSBs shall be stand-alone documents, provided in both editable document and PDF formats. Each ECSB shall detail the reason, instructions and illustrations to make the change. Associated parts information shall also be included. A system to control ECSBs shall be developed between the Contractor and the Engineer to control ECSBs, such as using note tools on the existing electronic PDF versions and/or the development of master lists of outstanding ECSBs.

22.02.02 Contractor Responsibility

The Contractor shall provide documents such as drawings, 3-D Computer-Aided Design (CAD) models, photographs and a family of operating and service manuals which shall provide the Engineer with the information necessary to properly operate and provide all maintenance functions for the given fleet of vehicles. These include drawings and manuals to safely and properly conduct:

A. Operation

B. Service and inspection

C. Troubleshooting

D. Running maintenance

E. Heavy repair/overhaul (vehicle and system/component level)

F. Part identification (to the lowest repairable level)

G. Wreck repairs

H. Modification of equipment (documenting as-built configuration)

22.03 As-Built Drawings

22.03.01 General

A. The Contractor shall provide the Engineer with a full set of component, system, arrangement and installation drawings, schematics and specifications for all parts and assemblies as provided on each type of car. These drawings shall be in both PDF format and in an Engineer-approved 3-D CAD format and shall meet the requirements of PRIIA Specification 305-910. This also includes providing a complete set of all as-built drawings for top assemblies, subassemblies and detail drawings used to manufacture all equipment used therein. Outline drawings of boxes, components and devices will not be sufficient. Each assembly, subassembly and arrangement drawing shall include a complete bill of material and parts list describing all items (including weight, original component manufacturer name and part number of the actual supplier of the part.) that form a part of the assembly. All assemblies and subassemblies are to be fully detailed. The drawing package shall also include drawings of every special gage, tool, jig or fixture used to correctly install and service these items.

B. All dimensions shall be shown in standard imperial units of inches and decimals, with a metric equivalent shown in parentheses adjacent to the imperial dimension. If a component or subassembly uses metric units as the primary system of measurement, then imperial equivalents shall be provided in parentheses.

22.03.02 Drawing Availability

A. Preliminary drawings needed to perform maintenance, repairs, testing or measurements shall be supplied prior to the delivery of the first completed car of each type. [CDRL 22-001]

B. A complete set of as-built drawings shall be delivered within 30 days after the delivery of the first car of each type, and within 30 days after the completion of the warranty period and all modifications. [CDRL 22-002]

C. A complete bill of material for the car, in electronic format (PDF), covering all major components and hardware, shall also be provided within 30 days after the completion of the last car of the base order. [CDRL 22-003]

D. The Contractor shall make available, for the life of the equipment, and without charge, hard copy drawings or electronic files that are required by the Engineer to conduct equipment modifications, conduct overhauls or make extraordinary repairs, such as those arising from accidents, etc.

22.03.03 Drawing Originals

The Contractor shall submit to the Engineer for review and approval, within 30 days after completion of first car of each base type and then again after completion of all modifications as-built drawings and 3-D CAD models of all assemblies, sub-assemblies and arrangements in accordance with this section. If the Contractor decides not to maintain the drawing originals, they shall be supplied to the Engineer at no cost. Likewise, if the Contractor terminates operations, all drawings pertaining to this project CAD files or any other Engineer approved media, shall be provided to the Engineer free of charge.

22.03.04 Electronic Files

Within 30 days of the delivery of the last car of the base order of equipment, the Contractor shall provide electronic files of all the drawings, 3-D CAD models and Finite Element Models (FEMs), the bill of material, as-built specification training materials and operation and maintenance manuals, in a file format to be determined by the Engineer. [CDRL 22-004]

22.03.05 Photograph Book

The Contractor will furnish, within 30 days of the delivery of the first car of each car type, two bound volumes of not less than 50 different color photographs, 8 in. by 10 in. (203 mm by 254 mm), showing the progression of construction of the first car of each type. The images shall also be supplied in digital format. [CDRL 22-005]

22.03.06 Photographs of Completed Cars

The Contractor shall furnish, within 30 days of the delivery of the first car of each car type, 10 sets of un-mounted color and 10 sets of un-mounted black and white photographs, at least 8 in. by 10 in. (203 mm by 254 mm), in size, of the first completed and painted car of each type of equipment, showing at least four different views of each car of equipment, including full front, 3/4 side, top and rear views. [CDRL 22-006]

22.03.07 Digital Format

All photographs shall be taken in digital format (jpeg), at high resolution (2400 x 3000 pixels). All photographic prints and files will be submitted to the Engineer within 30 days following completion and acceptance of the first car of each base type.

22.04 Conformed Specification

A. Within 30 days after completion of the last pilot car, the Contractor shall revise this Specification to provide an as-built specification and contract document. The revised document shall require Engineer review and approval. Two reproducible hard copies and two electronic copies of the approved version shall be provided. [CDRL 22-007]

B. The conformed specification shall include all changes to the specification made via approved waivers, variances and change orders. Subsequent changes to the specification made prior to the end of the warranty period shall require the conformed specification be revised.

22.05 Manuals

22.05.01 General

A. The Contractor shall provide a complete family of operating and maintenance manuals. The following manuals are required:

1. Equipment List (ELIST) [CDRL 22-008]
2. Maintenance Allocation Chart (MAC) [CDRL 22-009]
3. Operator's Manual [CDRL 22-010]
4. Service and Inspection Manual [CDRL 22-011]
5. Troubleshooting Guide [CDRL 22-012]
6. Running Maintenance Manual [CDRL 22-013]
7. Heavy Maintenance Manual [CDRL 22-014]
8. Integrated Schematic Manual [CDRL 22-015]
9. Illustrated Parts Catalog [CDRL 22-016]
10. Interactive Electronic Manuals [CDRL 22-017]

B. The manuals shall include full descriptions of all systems and components requiring maintenance or servicing. The manuals to be supplied shall contain information required for effectively understanding operation of the car as well as performing scheduled maintenance including general servicing, lubrication and inspections, system equipment testing, troubleshooting and adjustments, and repair/replacement of components and major subassemblies.

C. The Contractor is responsible for ensuring that subcontractors comply with this Specification and that they also provide the appropriate manuals. Contracts between the Contractor and subcontractors shall include appropriate language to ensure these documents are provided as required.

D. All manuals shall have, at a minimum, the following information on the front cover:

1. Contractor name
2. Customer name
3. Type of equipment
4. Car numbers and reporting marks

5. Date and level of revision

E. Contractor manuals shall be provided electronically in an editable Microsoft Word format or other Engineer approved software.

22.05.02 Manual Review and Availability

A. The Contractor shall develop a master plan and schedule for the development and completion of the manuals. [CDRL 22-018] This manual development plan shall be submitted to the Engineer no more than 180 days after NTP, and shall include the Contractor's plan for the development and acquisition of the manual content from suppliers and vendors, the schedule for the major completion points of the manuals, and a method to track the development of each manual that can be reviewed at the periodic project management meetings.

B. A full set of draft manuals, including those provided to the Contractor by suppliers, shall be submitted for Engineer review no less than 90 days prior to the release of the first car. If the manuals require revision, as determined by the Engineer, the Contractor shall revise and resubmit the draft manuals until all requirements are met. The first car shall not be released from the Contractor's facility until the Engineer has accepted the draft of the manuals for use in maintenance of the cars. The Contractor shall provide 10 full sets of manuals to the Engineer prior to Engineer acceptance of the first car.

22.05.03 Manual Updates

A. After delivery of the first car, and continuing through the end of the warranty period, should any changes to the car, components or maintenance requirements occur, the Contractor shall revise and update all affected manuals and shall submit hard and electronic copy manual updates to the Engineer. Upon the completion of the warranty period, the Contractor will issue 10 sets of finalized manuals to the Engineer, reflecting all changes made to the vehicles during production, delivery and operation, and the status of all cars at the time of warranty expiration.

B. Revisions to final draft and approved manuals shall be recorded on a control list in the front of each manual. The list shall be issued with each revision and shall show the date of each revision and the page reference. Updated lists and revisions shall be maintained in the manuals by the Contractor until the warranty period expires.

22.05.04 Work Management System

The manuals will also be used electronically in Amtrak's Work Management System (WMS). The Contractor shall work with the Engineer and Amtrak to ensure that this is implemented successfully.

22.05.05 Equipment List

A. An equipment list (ELIST) shall be prepared for all systems as listed in Section 22.05.06 below. It shall list all items that will require maintenance in a system-by-system functional orientation, down to the lowest level maintainable item, and shall allow each item's relationship to the next higher level. A system-by-system functional orientation means that all items shall be listed in the system where they function. If an item has dual functionality, it shall be listed where it has primary functionality. Conflicts as to function will be resolved by the Engineer. System numbering shall be consistent with the existing numbering system being used by CTDOT. Sections not applicable to this vehicle shall not be left vacant and shall be noted "Not Used" in all listings.

B. The ELIST is the foundation from which the Maintenance Allocation Chart (MAC) is to be developed.

C. Conditional approval of the ELIST shall be obtained before it is used to prepare the MAC.

22.05.06 Maintenance Allocation Chart

A. For each system on the approved ELIST, a MAC shall be prepared. A MAC is a chart or table used to determine what items require maintenance, what maintenance is required on those items, who will perform that maintenance, where the maintenance will be performed, and when the maintenance is required.

1. For each item on the ELIST, the MAC shall show:

   a. System Code,
   b. ELIST Number,
   c. Item Description,
   d. Device Name,
   e. Maintenance Task(s),
   f. Use on Code,
   g. Maintenance Level,
   h. Service Interval,
   i. Expected Service Life,
   j. Test Equipment,
   k. Special Tools,
   l. Reference Task Number,
   m. Craft,
   n. Mean Time to Repair (MTTR),
   o. Training (Required or Not Required),
   p. OEM Part Number,
   q. Vendor Code,
   r. Account Reference Number,
   s. Quantity,
   t. Spare Part,
   u. Ledger Account Number,
   v. System Safety Critical (Yes, blank for No),
   w. Safety Hazards (Present, Not Present),
   x. Personal Safety Equipment (Needed, Not Needed), and
   y. Time Required to Inspect.

2. The Contractor shall take the following into consideration as the MAC is developed:

   a. Consistent levels of detail for the breakdown of assemblies used in more than one vehicle system shall be ensured. For example, if DC electric motors were detailed to list: access cover, brushes, brush-holder, commutator and mounting brackets; all electric motors would consistently be listed in that manner.

   b. Tasks that call for tests are to be prescribed in order to determine the need to replace a part. For instance, fuses are to be checked for continuity before they are replaced unless a break is visually obvious. Procedures that call for replacement of parts without the use of fault isolation techniques and logic are prohibited by the Specification.

c. Overhaul tasks shall be required in the manuals whenever appropriate for maintenance and economy. The Contractor shall obtain the required information from the suppliers of equipment and components and include it in the manuals in the style and formats specified. CTDOT's option to subcontract overhaul tasks shall have no bearing or effect on the Contractor's responsibility to supply all overhaul information needed to maintain the vehicles and equipment in accordance with manufacturers' recommendations and in the most efficient manner.

d. Conditional Approval of the MAC shall be obtained by the Contractor before any manuals are submitted for review and approval.

B. Computer indexing of MAC-level numbers shall be established between the MAC task-level reference and the "Refer To" column. This shall be done in such a way that references from one task level to another will remain valid throughout MAC development.

22.05.07 Operator's Manual

A. The Contractor will develop operating manuals for use by train operating personnel, including the Operator and Conductor. Operator's manuals shall contain all information needed for the operation of the car, including definitions giving nomenclature, function, location and operation of all indicators, controls, components and subsystems utilized in the operation of the car. This shall include preparing the car for operation, securing the car from operation and operation of the car individually and as a train.

B. Emergency procedures and safety precautions of a specific nature applicable to the car shall be included. The manual shall give troubleshooting and diagnostic procedures sufficient to isolate faults and problems which are capable of repair by the operator and train crew, arranged in a format to allow ease of use under emergency and time-sensitive situations.

C. The operator's manual shall be divided into chapters as follows:

1. Introduction
2. General Description
3. Communications
4. Operating
5. Inspecting
6. Fault Isolation

D. On-the-Road Repair

The fault isolation and on-the-road repair sections of the operator's manual shall include, in summary form, all fault isolation and on-the-road repair procedures. These two sections shall include:

1. Index
2. Safety instructions
3. Instructions for communications during fault isolation
4. Authorized fault isolation procedures
5. Authorized on-the-road repairs
6. Equipment location diagrams

E. The operator's manual shall accurately portray and clearly illustrate all information required by the operator and train crew to correctly, efficiently and safely carry out their duties on the car in all

possible consist configurations. Illustrations shall include layouts of the equipment, showing major components and controls referenced in the text and their locations on the car.

F. An alphabetical index of subjects and equipment not mentioned in the table of contents shall be provided. All operating conditions shall be taken into account by the manual's description of unit functions. A fault isolation section shall be provided to list all possible unit or system malfunctions that are detectable by the train crew without the aid of test equipment. This shall include fault codes and corrective information supplied by the diagnostic system. This information shall be presented in tabular format listing each symptom with corresponding potential causes, test, checks and corrective actions. The goal of these fault isolation tables shall be to allow the train crew to identify operational problems and, where possible, isolate faults from consists to car, car to system and, in some cases, from system to subsystem.

22.05.08 Service and Inspection Manual

A. The Service and Inspection (S&I) manual shall contain all pertinent information that operating and maintenance personnel will require in order to perform all periodic inspections on the vehicles as required by the Contractor, subcontractors, CTDOT and the FRA for all periodic inspections including those occurring daily, every 92 days, every 184 days, annually, and every 4 years. Additional or differing intervals shall be included if used by the Engineer's maintenance provider. Inspections and servicing activities occurring on an interval that is not used by the Engineer's maintenance provider shall be included in the tasks shown for the next more frequent interval.

B. The inspection tasks described in this manual shall include, but are not limited to the following:

1. Item or system requiring inspection
2. Frequency or period of inspection
3. Inspection procedure, including location and description of system being inspected
4. Pass/fail criteria for inspection
5. Special tools, conditions or other requirements for inspection to be performed
6. Source of inspection requirement (Contractor, Amtrak, FRA, etc.)
7. Reference for inspection requirement (CFR, maintenance manual, etc.)

C. Inspection tasks shall be listed in order of frequency of inspection requirements, from daily to annual. A summary table shall be provided for quick reference that lists the item or system, frequency, source and reference for all required inspections.

D. This manual will also provide complete instructions for all pertinent maintenance activities for the routine operation of the cars that are required every 30 days, or more frequently, including:

1. Fresh water filling
2. Waste tank draining
3. Removal of trash
4. Installation and replacement of consumables
5. Inspection and replacement of filter elements
6. Cleaning and lubrication
7. Replacement of brake shoes and pads

E. This manual shall be provided in a comb-bound format approximately 5 in. wide by 8 in. tall (127 mm wide by 203 mm tall). The cover of the manual shall reference the Customer name, car numbers, reporting marks and types, the Contractor name, issuance date and revision level.

22.05.09 Troubleshooting Guide

A. This manual will contain detailed troubleshooting procedures, including those requiring the use of diagnostic test equipment and those that do not require such equipment, for all major systems, subsystems and components in the following categories:

1. Carbody
2. Trucks
3. Coupler and Draft Gear
4. Brakes
5. Door System
6. Interior
7. HVAC
8. Lighting
9. Communications
10. Electrical System
11. Water and Waste
12. Cab and Controls
13. Emergency Equipment

B. This manual shall provide procedures for the identification, diagnosis and proper correction of all possible car failures and malfunctions. This manual shall include Failure Symptom Analysis (fault isolation) tables which shall list potential equipment failures at any level, from a full trainset and car down to component and part, for the purposes of equipment troubleshooting. The troubleshooting tables shall include the failure symptom analysis table fault codes for each system with built-in diagnostics and fault information and corrective actions displayed by the diagnostic system, as well as any observable equipment conditions and symptoms. The troubleshooting tables shall contain at a minimum, the following column headings:

1. Fault Code (if not applicable to the specific symptom, list as "N/A")
2. Symptom
3. Possible Causes
4. Check / Inspect
5. Corrective Action

C. When there is more than one probable cause for a system or equipment malfunction, the most likely to have failed shall be considered first; however, consideration shall be given to accessibility and ease of replacement when the likelihood is equally shared by two or more causes.

D. Inspection and corrective maintenance procedures shall be organized so that maintenance personnel can easily reference them from the Failure Symptom Analysis table. These procedures shall include determination of the cause and isolation of the fault to replaceable parts, interface wiring or mechanical linkage. Diagrams of the relationships shall be provided to enhance comprehension.

E. The inspection and corrective maintenance procedures shall contain:

1. Identification of the system covered
2. A concise explanation of the troubleshooting format and how to use the procedure
3. Test equipment and tools required
4. Safety precautions that must be taken
5. A reference to the supporting block diagrams
6. Preliminary tasks that must be performed prior to initiating troubleshooting

F. Each chapter of the troubleshooting procedures shall contain the following sections:

1. Introduction, including general information, safety precautions, and definition of warnings, cautions, and notes with specific details
2. Operational and functional system descriptions
3. Troubleshooting
4. Inspection and corrective maintenance procedures

G. When applicable, each section shall indicate and list the applicable safety warnings and precautions, test equipment required, special tools required, and any consumables required. The manual format shall utilize diagrams and illustrations as required to enhance understanding. All procedures shall be proved out in the field on the pilot cars and shall be revised as necessary.

22.05.10 Running Maintenance Manual

A. The running maintenance manual shall contain an overview of the vehicle operation and a detailed description and analysis of the vehicle and its assemblies/subassemblies. The manual shall also contain, in a convenient form, all information required for on-car testing, troubleshooting, servicing and replacement of equipment down to the lowest level replaceable item. The running maintenance manual shall provide technicians with the maintenance procedures that are performed at the running repair level. Running maintenance is defined as that maintenance that can be performed on the inspection track or does not require taking the train out of service. The manual is to be divided into three volumes as listed below.

B. Running maintenance manual procedures shall be supported by illustrations. They shall be used to simplify, clarify or shorten the text. Illustrations shall be located on the same page or facing page of the text they support. A sequence of illustrations may be used in order to clarify or simplify a complex procedure. When one of several possible positions is described by text for a device, the position described shall be the same as the one shown by the illustration. Unless the location and access to the item is obvious, a locator view shall be included, or the assembly diagram provided at the beginning of the chapter may be referenced to ensure that the equipment orientation is clearly described.

C. Functional post-inspection testing and checkout test procedures shall be provided to verify serviceability or to detect failures of a system, subsystem, assembly, subassembly or component. Pretest setup instructions shall be included. Test procedures shall be used as a prerequisite for the generation of fault isolation procedures to fault isolate to a system, subsystem, assembly,

subassembly or component. The types of tests that can be performed fall into the following categories:

1. Operational Test - Procedure required to ascertain only that a system or equipment is operable. These tests should require no special equipment or facilities other than that installed on the car and shall be comparable to the tests performed by the Operator. It is not intended that the operational test of the unit meet the specifications and tolerances ordinarily established for overhaul or major maintenance periods.

2. Functional Test - Procedure required to ascertain that a system or equipment is functioning in all aspects in accordance with minimum acceptable system or unit design specifications. These tests may require supplemental support equipment and shall be more specific and detailed than an operational test. The test shall contain all necessary information to ensure system or unit operational reliability, without reference to additional documents.

3. System Test - Procedure containing all adjustment specifications and tolerances required to maintain system and unit performance at maximum efficiency and within design specifications. The test shall be self-contained and may duplicate other tests.

22.05.11 Heavy Maintenance Manual

A. Heavy maintenance is defined as the maintenance that may be performed on the shop track or one of the heavy maintenance tracks if the train is taken out of service. Heavy maintenance tasks will generally require more than one 8-hour shift to complete. The Heavy Maintenance Manual shall contain a detailed description and analysis of all mechanical, electrical and electronic assemblies/subassemblies so that the Engineer's overhaul facilities can effectively and safely service, inspect, adjust, troubleshoot, repair, overhaul and test these assemblies. Contractor and sub - suppliers shall provide all information needed for comprehensive repair and overhaul work at least as comprehensive as that used by the suppliers' own service and repair shops, whether the car parts were manufactured by them or purchased from others. The manual shall provide information for the test, repair and overhaul of each repairable component of the assembly. No component shall be considered disposable or deemed non-repairable except where agreed to by the Engineer.

B. Installation and removal of equipment in full detail, down to the lowest level of replacement items (assembly, subassembly or component). The procedures shall clearly describe the step-by-step operation in a logical, work flow sequence to safely gain access to, and subsequently remove the item. Prerequisite operations, inclusive of access panel or plate openings, removal of other obstructing components, and deactivation of power and other pertinent safety precautions and/or warnings shall be included or appropriately referenced. Exact quantities of attaching hardware to be removed shall be included in the procedures. The statement "reverse of remove" may be used judiciously. Installation procedures that are basically the same as the removal procedure, but require some additions, such as torque values for bolts, replacement of O-rings and lubrication of a component, can be handled within highlight statements to that effect in the removal procedure. If this is done, the statement "reverse of remove" may still be used. Installation instructions for procedures that are complex and require additional step-by-step detail, or are significantly different from that removal procedure must be provided.

C. Exact quantities of hardware shall be identified. If, during the prove-out or validation of a "replace" task, the highlighted data do not enable the maintenance technician to correctly install the subject item, the highlighted information shall be deleted from the removal procedure. A step-by-step installation procedure shall be added to the "replace" task. Step-by-step procedures shall be provided for any adjustment or alignment required as a result of replacement of any equipment, or to determine that a system, subsystem, assembly, subassembly or component meets required standards. Detailed procedures shall be provided to determine the accuracy of, and to correct and adjust instruments, diagnostic equipment and test measuring devices used for precision measurement. Calibrations are to be performed with an instrument that is certified to a standard of known accuracy to detect and adjust any discrepancy in the accuracy of the instrument being calibrated.

D. The manual shall include descriptions of how each assembly/subassembly operates within the car system. Each shall include:

1. Block diagrams
2. Signal flow diagrams
3. Simplified schematics
4. Functional wiring and piping diagrams
5. Completely detailed overhaul procedures

   a. Test and evaluation procedures equivalent to that performed by the original manufacturer, including the requirements for specialized test equipment. The Contractor is to procure or fabricate and provide to the Engineer all such specialized test equipment.

   b. Rewinding procedures in full detail for all rotating and wire-wound apparatus, except as agreed to otherwise by the Engineer.

   c. Disassembly/assembly procedures required for the disassembly and assembly of assemblies, subassemblies and components at the heavy repair level of maintenance shall be provided. Assembly instructions shall include all pertinent assembly criteria, including clearances, backlash dimensions, torque values and similar data. Final testing, with pass/fail criteria, of the end item shall be provided by reference.

   d. For overhauls, the maintenance action required to restore an item to a completely serviceable and operational condition. Overhaul is not normally performed on the car and does not necessarily return an item to like-new condition.

   e. Rebuilds include those services and actions necessary for the restoration of equipment to like-new condition in accordance with original manufacturing standards. Rebuild is the highest degree of material maintenance applied to Engineer's equipment. The rebuild operation allows returning to zero those age measurements including, but not limited to, hours and miles, considered in classifying the Engineer's equipment and components.

   f. Complete instructions for use, drawings and parts information for all special tools that are required to be provided to the Engineer by the Contractor.

   g. The weights of all components and assemblies that weigh more than 50 lbs (23 kg). In addition, the weights of major component assemblies shall be supplied such as the truck, air conditioning compressor, air compressor, etc.

   h. Maintenance, calibration and adjustment, repair and overhaul of all diagnostic test equipment.

22.05.12 Integrated Schematic and Wiring Manual

A. The integrated schematic manuals shall include all electrical, hydraulic, pneumatic, mechanical, refrigerant and waste water system schematic diagrams as used on each car type, broken down by major system. All schematic drawings will be provided electronically per PRIIA Standard 305-910. The manual shall provide schematic and wiring diagrams including (but not limited to) the following:

1. Electrical power distribution
2. Trainline assignments and connections to car-borne equipment
3. Door control system
4. Lighting system (interior and exterior, in normal, standby and emergency modes)
5. Communications system, including PA, intercom and passenger information system

6. HVAC system (electrical, refrigerant and air flow schematics)
7. Brake system (electrical, mechanical and pneumatic)
8. Main reservoir air distribution system
9. Fresh water distribution and waste retention systems (electrical, pneumatic and water routing)
10. Cab and controls

B. The schematics shall include all required information for maintenance, troubleshooting and repairs, including specific identification of wires (size, type and label), circuits, components, junction boxes and termination points, locations of components, voltages and pressures, hoses and pipes (size, type and rating), filters, adjustment points, direction of flow, function, and other information as necessary.

C. Lists, including a to-from list and bundles list, shall be provided. Indexes of all components, electrical and air shall be provided. An additional section, separately numbered, shall be provided to define the requirements for software integration. A full list of software, generation of signals, process of the signals at points signals may be checked, values and where used shall be provided.

D. The integrated schematic manual shall be supplied in 11 in. tall by 17 in. wide (279 mm tall by 432 mm wide), horizontal format, spiral bound with a protective laminated cardstock front and back cover.

22.05.13 Illustrated Parts Catalog (IPC)

A. General

1. The Illustrated Parts Catalog (IPC) shall list and describe every item of each system. The list shall include:
   a. Figure and Index Number,
   b. Contractor and Subcontractor Part Numbers,
   c. Part Description,
   d. Quantity,
   e. "Use On" Code, and
   f. CTDOT Part Number.
2. The CTDOT Part Numbers will be provided by the Engineer, following approval of the draft IPC, in a column provided by the Contractor for that purpose.
3. The parts listing shall be designed to show each part's relationship to the next higher assembly. The listing shall also include a reference to the Figures in which full, cut-away and exploded drawings shall show all parts.
4. The IPC shall include General and System Tables of Contents. Each table shall include two separate listings: numerical by Figure Index number and alphabetical by name of part.
5. If a service or maintenance task requires numerous parts, these parts shall be listed consecutively and preceded by a kit number.

B. Style and Format Requirements

Illustrated Parts Catalog sections shall be developed for each of the manual's vehicle system divisions. Each system shall contain the following:

1. Front Matter,

2. Introduction,
3. Parts List,
4. Illustrations,
5. System Numerical Index, and

C. Technical Requirements

The Illustrated Parts Catalog sections shall provide maintenance and stores personnel with the information needed to identify and requisition all replaceable assemblies, subassemblies, components and parts used on the vehicles. The organization and format of the Illustrated Parts Catalog shall be as described in the following paragraphs. The Illustrated Parts Catalog shall contain:

1. Front Matter

   The Front Matter shall include the following:

   a. A title page,
   b. A Table of Contents listing figure titles in alphabetical order, and
   c. A list of illustrations with the figure titles arranged in figure number order.
   d. A list of names and addresses of all parts suppliers.

2. Introduction

   The Introduction shall include the following:

   a. An illustrated explanation of how to use the catalog
   b. An explanation of "Use on Code" and of the method used to list similar assemblies.
   c. A list of abbreviations.
   d. A list of names and addresses of all vendors and manufacturers supplying the equipment listed in the Illustrated Parts Catalog, including the vendor identification prefix codes.

3. Parts List

   The Parts List shall include and consider the following:

   a. A listing and illustrations for all parts except the following:
      i. Parts which lose their identity by being welded, sealed, or bonded to other pieces to make a permanent assembly.
      ii. Bulk stock such as lockwire, friction tape and electrical tape.
      iii. Structural items such as stringers, stiffeners, and skin that have been welded in place.
   b. Parts list figures representing major assemblies and installations. Subassemblies shall usually be broken down within their assembly figure, but shall become a separate figure if very large or complex.
   c. A listing of parts in top-down format. This type of breakdown is a listing of assemblies, subassemblies, detail parts and hardware in the order they appear on the manufacturer's Bill of Materials. The parts list shall always begin on a right-facing page with the first corresponding illustration on the left-facing page.
   d. Index numbers assigned to all parts listed. For each figure, the index numbering shall start with 1 and be keyed to the figure illustration.
   e. All part numbers assigned by the Contractor and the Manufacturer shall be identical to numbers shown on the Bills of Material of drawings.

f. A part number column with part numbers assigned by the Contractor for all listed parts. If a part is manufactured by anyone other than the Contractor, the supplier part number shall appear in the part number column next to the Contractor part number.

g. Indentation to show the relationship between installations, assemblies and subassemblies. The indentation shall be indicated by periods, one period to signify each indentation as shown here:

   Installation

   i. Detail Parts for Installation

   ii. Hardware for Installation

   iii. Assembly

   iv. Detail Parts for Assembly

   v. Hardware for Assembly

   vi. Subassembly

   vii. Detail Parts for Subassembly

   viii. Hardware for Subassembly

h. Descriptions of listed parts taken from the manufacturer's Bills of Material. The descriptions shall be arranged as follows:

   i. For all installations, assemblies, sub-assemblies/components and detail parts, the main modifier(s) shall precede the identifying noun name. If required, the words "installation" or "assembly" shall follow the noun name. Additional modifiers (such as location) shall follow the noun name and words "assembly" or "installation", e.g., CIRCUIT BREAKER PANEL ASSEMBLY, BACKWALL.

   ii. For all hardware, the identifying noun name shall precede all modifiers, e.g., SCREW, MACHINE, PAN HD, 8-32UNC x ¾-inch LG.

i. Descriptions shall be in uppercase type

j. References to other figures for Next Higher Assembly or additional Figure (such as adjacent, interfacing assembly) for Breakdown. These references shall be in upper and lowercase type and be located directly below the part description on a separate line. The first line of each assembly shall call out the assembly number and note the next higher assembly(ies) it is used. It shall also include the item number the subassembly is identified by on the next higher assembly illustration.

k. Quantity column listing the quantity used on each assembly as shown in the manufacturer's Bill of Materials.

l. A "Use on Code" column indicating which vehicles the listed part is used on. This column is left blank if the item is used on all vehicle types.

m. A CTDOT part number column containing the Engineer-assigned part number for the listed part.

n. The first figure shall serve as a locator for all subsystems, directing the user to subsequent figures where each system is further broken down. System assembly figures shall be used where there are too many parts or subassemblies within the system to fit the single illustration format. These shall immediately precede the final breakdown illustrations of their respective subsystems.

o. An "End of List" statement shall appear at the end of each Parts List figure's listing.

4. Illustrations

   The Parts List Figure Illustrations shall:

a. Precede the parts listing for each figure. If a figure requires more than one sheet of illustrations, all illustration sheets shall precede the parts listing for that figure.

b. Have a figure title for each sheet of illustrations. If a figure has more than one sheet of illustrations, the illustration title shall indicate Sheet 1 of 3, Sheet 2 of 3, etc.

c. Use figure titles that are right-reading with all modifiers preceding the noun name as shown here:

d. FIGURE 147, "B"-END WALL PANEL INSTALLATION

e. Use line drawings with enough detail to identify all parts.

f. Use index numbers keyed to the Parts List in conjunction with leader lines to locate all listed parts.

g. Explode hardware only when needed to show the detail parts of an assembly. When one piece of a group of attaching hardware is visible, one leader line and stacked index numbers shall be adequate to show location.

h. Subassemblies shall be broken down in the following manner:

   i. Subassemblies broken down within their overall assembly figure shall be identified on the main illustration view with an index number and the note, SEE DETAIL A. A separate detail illustration shall show the breakdown of detail parts for that subassembly. If more than one detail illustration is required for a subassembly, each shall be identified in alphabetical order.

   ii. Detail illustrations shall be boxed and identified with the words, DETAIL A in the lower right-hand corner. If the view chosen for the detail illustration is oriented differently than the main view, a rotation note shall be provided in the lower left-hand corner of the detail box.

5. Numerical Index

The Numerical Index shall be a complete listing of all part numbers included in the System Parts List.

a. Different part numbers shall not be assigned to identical parts, nor shall identical part numbers be assigned to different parts.

b. Part numbers shall be listed in alphanumeric order beginning from the extreme left-hand position. The order of precedence shall be as follows: the letters A through Z; numerals 0 through 9. The alphabetic O shall not be used to avoid confusion with the number zero which may be used. The alphabetic I shall not be used to avoid confusion with the number one which may be used. Spaces and symbols, such as dashes and slashes, shall be subordinate to alpha characters and take precedence over numeric characters.

c. Each part number shall be followed by the applicable locator (system, figure, index number).

d. The same part number may appear more than once on the same listing.

e. Complete part description is needed including size, stock, plating and thread type for hardware, and socket type with current rating for lamps and bulbs, for example.

f. Separate part numbers shall be provided for any part of an assembly that can be obtained for replacement including, for example, lenses and their retainers, and boxes and their separate lids or covers.

g. Quantities of hardware shall be listed to match quantities shown on the fields of source drawings such that the quantities reflect those amounts used by the actual assemblies.

h. Nomenclature for equipment labels shall be provided by the Part List description if actual label wording appears on source drawings.

i. Consistency shall be employed in listing format. For instance, if a word is abbreviated in one line item description, it should always be used for like purposes in abbreviated form.

22.05.14 Interactive Electronic Manuals

A. General Requirements

1. The Contractor shall provide a PC-based Interactive Electronic Manual (IEM) which shall structurally integrate and correlate all text and graphics documentation related to the equipment and components [CDRL 22-017]. It shall include electronic copies of all the functional manuals discussed herein and all functional descriptions, troubleshooting guides, repair and overhaul procedures, and support information (such as how to use any new or special tools). The electronic application shall be browsable, with a content index and data search features, allowing the user to find information on the cars. The application may consist of a number of linked modules for convenience of development, revision, and update.

2. The IEM shall be designed so that it is easily updated by CTDOT personnel after the warranty period has expired. Updates may include additional or revised illustrations, text, information linking, superseding part numbers, etc. The Contractor shall demonstrate this feature for approval by CTDOT. The tools allowing editing of the IEM as well as training on how to use such tools, must be provided by the Contractor.

3. All illustrations shall be adapted (sized, made scrollable) as necessary and oriented for the displays of personal computers used for the IEM application. The content of the IEM must be legible on a computer screen and zooming capabilities must be provided to allow detailed view of illustrations, drawings and schematics.

4. All multimedia information shall be printable on demand when the computer used to access the information is connected to a printer. The printed format shall be similar to that of the paper copy of the manual.

B. Development Process and Tools

1. Commercial off-the-Shelf (COTS) authoring, multimedia development and/or web media design software shall be used to for developing the IEM. Custom programs, coding, or programming shall not be used to develop, edit, or use the IEM.

2. The development tools and search engine (browser) shall be selected and approved by CTDOT before development begins. The major selection criteria is an intuitive user interface for CTDOT employees from every department which will use the IEM. Additional consideration in selecting the development environment or authoring tool(s) shall include ease of use in revising the IEM (such as text, illustrations, and non-linear links, etc.) throughout the life of the fleet. The selected tool(s) shall be demonstrated during a design review when sample manuals and tables of contents are presented. At that time the Contractor shall describe the development process, especially how input and updates/revisions from multiple sources will be managed.

3. The IEM applications shall be capable of running on a 350MHz Pentium II personal computer (PC) with SVGA graphics, CD-ROM, 48MB of RAM and a 15 GB hard drive. The Contractor shall provide two (2) ruggedized portable laptop computers with the latest version of Windows to CTDOT as deliverables to be initially used for running the IEM application. The applications shall be designed to operate on both Local Area Networks (LAN) and Wide Area Networks (WAN) and shall be fully compatible with the following database management systems:

   a. Oracle SQL Net version 2 (or higher) and Oracle version 7.2 (or higher)

   b. Sybase Open Client 10.03 (or higher) and Sybase SQL Server 11.0.2.1 (or higher)

4. The IEM should also be compatible with the latest approved version of the Windows operating system. CTDOT is currently utilizing Windows 10, but the final operating system version will be provided by CTDOT at FDR.

5. The IEMs shall allow viewing and provide "touchpoint" support of the following types of file formats:

   a. Text and line drawings stored in an electronic image format with CITT Group IV compression.

   b. Vector drawings in their native format, including AutoCad (DWG/DXF), HPGL (PLT), Intergraph Microstation (DGN), and Computer Graphics Metafile (CGM).

6. Help Function:

   Custom context-sensitive help shall be available from anywhere within the IEM. Everything the user needs to know to fully utilize the features of the IEM shall be covered in the "Help" feature. The Contractor-developed IEM User Guide shall include an organized, indexed printout of all context-sensitive and general "Help" screens.

C. User Interface:

1. The user interface shall be consistent and intuitive, employing on–screen "buttons" for the most important or frequently used options and menus, submenus and dialog boxes for additional features and functions. The interface shall be designed for use with a pointing device, with menu or button commands available alternatively by keyboard command.

2. In cases where the availability of many features or options could become confusing, the context-sensitive "Help" feature shall provide guidance that eliminates the need for the user to look up instructions in a paper manual. Where a specific button is available on different screens, the screen locations shall be consistent screen-to-screen. Ergonomics of the screen controls shall be according to Paragraph 5 of the latest revision of MIL-STD-1472G.

D. Information Linking:

1. General

   a. Information shall be linked in a variety of linear and non-linear ways, depending on the user's starting point. The user shall be able to read and scroll through the text and illustrations on the screen in a linear fashion, just as in a hard copy manual. The user shall also be able to "click" on highlighted text (hypertext) to access relevant information, such as associated text, illustrations, drawings, schematics and parts data.

   b. The IEM shall include a Table of Contents, an Alphabetical Index, and a List of Illustrations with the listings linked to the associated text, Detailed Parts List, a Graphics and Illustrations Index, and a MAC Task Index. When a listing is "clicked" on, the associated text, Detailed Parts List, or illustration shall appear on the screen.

2. Maintenance Instructions IEM

   a. Component/part names in the text shall be linked to the illustration accompanying the text. The user shall be able to "click" on the component/part name and an exploded view of the illustration where that item is located with its index number highlighted shall appear on the screen.

   b. Index numbers for the components/parts on the illustrations shall be linked to the associated information in the IPC. When a figure index number is "clicked" on within an illustration, the Detailed Parts List information for that part shall appear on the screen.

3. IPC IEM

a. Figure Index Numbers and component/parts on the Detailed Parts List shall be linked to the accompanying illustration. The user shall be able to "click" on the part and obtain an exploded view of the illustration where that item is located with the index number highlighted.

b. Figure Index numbers for the parts on the illustrations shall be linked to the associated information on the Detailed Parts List. When a figure index number is "clicked" on within an illustration, the detailed information for that part shall appear on the screen.

4. Search Capabilities:

a. IEM Maintenance Instructions

As a minimum, the user shall be able to search the Maintenance Instructions within the IEM by MAC Number, system, subsystem, Section, Chapter, subheading numbers and/or titles, or description (both by keyword and by text string).

b. IEM Illustrated Parts Catalog

The user shall be able to search the IEM IPC by system, subsystem, description (both by keyword and by text string), OEM Part Number, Contractor Part Number, CTDOT part Number, and any other number by which a part is identified. The user shall also be able to link to locations where the same part is used on other systems or subsystems in the vehicle.

E. Warranty Updates:

The IEMs shall be electronically updated on a regular basis during the warranty period. The Contractor shall provide the updated files to CTDOT along with information supporting how the files are to be incorporated into the existing data. CTDOT will be responsible for incorporating the files onto the CTDOT computers. Revisions shall be provided for any changes, whether required by change of design or procedures or due to errors and omissions. Revisions shall be kept current during the warranty period and supplied to CTDOT before or coincidental with the arrival of the altered parts or components. After the warranty period, revisions shall be supplied to CTDOT on an as-required basis for a period of five (5) years. An electronic list of changes to the IEMs shall be maintained and available to the user. After each IEM update, the Contractor shall provide CTDOT with two (2) copies on CD-ROMs of the latest version of the complete IEM for installation on additional PCs and/or laptops. The IEM shall not require any licensing for use or installation and shall allow CTDOT to install the IEM on an unlimited number of computers and/or laptops.

22.05.15 Manual Quantities to be Provided

Name	Quantity
Operator's Manual	200
Service and Inspection Manual	50
Running Maintenance Manual	10 sets
Troubleshooting Manual	10 sets
Heavy Maintenance Manual	10 sets
Illustrated Parts Catalog (IPC)	10 sets
Integrated Schematic Manual	10 sets

22.06 Vehicle History Books

A. The Contractor shall produce a vehicle history book for each completed rail car. The vehicle history books shall be a specific record of production, testing, inspection and relevant documentation for each individual vehicle. [CDRL 22-019]

B. The vehicle history book shall contain original documents unless specified otherwise.

C. All documents shall be marked with the carshell serial number, the production sequence number or the road number for the completed vehicle.

D. The Contractor shall provide two electronic and two paper sets of the vehicle history book for each car; one that contains the original documents, and one copy. The volume with the original documents shall be appropriately labeled. Vehicle history books shall be provided in three-ring binders. Documents shall be copied double-sided where practical.

E. At a minimum, each vehicle history book shall contain the following:

1. Table of contents
2. Production control cross-reference sheet, listing:
    a. Carshell serial number
    b. Shop order/production sequence number
    c. Final car reporting marks and road number
3. Production schedule for each car showing start and end dates for each major stage of manufacturing
4. List of all production drawings by number and revision status (release date, current revision, and outstanding engineering change requests at time of production)
5. List of all parts by supplier and part number (bill of material)
6. List of all serialized components
7. Truck records (separate set of records for each truck)
    a. Inspection records
    b. Truck assembly sequence
    c. Truck assembly weight certificate
    d. Wheel/axle pressing graphs
    e. Truck to carbody attachment record
8. Log of all non-conformances including status
9. Component test certificates
10. Test records:
    a. Master test plan
    b. Test procedures
        i. Production tests
        ii. Acceptance tests
    c. Record of measurements and results
11. Critical dimensional inspection report
    a. Carshell dimensional inspection (prior to production)
    b. Carbody leveling, balancing and centering record
    c. Carbody overall dimension measurement, including compliance with clearance diagram
    d. Coupler height measurement

e. Scale certificate for completed car (dry weight)

12. Records of all required inspections
13. USPHS Certification
14. FRA documentation
15. Copies of required cab car inspection forms (originals are to be installed in the appropriate form holders in the cab of the car)
16. Record of compliance with FRA regulations
17. Completed pre-shipment checklist
18. Shipping approval form
19. Engineer acceptance form
20. Transfer of title of the car from Contractor to Engineer (with original wet-ink signature of Contractor's representative).

F. The vehicle history book shall be produced in an electronic Adobe PDF format. Procedures, electronic signatures and controls shall be established to ensure the validity of information in this document at all times.

G. Each vehicle history book shall be presented to the Engineer for review prior to the car being released from the Contractor's facility.

22.07 Training

22.07.01 Description

A. The Contractor shall develop a detailed, comprehensive training program for all personnel involved with the coaches. The program shall include several in-depth instructional modules covering the vehicle as a whole and all of its applicable subsystems and equipment, including all interfaces. Each of the training courses shall include the following course categories:

1. Introduction and Familiarization;
2. Operation and Fault Isolation;
3. Servicing and Maintenance;
4. Daily Inspection;
5. Periodic Inspection;
6. Special Tools and Test Equipment; and

B. The training program shall be divided into five course levels: Introductory Familiarization and Inspection, General Familiarization and Inspection, Basic Training, Advanced Training and "As Deployed". All courses shall include the use of the applicable maintenance manual documentation provided under this Contract and incorporate all pertinent information approved by the Engineer and necessary to comply with the requirements of 49 CFR Part 238.109 (or applicable newer standards, as of the execution date of the Contract). The five course levels shall be as follows:

1. Introductory Familiarization and Inspection Courses

These training courses will provide the necessary introductory training to CTDOT personnel to allow for the start of pilot car testing on CTDOT property. These training courses shall be designed, developed and conducted for two separate groups of personnel: Maintenance of Equipment (M of E) and Train and Engine (T&E). The Introductory Familiarization and Inspection Courses shall include, but not be limited to, Introduction and Familiarization (for both M of E and T&E forces), Operation and Running Fault Isolation, including towing and consist set-up (for both M of E and T&E forces), Calendar Day Inspection (M of E only). The pilot sessions of these training courses shall begin upon arrival of the pilot car and all training sessions shall be complete prior to the start of pilot car testing on CTDOT property.

2. General Familiarization and Inspection Courses

   These training courses shall be designed, developed and conducted for two separate groups of personnel: M of E and T&E. The General Familiarization and Inspection Courses shall include, but not be limited to, Introduction and Familiarization (for both M of E and T&E forces), Operation and Running Fault Isolation (for both M of E and T&E forces), Calendar Day Inspection (M of E only), and Periodic Inspections through Year One (the first calendar year of the car in revenue service) (M of E forces only). The pilot sessions of these training courses shall begin no later than seven (7) months prior to the Conditional Acceptance of the first car and all training sessions shall be completed no later than sixty (60) days prior to the Conditional Acceptance of the first car.

3. Basic Training Courses:

   The Basic Training Level Courses shall be provided for each of the vehicle subsystems, and shall cover each individual vehicle system with topics including, but not limited to, theory of operation, applicable electrical and/or pneumatic schematics (including schematic narratives and integration of the individual system with the vehicle as a whole), on-vehicle fault isolation and troubleshooting, on-vehicle servicing, maintenance and component replacement, including the use of any Special Tools and Test Equipment, Daily Inspections, and Periodic Inspections (up through Year 5 of the car in revenue service). The pilot sessions of these training courses shall begin no later than thirty (30) days after the Conditional Acceptance of the first car. At least one regular session of each of the Basic Training courses shall be completed six (6) months after the pilot sessions. The last regular session of each of the Basic Training courses shall be completed prior to the end of warranty of the first car.

4. Advanced Training Courses

   The Advanced Training Courses shall be provided for each of the vehicle subsystems and shall cover each individual vehicle system with topics including, but not limited to, in-depth off-vehicle system maintenance (up through Year 5 of the car in revenue service), use of Bench Test Equipment and Portable Test Equipment (PTE), advanced component replacement, and advanced off-vehicle troubleshooting. The pilot sessions of these training courses shall begin no later than six (6) months after the Conditional Acceptance of the first car. At least one regular session of each of the Advanced Training courses shall be completed six (6) months after the pilot sessions. All sessions of the Advanced Training courses must be completed prior to the end of warranty of the first car.

5. "As-Deployed" Training Courses

   The "As-Deployed" training courses shall be provided for each of the vehicle subsystems and shall cover all changes made in equipment or procedures since the Basic and Advanced training sessions were first presented. These sessions shall use final manuals, schematics, and other Deliverables from Section 22.5. The pilot sessions of these training courses shall begin no later than three (3) months after the end of warranty of the first car. All sessions of the "As-Deployed" Training courses must be completed prior to the end of warranty of the last base order car.

C. Program development shall involve the Contractor's and major supplier's training professionals and Subject Matter Experts (SMEs).

D. Within eighteen (18) months of Notice to Proceed, the Contractor shall submit for approval a detailed description of its educational program and a schedule for its pilot presentations based on the development status of the vehicle. The submittal shall include details of the course content for each class, description of training materials to be utilized, and a list of anticipated instructors with resume(s) of their qualifications. [CDRL 22-020]

E. The program shall be scheduled to commence at the time the pilot vehicle is delivered to the Engineer.

F. The training program shall place special emphasis on material which is safety-critical, required by the FRA, complex, new to the Engineer and/or different from the Engineer's prior practices.

G. Computer programs and hardware used in the training program shall be Windows compatible, using an operating system selected by the Engineer at time of Notice of Award or when needed by the Contractor, whichever is later.

H. The Contractor shall work closely with the Engineer's own training staff so that preparation and presentation of course material complements the Engineer's training practices.

I. Pilot Training Sessions:

1. An initial pilot presentation shall be scheduled by the Contractor for each course. Course content and material to be utilized in the pilot, including Student Guide Instructor Guide and presentation material shall be submitted to the Engineer at least ninety (90) days prior to the pilot training session date for review by the Engineer. The pilot training session will not commence until the Engineer has provided Conditional Acceptance of the submitted training materials.

2. Each pilot session shall be presented to selected candidates by the Engineer from respective target population with different levels of knowledge and skills.

3. Engineer and Contractor representatives shall take part in the certification of the initial pilot presentation. The Contractor will ensure at least one of its Subject Matter Experts (SMEs), who is qualified on the system being covered in the specific training session, along with the major supplier's SME are present at each presentation.

4. Following the pilot presentation, the Contractor shall review student examinations and/or Engineer or instructor observations to evaluate student learning and course effectiveness toward attaining the learning objectives, and will make the necessary corrections and improvements to the training program where needed.

5. A second pilot course presentation scheduled by the Contractor may be required by the Engineer in order to validate the changes and improvements implemented to each pilot course previously presented.

6. Only upon acceptance of the pilot course presentation by the Engineer, shall two additional train-the-trainer classes be conducted by the Contractor for Engineer training personnel to demonstrate the proper level of instruction and to fully acquaint the Engineer's training personnel with the material.

7. The Contractor's Instructors shall then provide three regular classes to Engineer maintenance and transportation personnel.

8. The Contractor shall provide the option to allow the Engineer to purchase additional training sessions of any training course.

9. The Contractor shall establish a Training Program Delivery Schedule of the validated courses with the Engineer. Course delivery shall begin within fifteen (15) days following course approval by the Engineer.

22.07.02 Lesson Plans

A. Training courses shall consist of a series of instructional classes for each vehicle system or topic, as applicable. Training shall be organized into 3.5-hour segments. One day of training shall consist of two segments, each comprised of units of one-hour maximum duration. Instruction shall include the functionality of each system, subsystem, assembly, and subassembly, and the essentials of their operation and maintenance, as appropriate. [CDRL 22-021]

B. Contents

A lesson plan shall be developed for each unit of instruction, whether conducted in the classroom or field, and shall include the following:

1. Student prerequisites, including CTDOT craft or job category which shall be determined in cooperation with the applicable departments of the Engineer (i.e., M of E, T&E, Training, etc.), prior knowledge, and skills;
2. Measurable learning objectives
3. Material covered, which shall include safety considerations;
4. Time frames for instructional units of the lesson;
5. Lists of training aids/unit and other training technology;
6. Set-up time and lists of equipment and activities for the Field Instruction portion of the training;
7. Safety, protective equipment and hazards;
8. Instructor preparation;
9. Student preparation;
10. Evaluation of students (tests), both written and hands-on observations per 49 CFR Part 243. The number of Test Questions should vary depending on the length of the training (1-2 days of training: 10-15 questions; 2 or more days of training: 20-25 questions);
11. Lesson summary;
12. Student application of material;
13. Student assignments; and
14. Course evaluation capabilities by the students shall be built into each course, at least once within each major topic or system. Course evaluation capabilities shall be in a form which provides quantifiable results on an individual basis.

22.07.03 Instructor Guides and Student Guides

For each course the Contractor shall furnish the following:

A. Instructor guides in three-ring binders containing a series of lesson plans covering all training materials for the complete course, divided into class topics and individual presentation units. [CDRL 22-022] The guides shall include:

1. A table of contents, providing a breakdown and listing of all topics contained in the Instructor Guide.
2. An introduction including course outline, purpose, objective, and testing and evaluation procedures.

3. An instructor preparation guide, including topics to be reviewed by the instructor prior to presenting the course, such as applicable sections of the maintenance manual, integrated schematics manual, illustrated parts catalog, and other selected documents as appropriate.

4. Class instructions for each unit of instruction, including all information necessary for presentation to the class in a logical, systematic approach, including purpose; objectives; student material and handouts; tests and evaluations; administration requirements; time frames; and lesson plans. Class instructions shall explain how best to integrate audio/visual aids and other training technology into each lesson plan. Instructor notes shall be included and incorporate any topics covered during the classroom training sessions led by the Contractor that are not detailed in the participant training materials.

5. Detailed activity checklists for the field instruction portion of the training course, to ensure that each session of the training courses is consistent. These checklists shall also include detailed instructions on how to insert or simulate faults on-board the vehicles, and how to clear these faults once the training course is complete. These checklists shall also include expected time durations for the activities to be covered during the field instruction portion of the training courses.

6. Student guide notations or materials: Instructors shall have notations on pages to indicate which information is also provided in the student guides. Copies of materials provided to students shall be provided to instructors where they differ from instructor materials.

7. Index: A complete list of training aids/unit and training technology shall be provided and cross-referenced to the lesson plan where they are used.

B. Student guides in three-ring binders, containing all classroom material required by the student for the course, divided into class topics and individual presentation units. The student guide shall contain materials necessary to allow for self-study and shall include a copy of the slide presentation provided during the training course. [CDRL 22-023]

C. Audio/visual aids, including overheads (viewgraphs), slides and handouts. Video-recorded presentations, if deemed appropriate for the instructional guides, shall be in electronic format, shall be approved by the Engineer, and shall include closed-captioned versions of all video presentations.

D. Any revisions made by the Contractor to the training materials shall be submitted to the Engineer for review and approval.

E. The Contractor shall ensure that the training materials be kept up to date due to any design changes or fleet modifications.

F. The Contractor shall additionally provide computer-based training consisting of all of the inputs needed, such as video clips, simulations, computer animations, 3D drawings and working mock-ups.

22.07.04 Classroom Instruction

A. All instruction shall be conducted on the Engineer's property according to the Engineer's schedules for a three-shift, seven-day-a-week operation, except on CTDOT's holidays. The Contractor will video record all classroom and field instruction.

B. Instructional aids such as relays, printed circuit boards, test equipment, special tools, mock-ups, models and the like, and training technology such as computers, software, and overhead projection panels, shall be used in the presentation of the training program and/or for hands-on demonstration and training, and shall be furnished to the Engineer upon completion of the program.

C. Instructors shall have all subject matter, training aids, procedures, and necessary requirements available and organized prior to the start of any class

D. Training shall be provided to the Engineer at one location on CTDOT property. Training at this location shall be provided to the trainers and/or the maintenance crafts, possibly on all three shifts.

22.07.05 Field Instruction

A. All training courses shall include a field instruction portion, involving the use of the cars, including both maintenance and basic operating principles, and shall be presented by instructors having thorough experience in maintenance servicing and systems operation as required.

B. Instructors shall have all subject matter, training aids, procedures, and necessary requirements available and organized prior to the start of any class.

C. The Contractor shall make available one car of each type on Engineer property for instructional purposes.

D. The Engineer will make available, upon proper notice, locomotives, cars and trains at accessible shop locations for instructional purposes. Participants will be required to demonstrate competency in performing inspections, troubleshooting, etc., during the field instruction sessions as per 49 CFR 243.

E. The hands-on portion of the training courses shall include the insertion or simulation of faults for the students to troubleshoot. The instructor guides shall include detailed instructions on how to insert or simulate these faults and how to clear these faults once the training course is complete.

22.07.06 Course Content

Each course of the training classes shall be conducted over a period of 90 days and shall be presented in the numbers required for each different session (i.e., friction braking, HVAC, ATC, etc.) of each training course with 12 attendees per session for each system. Prior to the delivery of the pilot session of each course of training, the Contractor shall hold a course review working session with the Engineer wherein the Engineer will determine if the course is ready for presentation. The modules for the five levels of training (Introductory Familiarization and Inspection, General Familiarization and Inspection, Basic Training, and Advanced Training, "As-Deployed") shall be as follows:

A. Introductory Familiarization and Inspection:

1. Module 1 – Overview: Utilizing top-level materials and photographs and/or video clips of controls and indicators, this module shall cover the basics of the vehicle, including differences from existing vehicles in the Engineer's fleet. (Note: This module will be included in both the M of E and T&E courses).

2. Module 2 - Component Location and Operation: Utilizing the manuals, student guides, training aids/unit and training technology, this module shall cover the location and operation of the features on the coaches, and the subject matter shall be presented in a logical manner. (Note: This module will be included in both the M of E and T&E courses.)

3. Module 3 – Basic Testing and Running Fault Isolation: Utilizing the manuals, student guides, training aids/unit and training technology, this module shall cover towing and consist set-up procedures, conducting system self-tests, conducting brake tests, identification and correction of basic faults utilizing on-vehicle diagnostics and observable symptoms. Subject matter shall be presented in a logical manner. (Note: This module will be included in both the M of E and T&E courses)

4. Module 4 - Calendar Day Mechanical Inspection – Utilizing the manuals, student guides, training aids/unit and training technology, this module shall cover all CTDOT and regulatory agency requirements necessary on a daily basis. Subject matter shall be presented in a logical manner. (Note: This module will be included in the M of E course only.)

B. General Familiarization and Inspection shall contain the following modules:

1. Module 1 – Overview: Utilizing top-level materials and photographs and/or video clips of controls and indicators, this module shall cover the basics of the vehicle, including differences from existing vehicles in the Engineer's fleet. (Note: This module will be included in both the M of E and T&E courses.)

2. Module 2 - Component Location and Operation: Utilizing the manuals, student guides, training aids/unit and training technology, this module shall cover the location and operation of the features on the cars. Subject matter shall be presented in a logical manner. (Note: This module will be included in both the M of E and T&E courses.)

3. Module 3 – Operation, Basic Testing and Running Fault Isolation: Utilizing the manuals, student guides, training aids/unit and training technology, this module shall cover towing and consist set-up procedures, conducting system self-tests, conducting brake tests, identification and correction of basic faults utilizing on-vehicle diagnostics and observable symptoms. Subject matter shall be presented in a logical manner. (Note: This module will be included in both the M of E and T&E courses.)

4. Module 4 - Calendar Day Mechanical Inspection – Utilizing the manuals, student guides, training aids/unit and training technology, this module shall cover all CTDOT and regulatory agency requirements necessary on a daily basis. Subject matter shall be presented in a logical manner. (Note: This module will be included in the M of E course only.)

5. Module 5 - Periodic Inspection: Utilizing the manuals, student guides, training aids/unit and training technology, this module shall cover all CTDOT and regulatory agency requirements necessary to perform periodic inspections up through Year 1 of the coaches in revenue service. Subject matter shall be presented in a logical manner. (Note: This module will be included in the M of E course only.)

C. Basic Systems Training Courses shall contain the following modules:

1. Module 1 - System Overview: Utilizing the manuals, student guides, training aids/unit and training technology, this module shall cover basic overview of system location, purpose, functionality, and capabilities; and sub-system assembly location, description, and functionality. Subject matter shall be presented in a logical manner.

2. Module 2 - Theory of Operation: Utilizing the manuals, Integrated Schematic Manual, Schematic Narratives, student guides, training aids/unit, and training technology, this module shall cover theory of operation, including system control and operation, and system interfaces on the coach as a whole. Subject matter shall be presented in a logical manner.

3. Module 3 – On-Vehicle Servicing and Maintenance: Utilizing the manuals, student guides, training aids/unit, and training technology, this module shall cover applicable on-vehicle inspection, adjustment, maintenance, and component replacement and/or repair up through Year 5 of the coaches in revenue service. Subject matter shall be presented in a logical manner.

4. Module 4 - Special Tools and Test Equipment: Utilizing the manuals, student guides, training aids/unit, and training technology, this module shall cover the set-up, calibration, use, and maintenance of on-vehicle special tools and test equipment required for the coaches. Where special tools and test equipment are computer-based, instruction shall cover how to use the software. Subject matter shall be presented in a logical manner.

D. Advanced Systems Training Courses shall contain the following modules:

1. Module 1 - In-Depth Off-Vehicle System Maintenance: Utilizing the manuals, student guides, training aids/unit, and training technology, this module shall cover all off-vehicle tasks for extended maintenance cycles. Subject matter shall be presented in a logical manner.

2. Module 2 - Bench Test Equipment: Utilizing the manuals, student guides, training aids/unit, and training technology, this module shall cover the set–up of, calibration of, use of, and maintenance

required for bench test equipment. When test equipment is computer-based, instruction shall cover how to use the software. Subject matter shall be presented in a logical manner.

3. Module 3 - Advanced Off-Vehicle Component Replacement: Utilizing the manuals, student guides, training aids/unit, and training technology, this module shall cover off-vehicle repair and/or replacement of sub-system assemblies and components. Subject matter shall be presented in a logical manner.

4. Module 4 - Advanced Off-Vehicle Troubleshooting: Utilizing the manuals, Integrated Schematic Manual, Schematic Narratives, student guides, training aids/unit, and training technology, this module shall cover in-depth off-vehicle troubleshooting techniques. Subject matter shall be presented in a logical manner.

22.07.07 Instructor Qualifications

Instructors shall be expert in their subject area, be fluent in English, and be experienced trainers and/or trained in adult education training techniques. The Contractor shall supply the Engineer with instructor qualifications, and the Engineer shall approve all instructors. A qualified Contractor instructor shall be present at all times to instruct or to witness the instruction; a qualified system vendor instructor may also be present. [CDRL 22-024]

22.08 Deliverables

A. Instructor Guides for each training course shall be provided as noted below. Instructor Guides shall include, at a minimum, handouts, overheads, slides, CD-ROMs or DVD disks, and training technology.

   1. Two draft copies shall be provided per course for Engineer review 90 days prior to the pilot session of each training course.

   2. Upon incorporation of the Engineer's review comments, two copies shall be provided per course immediately prior to the pilot session of each training course.

   3. Each Instructor Guide shall be updated after each training course has been validated. 12 final copies shall be provided per course prior to the presentation of the remainder of each training course.

B. Student Guides for each training course shall be provided as noted below.

   1. Two draft copies shall be provided per course 90 days prior to the pilot session of each training course.

   2. Upon incorporation of the Engineer's review comments, 12 copies shall be provided per course immediately prior to the pilot session of each training course.

   3. Each Student Guide shall be updated after each training course has been validated. 150 final copies shall be provided per course prior to the presentation of the remainder of each training course.

C. Any training units not otherwise supplied above which are required for training shall be provided 90 days prior to the pilot session of each training course.

D. The Contractor shall provide training units for the friction brake and HVAC systems [CDRL 22-025].

   1. These training units shall demonstrate the system's functions and faults and shall have the ability to have full troubleshooting procedures be conducted on them, as would be done on the vehicle.

The training units shall allow defects to be programmable by the Instructor to simulate actual failure modes.

2. The training units shall utilize a simulator where appropriate due to safety and space constraints (i.e., no voltages over 220VAC). An easily accessible emergency shut off switch is needed for each powered simulator unit.

3. The training units shall be constructed in such a way as to preclude their use on the vehicle.

4. Friction Brake: One carset of friction brake equipment, complete with all control units, brake pipe control unit, reservoirs, one conductor's valve, one tread brake unit of each type, one disc brake actuator control unit, if disc braking is required, one complete parking brake system, slide control magnet valves, loco-haulage brake system, all cutout cocks, and all other components necessary to form a complete functional system shall be provided as a training unit. Provision shall be made for supply of compressed air from an external source through a quick-disconnect coupling, cutout cock, filter, and air drier within the unit. Gauges shall be provided to indicate pressure in each reservoir, brake pipe, and brake cylinder. An electrical control panel shall be provided in the unit to permit simulation of all input signals to the system. Provision shall be made for the supply of 110 VAC power through a connector, and suitable power supplies shall be provided within the unit for all voltages and signals required by the system. The training unit shall be mounted on a test stand with wheels.

5. HVAC: One HVAC system training unit, complete with controls, shall be provided. The training unit shall be mounted on a stand with wheels, and include a power supply and all necessary connections to power and operate the equipment from shop power.

E. Training sessions, conducted by the Contractor, in accordance with this section:

1. Introductory Familiarization and Inspection Course Pilot Training Session: at the time of arrival of the pilot vehicle, with the balance of the training to be provided as soon thereafter as possible, to allow the vehicles to begin testing on CTDOT property.

2. General Introduction and Familiarization Course Pilot Training Session: no more than seven (7) months prior to the Conditional Acceptance of the 1st coach, with the balance of the training to be provided no later than sixty (60) days prior to the Conditional Acceptance of the 1st coach.

3. Basic Training Course Pilot Sessions: no more than thirty (30) days after the Conditional Acceptance of the 1st Coach, with the balance of the training to be provided prior to the end of warranty of the 1st Coach.

4. Advanced Training Course Pilot Sessions: no more than six (6) months after the Conditional Acceptance of the 1st Coach, with the balance of the training to be provided prior to the end of warranty of the 1st Coach.

5. "As-Deployed" Training Course Pilot Sessions: no more than three (3) months after the end of warranty of the 1st Coach, with the balance of the training to be provided prior to the end of warranty of the last base order car, or when determined that all modifications needed are implemented, or as directed thereafter by the Engineer.

6. The following courses shall be furnished to the Engineer:

Course	Number of Sessions (Includes At Least 1 Pilot Session)	Instructor Guides	Student Guides
Introductory Familiarization and Inspection			
M of E Training	6	12	150

Course	Number of Sessions (Includes At Least 1 Pilot Session)	Instructor Guides	Student Guides
T & E Training	6	12	150
General Familiarization and Inspection			
M of E Training	6	12	150
T & E Training	6	12	150
Basic Training			
Air Brakes/Air System	6	12	150
Carbody/Coupler/Suspension/Trucks	6	12	150
Cab Signal/PTC	6	12	150
Doors	6	12	150
Diagnostics & Event Recorder	6	12	150
Communication/Lighting	6	12	150
HVAC	6	12	150
Power Collection & Distribution	6	12	150
Auxiliary Systems	6	12	150
Water/Waste	6	12	150
Advanced Training Courses			
Air Brakes/Air System	6	12	150
Carbody/Coupler/Suspension/Trucks	6	12	150
Cab Signal/PTC	6	12	150
Doors	6	12	150
Diagnostics & Event Recorder	6	12	150
Communication/Lighting/Signs	6	12	150
HVAC	6	12	150
Power Collection & Distribution	6	12	150
Auxiliary Systems	6	12	150
Water/Waste	6	12	150
As-Deployed Training Courses			
Air Brakes/Air System	6	12	150
Carbody/Coupler/Suspension/Trucks	6	12	150
Cab Signal/PTC	6	12	150
Doors	6	12	150
Diagnostics & Event Recorder	6	12	150
Communication/Lighting/Signs	6	12	150
HVAC	6	12	150
Power Collection & Distribution	6	12	150
Auxiliary Systems	6	12	150
Water/Waste	6	12	150

F. Two sets of multi-session CD-ROMs or DVD disks, which contain the materials described above, shall be furnished and shall:

1. Include all graphics and text in Microsoft Office Suite formats;

2. Allow for the text access and revision from within the documentation in Microsoft Office Suite formats;

3. Provide graphics and drawings in Microsoft Office Suite supported graphic formats, specifically CGM (Computer Graphics Metafile) or PCX (PC Paintbrush Format); and

4. The version of Microsoft Office Suite must be agreed to by the Engineer prior to the development of the material.

G. Five master sets of CD-ROMs or DVD disks.

H. Updated sets of all deliverable materials reflecting all changes made to the coaches through the end of the warranty period.

22.09 Contract Deliverable Requirements List

CDRL #	Title	Car Type
22-001	Preliminary Drawings	All
22-002	Top Assemblies As-Built Drawings	All
22-003	Car Bill of Materials	All
22-004	Electronic Drawing Files	All
22-005	Photograph Book	All
22-006	Completed Cars Photographs	All
22-007	Conformed Specification	All
22-008	Equipment List (ELIST)	All
22-009	Maintenance Allocation Chart (MAC)	All
22-010	Operator's Manual	All
22-011	Service and Inspection Manual	All
22-012	Troubleshooting Guide	All
22-013	Running Maintenance Manual	All
22-014	Heavy Maintenance Manual	All
22-015	Integrated Schematic Manual	All
22-016	Illustrated Parts Catalog	All
22-017	Interactive Electronic Manuals	All
22-018	Master Plan and Schedule for the Completion of the Manuals	All
22-019	Vehicle History Books	All
22-020	Educational Program Outline	All
22-021	Lesson Plans	All
22-022	Instructor Guides	All
22-023	Student Guides	All
22-024	Instructor Qualifications	All
22-025	Training Units	All
22-026	Cab Simulator Module	All

* End of Chapter 22 *

Technical Specification

CTDOT Single-Level Passenger Rail Cars

Chapter 23

Customer Variables

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23.00 Customer Variables

23.01 Overview

In order to accommodate the specific requirements of different customers that acquire cars using this specification, the features, components, systems and testing requirements described in this chapter shall be designated by each customer for application to the vehicles being designed and built under this Specification and may vary from one contract to another. These features, systems, components and requirements shall conform to all applicable specifications and references as contained in other chapters. All components, systems and requirements not specifically identified within this chapter shall be in conformance with the applicable requirements found elsewhere in this Specification.

23.02 Supplemental Regulations, Standards, Specifications & Drawings

The following documents and regulations pertain to this chapter and supplement the applicable regulations, standards, specifications and drawings identified in Chapter 2. This list is not all-inclusive and does not relieve the Contractor of its responsibility to conform to all requirements and standards that are applicable to the design and manufacture of the systems and components described below.

23.02.01 Specifications

Not used.

23.03 Exterior Graphics

23.03.01 General

A. The Engineer shall supply all required details regarding the exterior graphics, styling, paint and decals. The Contractor may request minor modifications to the size, location and placement of decals, striping and paint application in order to accommodate carshell features, equipment, maintenance points or other obstructions that will affect the quality, appearance or longevity of the decals or graphics.

B. All decals, graphics and signage shall be specified and designed to function in the operational, environmental and climatic conditions specified in PRIIA Specification 305-912 with no fading, material degradation, delamination, discoloration, shrinkage or expansion, wrinkling or peeling.

C. All paint shall include, at a minimum, a primer coat, color coat and clear coat, applied in accordance with manufacturer specifications.

23.03.02 Paint and Styling

The Contractor shall provide paint chips to be used for precise color matching for all paint application. [CDRL 23-001]

23.03.03 Car Numbers, Reporting Marks and Names

The Engineer shall provide the reporting marks, road numbers and other car-specific identifiers to the Contractor.

23.03.04 Decals and Exterior Arrangement

A. Engineer-specific decals and graphics shall be installed in accordance with the Engineer's standards for service name, logo and identity.

B. All decals shall be retro-reflective unless specified otherwise.

C. Signage used to identify specific components, service-related items or maintenance points on the vehicles shall be designed and installed in accordance with Amtrak's signage manual.

D. Emergency-related decals and signage shall conform to all applicable APTA standards and FRA requirements.

23.04 Seats and Interior Arrangement

See Chapter 9.

23.05 Interior Décor – Additional Customer Requirements

See Chapter 9.

23.06 Contract Deliverable Requirements List

CDRL #	Title	Car Type
23-001	Paint Chips for Color Matching	All

* End of Chapter 23 *

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Technical Specification

CTDOT Single-Level Passenger Rail Cars

Chapter 24

Software

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24.00 Software Systems

24.01 General

24.01.01 Purpose

A. The purpose of this section is to ensure that the software, as defined below, is of the highest quality and meets the standards and guidelines listed below.

B. This section applies to all software, microprocessor-based systems supplied for this project, including vehicle subsystem controls, test equipment, data analysis, fault analysis and training deliverables.

C. This section shall also apply to the programming of all programmable devices, including microprocessors, microcontrollers, Programmable Logic Devices (PLD), Application-Specific Integrated Circuits (ASIC), or Field Programmable Gate Arrays (FPGA), etc.

24.01.02 Software Systems Justification

The Contractor shall submit a life cycle cost justification for each software application not explicitly required by this specification. This justification shall include, but not be limited to, a comparison between a hardware (e.g. relays, and discreet electronic) and a software-based system. For this calculation, the Contractor shall use an "end of life" or obsolescence of the hardware (microprocessor and associated ICs) of 10 years and Military Handbook MIL-HDBK-217, Ground Mobile. Based on this analysis, the Engineer will approve or disapprove the use of additional software systems. [CDRL 24-001]

24.01.03 Software Systems Requirements

A. Software System Classification

Hardware and software requirements depend on the degree to which the hardware and/or software is custom-designed for or applied to this project.

1. "Commercially available" or "Commercially Off The Shelf" (COTS) hardware or software shall be readily available in the US through retail and wholesale sources and shall be subject to all requirements, except as noted in this section.

2. "Non-commercially available" hardware or software shall be developed or modified according to the requirements in this section.

B. Time and Date Processing

1. All software and hardware delivered or developed under this Contract shall be capable of handling dates in the range from 2000 to 2099. The date data processing shall not experience abnormal ending and/or invalid or incorrect results from the hardware, software, data repository or firmware in operation as part of CTDOT's business processes. Each hardware, software, data repository or firmware's date data interface shall support a four-digit year format.

2. The master real time clock for all subsystems that are connected to the vehicle network shall be provided by the "Train Monitoring System (TMS)." All subsystems shall synchronize to the master clock. All time displayed to the train crew, maintenance personnel, or passengers shall be adjusted to the local time and shall automatically be adjusted to daylight saving time. The start and end dates for daylight savings time for all systems shall be adjustable by the Engineer via a configuration of the TMS.

24.01.04 Software

A. Software Development Process

All Non-COTS software shall be in accordance with IEEE Std 1558-2004, Standard for Software Documentation for Rail Equipment and Systems, and the requirements stated within this specification. The IEEE Std 1558 requirements shall be for a "Type 5" procurement as defined within that standard except as noted below.

B. General Features

1. Software shall perform the following basic functions:

   a. Implement the desired control scheme such that the specified performance is achieved.

   b. Monitor all inputs for unsafe, erroneous, or unknown conditions or combinations of conditions.

   c. Sample all input conditions at rates sufficient to detect and remedy all unsafe or damaging conditions in the shortest possible time. Sampling rates and program execution times shall be such that the control system is not the limiting factor in response to unsafe or damaging conditions. All software shall be designed to ensure that the timing requirements for safety related tasks are always met.

   d. Limit all output commands to safe levels for all combinations of input conditions, to avoid equipment damage and hazards to personnel.

   e. Perform system self-diagnostic routines and respond promptly, safely, and predictably to detected faults. The self-diagnostics shall include tests for program corruption and integrity in read/write memories such as (Electronically Erasable Programmable Read Only Memory) EEPROM and flash Programmable Read Only Memory.

   f. Respond safely and predictably when powering up or recovering from power interruptions. All power interruptions likely to have corrupted temporary storage shall be detected and cause the system to reinitialize all affected routines and temporary data. Detection of power interruptions may be by hardware.

   g. Permit thorough interrogation of all input, output, and internal conditions by internal, system level, vehicle level and external diagnostic equipment.

   h. Software version numbers shall be included within the firmware code and shall be accessible via laptop Portable Test Equipment (PTE), the TMS, and on the system's display. Every change to software shall be reflected in an update to the version number. If the software includes data or parameter files which can be modified by the Contractor, its suppliers, or by the Engineer, a modification to such files must be reflected in a change to the software version number.

2. Undocumented software features are prohibited.

C. Contractor Activities

1. The Contractor, as system and software integrator, shall be responsible for the overall quality of all software supplied as part of this contract. If the Contractor also develops software, it shall consider the team that develops software as a supplier.

2. Quality Control Plan

   The Contractor shall develop a car level software quality control plan which defines how it will manage and oversee the software development of its suppliers. The software quality control plan may be a section within the Contractor's project quality plan. [CDRL 24-002]

3. The Contractor shall develop a car level software plan which details all software on board and lists all outputs and inputs between systems with definitions of the signals, sources, and destinations of each signal. [CDRL 24-003]

D. Software Quality Audits

The Contractor shall conduct periodic software quality audits of all Non-COTS suppliers. The Engineer reserves the right to conduct a software quality audit at any time during the software design and development phase. At a minimum the Contractor shall, and shall require its subcontracted suppliers to, plan for an audit to be performed at the Final Design Review (FDR). The results of all audits shall be submitted to the Engineer for review and acceptance. [CDRL 24-004] Remedial action for all open comments from any audit shall be submitted to the Engineer for review within 90 days of the audit. The Engineer reserves the right to attend any audit along with the Contractor. The audit shall include:

1. Configuration control audit
2. Physical, functional, and in progress audits as defined by IEEE, Std 730
3. Coding standard compliance audit
4. Unit testing, and verification and validation testing report

E. Software Testing

The Contractor shall witness all software verification and validation testing prior to the release of any software. The Engineer reserves the right to attend these tests along with the Contractor.

F. Configuration Control

1. The Contractor shall develop a Software Configuration Control Plan (SCCP) for tracking software changes to individual cars on the Engineer's property until the end of the warranty period and all retrofits are complete. The SCCP shall also control software on non-car equipment such as PTE's, BTE's, and the like, and shall include a mechanism to ensure continuing compatibility between car software and non-car software. This plan shall be submitted for review and acceptance by the Engineer. [CDRL 24-005] It shall be consistent with the Contractor's approach to configuration control of hardware and require similar approvals and tests.

2. The Contractor shall maintain a database of the software version of every software item on each car and in each piece of non-car equipment. The database shall be kept current by the Contractor at all times and made available upon request. The software version status of every software item on the car shall be provided in the Car History Book. The software version status of every software item on each piece of non-car equipment shall be provided by the Contractor with the delivery of the equipment.

   a. Delivery of Software

      i. At the end of the warranty period and for each software release thereafter, the Contractor shall provide to the Engineer on digital media to be approved by the Engineer, all executables, updated software documentation, updated user documentation, and a Software Version Description (SVD). [CDRL 24-006] The requirement for electronic copies and documentation shall apply to every delivery of software for non-car equipment.

      ii. The SVD shall contain a description of problems addressed, known problems yet to be addressed, features added, requirements added or changed, design changes, changes to related software documents and evidence of document review, test plan, and test results.

G. Software Development Documentation

1. The Contractor shall submit, and shall require its subcontracted suppliers who develop software to submit, for the Engineer's review and approval, documentation to ensure a mature software development process that has been fully verified and validated and can be maintained in the future. [CDRL 24-007] The two paths listed below are offered.

a. Submit all the documentation as required by IEEE, Std 1558, for type 5 software.

Document Name	Software type	IDR	FDR	New Software Releases
Software Project Management Plan (SPMP)	All	Yes	No	No
Software Quality Assurance Plan (SQAP)	All	Yes	No	No
Software Configuration Management Plan (SCMP)	All	Yes	No	No
Software Verification and Validation Plan (SVVP)	All	Yes	No	No
Software Verification and Validation Report (SVVR)	All Non-COTS	No	No	Yes
Software Requirement Specification (SRS)	All Non-COTS	Yes	Yes	Yes
Interface Control Document (ICD)	All	Yes	Yes	Yes
Software Design Description (SDD)	All Non-COTS	No	No	Yes
Database Design Description (DBDD)	All	Yes	Yes	Yes
Software Requirement Traceability Matrix (SRTM)	All Non-COTS	Yes	Yes	Yes
Software Test Plan (STP)	All Non-COTS	Yes	No	No
Software Test Procedure (STPr)	All Non-COTS	No	Yes	Yes
Software Test Report (STR)	All Non-COTS	No	No	Yes
Software Version Description (SVD)	All	No	No	Yes
Software User Manual (SUM)	All Non-COTS PTE/BTE	Yes	Yes	Yes

Table 24-1

2. In order to reduce the amount of submittals, the Contractor may combine the documents by IEEE, Std 1558, for type 5 software as follows:

   a. The SPMP, SQAP, SCMP, SVVP, and STP shall be combined into one document entitled Software Development Plans (SDP). This SDP shall include all the requirements of the individual documents.

   b. The SRS, SDD, DBDD, STPr, STR, and SVVR shall be combined into one document entitled Software Documentation (SD). This SD shall include all the requirements of the individual documents. It is expected that this document would be developed as a database and would be expanded and updated as the software is developed and tested.

   c. The ICD and DBDD shall be combined into one document entitled Software Interface Document (SID). This SID shall include all the requirements of the individual documents.

   d. The SVD and SUM, if required, shall be standalone documents.

Document Name	Software type	PDR	FDR	New Software Releases
Software Development Plan	All	Yes	No	No
Software Documentation (SD)	All Non-COTS	Yes	Yes	Yes

Document Name	Software type	PDR	FDR	New Software Releases
Software Interface Document (SID)	All Non-COTS	Yes	Yes	Yes
Software Version Description (SVD)	All	No	No	Yes
Software User Manual (SUM)	All Non-COTS PTE/BTE	Yes	Yes	Yes

Table 24-2

e. Regardless of which path is chosen, the Contractor or software supplier shall develop the SRS based on the technical specification requirements. The SRS shall fully link to each technical requirement. The Contractor shall submit an SRTM with the first release of the SRS to the Engineer. The SRTM shall use the technical section reference identification numbers as defined in the technical specification as the reference to link to the software requirement. The Contractor shall update and submit an updated version of the SRTM with each document released, strictly following the software life cycle process. The Contractor and supplier shall not proceed in the software development until the SRS document is reviewed and approved by the Engineer. The Contractor shall submit software documentation to the Engineer based on the software life cycle.

f. In order for the Engineer to update, modify, or replace a system on the cars at a later date, the following documents shall be marked "Non-Proprietary": ICD, DBDD, SID and SUM.

g. The Contractor shall perform a demonstration to ensure that the ICD and DBDD or SID is complete and accurate.

H. Operating Systems and Languages

1. Software may be written in a high or low-level language; however, high-level languages such as C/C++ are preferred. The language, compiler, and its implementation for the selected microprocessor system shall be commercially available in English.

2. All languages and operating systems shall have an acceptable customer base and be in widespread use. Use of commercial operating systems such as Windows™ for onboard applications is prohibited, unless approved by the Engineer on a case-by-case basis.

3. Where approved for non-onboard applications such as PTE and BTE, software running on Windows™ shall include a Windows™ format help file to provide context sensitive help to the user of the software.

4. All compilers shall be approved by the Engineer based on previous service history.

5. The Contractor shall, and shall require its subcontracted suppliers to, have a software coding standard for each programming language which shall define header information, comment requirements, module size, etc., similar to NASA C Style Guide SEL-9403.

I. Commercial Off-the-Shelf Software

1. Some software supplied under this contract may be commercial-off-the-shelf when approved by the Engineer such as operating systems supplied for the PTE and BTE.

2. For Commercially Available Software, the following shall be supplied:

   a. The original data storage/transfer media (CD-ROM) functional and usage details

   b. All manuals

c. All licenses required for the Engineer's site use

J. Software Testing

1. All system or subsystem level features and functions of software systems which implement system or subsystem-level requirements of the Technical Specification that are allocated to software shall be testable. Field testing shall use the PTE and procedures provided under this Contract.

2. For features which are only testable off the car with special equipment, all such equipment shall be supplied by the Contractor as test equipment and become the property of the Engineer. This equipment shall provide the logic, sequencing, and emulation necessary to verify that the software functions as intended. In lieu of separate equipment, appropriate test functions may be provided within the PTE.

3. The Contractor shall, and shall require its subcontracted suppliers to, perform unit and module interaction testing on all software components. This unit testing shall provide 100% coverage unless approved by the Engineer. Automatic test tools, such as Vector Cast may be used. As a minimum full branch testing, data range and boundary testing, and error trap testing shall be completed. All unit testing results shall be fully documented in a unit testing report which shall be submitted to the Engineer for review and approval. [CDRL 24-008]

4. Type tests of all software systems shall verify the proper operation of all software features, including diagnostics. The type tests shall demonstrate that the system under test can successfully recognize and report all faults listed in the TMS Fault Management Plan described in T 16.07, Fault Management Description, and all other events and parameters reported to the TMS. The Contractor shall submit the results of the type tests to the Engineer for review and approval. [CDRL 24-009] Where such tests may result in damage to the system hardware, the fault or event may be simulated to avoid damage to the hardware. Such testing shall be performed any time the software is changed, prior to putting it into service.

5. Software testing shall be a prerequisite to higher level testing, such as system level and vehicle level tests. Software validation test procedures must be approved by the Engineer prior to the execution of the tests.

6. After the initial version of software is installed on the cars, all software revisions shall be tested by the supplier in the supplier's facilities (laboratory) in accordance with its testing processing and procedures. After successful completion of such tests, a test version of the software revision shall be placed on a limited number of cars and dynamically tested for a period of time as approved by the Engineer. Only after results of the dynamic tests on a limited number of cars have been approved by the Engineer shall a new software revision be applied to the fleet or any portion of the fleet.

7. Application of any software revision to any portion of the fleet at any time shall be in conformity with the approved Configuration Control Plan of this section.

K. Software Version Numbers

Software version numbers shall be included within the firmware code and shall be accessible via the PTE and the TMS.

L. Software Security

Vehicle software systems shall be secured against unauthorized access and attack, both from within the vehicle itself and from the wayside. Security requirements shall apply both when the vehicle is in revenue service and when the vehicle is out-of-service for maintenance or storage. Security measures shall be designed and implemented such that their effect on reliability, availability and basic system operation is minimized.

M. Software Update

1. It shall be possible to update all application software with the exception of approved programmable devices (E.g. ASIC, CPLD, etc.) via the PTE connected to the system directly or via the USP. Any partial or interrupted software update shall automatically return the system to the previous version of software and not leave the system in an unconfigured state.

2. The time required to upload the entire software complement for a given system, including time to replace firmware embedded in FPGAs, CPLDs, etc, shall be no more than fifteen (15) minutes.

N. Transfer of Software to Replacement Devices [CDRL 24-010]

1. In order to ensure the long-term maintainability of programmable devices, it is required that:

   a. The Contractor shall provide master copies of the compiled executable for all programmable devices such as ASICS, CPLD's, FPGA's and Read Only Memory Devices.

   b. The Contractor shall also provide 10 sets of the necessary equipment and software to transfer the compiled software to new devices and to verify the integrity of the copy.

2. If the requirements of part A of this subsection are not possible to meet for any programmable device, the Contractor shall provide the Engineer with a sufficient number of replacement preprogrammed devices to supply the fleet for 30 years of service.

O. Software Escrow

1. The Contractor shall arrange, at its expense, for a complete copy of all proprietary software and source code used on the vehicle, and licensed copies of all of the compilers, linkers, etc. used to develop it, to be deposited with an escrow agent on the date of Conditional Acceptance of the first railcar by CTDOT and shall provide to CTDOT with all information needed for CTDOT to directly access the escrowed software and source code. On that date, the Contractor shall provide CTDOT with written confirmation from the escrow agent that such deposit has been made. Contractor shall arrange for updating the escrow deposit with all modifications and changes to the software and shall deposit a renewed copy of such source code whenever the software has been updated. The source code deposited shall include comments, explanations, and instructions to compile the software, and all software utilities and other materials necessary for use of source code. The costs of the escrow shall be borne by the Contractor and, subject to Section 3 below, the duration of the escrow shall be coterminous with the final railcar warranty period plus 30 years.

2. The escrow package shall be released from escrow to CTDOT upon: (a) failure of the Contractor to function as a going concern or operate in the ordinary course; or (b) the voluntary or involuntary bankruptcy of the Contractor; or (c) if, based on an independent third party assessment, the Contractor, its supplier, or any successor no longer supports the product at a reasonable cost. Upon release from escrow, and notwithstanding anything in this Agreement to the contrary, CTDOT shall have the right to use, copy, and modify the source code in order to use and support the software for the system. Regarding any release to CTDOT of the source code, CTDOT and its authorized representative(s) shall have the right to use the source code in order to use and support the software for the system, including the right to engage the services of a third party to assist CTDOT to use and support the software for the system.

3. The source code held in escrow shall be the latest version installed on the vehicles. The Contractor shall demonstrate that the source code held in escrow compiles to produce the same executive with the same CRC or checksum as installed on the vehicles. Should the compilation process prohibit matching of the CRC or checksum, additional techniques to inspect differences in the generated executive including the use of comparison software and function testing can be employed to prove equivalency. Such techniques are to be approved by the Engineer. The Contractor shall develop a software executable generation procedure which details a step-by-step

procedure to configure the workstation, produce the executable, produce the installation package, provide the verification method, and install in the system. The Contractor shall, along with CTDOT, witness the execution of the software executable generation procedure. The escrow package shall be developed on a virtual machine (e.g VMware) to all for ease of used if the package is release. A copy of the virtual machine shall be include in the escrow package. The Contractor shall provide sufficient documentation of the source code to allow the Engineer to maintain it, troubleshoot it and adjust parameters. [CDRL 24-011]

4. The development software held in escrow shall be of the same version used to develop the software currently installed on the vehicle.

24.01.05 Hardware

A. Hardware Platform

1. All carborne and custom computer hardware shall be designed and constructed in accordance with the general electronic design principles of Section 18.27, Electrical and Electronic Designs, and 18.28, Electrical Devices and Hardware.

2. Any computers, whether portable or not, and any microprocessor hardware shall be readily available through retail and/or wholesale outlets in the U.S.

3. The microprocessor-based systems shall be based on an established family of microprocessors in wide use in the control system industry and the rail industry. The type and availability of each microprocessor shall be included in the design review package.

4. Any use of commercially-available computer boards for on car applications must be specifically approved by the Engineer on a case-by-case basis. Such approval will be based upon a technical review of the product's suitability for use in a commuter rail environment, product documentation and proof that a supply will be available for the expected life of the vehicles.

B. Microprocessor Systems Shutdown

A special algorithm shall be provided to ensure that:

1. Computer shutdown and restart occur in a safe and predictable manner.

2. Spurious faults are not generated during shutdown or restart.

3. Stored diagnostic data is not lost during shutdown or restart.

4. Time stamp integrity is maintained on all diagnostic data through any shutdown and restart process, including immediately after restart.

C. Program and Data Storage

1. All onboard microprocessor-based systems shall store software and diagnostic data in non-volatile flash memory, or EEPROMS. The use of mechanical hard drives or optical disks is prohibited for data storage on all systems, except the network video recorders.

2. All flash memory and other memory devices with a finite number of read/write cycles shall be implemented in such a way that one sector or memory location is not written to repeatedly, thus shortening the life expectancy of the device. The life expectancy of such devices as used on the vehicle shall not be less than 30 years. The memory and processor capacity shall be designed to allow program expansion without hardware modification. Expandability and capacity requirements are as follows:

   a. The memory needs of the installed software, backup copy, if required, during software update and data files shall not utilize more than 50 percent of the installed memory capacity at Type

Test. This requirement applies individually to each type of memory installed, whether it is EEPROM, Flash PROM, or RAM.

b. Peak processing time demands shall not be greater than 75 percent of the available processor capacity.

D. Electrical Isolation and Pre-Processing

1. All processor system input and output signals shall be isolated. High voltage inputs and outputs shall be isolated external to the microcomputer card rack. Low voltage (battery and logic voltage level) inputs and outputs shall be isolated from the input power. The isolation for the outputs can be external to the microcomputer card rack. The isolation shall accomplish the following:

   a. Protect and isolate the system from damage due to over-voltage, under-voltage, transients, shorts and open circuits

   b. Perform necessary voltage translations

   c. Remove noise and undesired signals

   d. Pre-processing to limit, discriminate and format those signals that would otherwise require excessive processor time

2. Isolation devices shall consist of optical isolators, transformers, relays, and other circuits appropriate to the application.

E. Batteries and Super Capacitors

1. The use of super capacitors is acceptable for real time clock or other requirements typically performed by a battery, provided the super capacitor can maintain clock or data for a minimum of 90 days. The use of batteries within control units for maintenance of a real-time clock, or for safe shutdown must be approved by the Engineer.

2. If approved by the Engineer, all batteries shall be implemented as follows:

   a. Batteries shall be sized to retain data for at least six months without charging, and shall be located such that leakage cannot damage any control system components.

   b. Battery life shall be no less than 5 years, regardless of type.

   c. Systems using standby or back-up batteries shall annunciate the need for battery replacement such that the battery continues to perform its function until it can be replaced at the next periodic maintenance.

   d. Batteries shall not be connected by soldering.

3. Necessary RAM control data shall not depend on battery back-up, but shall be stored in non-volatile memory and "shadowed" to RAM for use.

F. Maintenance and Related Tools

1. Portable Test Equipment (PTE) and Bench Test Equipment (BTE)

2. For custom software that is resident in test computers, the Engineer shall be given a license for unlimited use of the software for the approved purposes of this Contract. Licenses shall not be linked to specific hardware serial numbers. In addition, PTE and BTE equipment software documentation, compliant with this section, shall be furnished. PTE and BTE software shall be subject to the approved Configuration Control Plan of this Section. The operating system employed for the PTE shall be the most-advanced, user-friendly system available at the time of

system design and development. While it is anticipated that the system will be Microsoft Windows™ based, advances in technology may preclude this from being the best choice. Accordingly, identification of the system to be used will be made by the Engineer at the time of design review.

24.01.06 Reliability

If more than two unplanned maintenance releases of any individual software configuration item (SCI) are required during formal type testing through the end of the warranty, the Engineer may require the Contractor to perform a full independent software quality review. This review shall include all aspects of a software audit as listed in this section plus a full independent software verification and validation of the software.

24.01.07 Safety

A. The use of software in safety-critical or related applications must be approved by the Engineer.

B. If the Engineer approves the use of software in a safety-critical or related application, it shall be developed in compliance with EN-50128 SIL4. In addition to the requirements of this Section, any software, firmware, processing device or computer providing a safety-critical function shall comply with the requirements of Section 3.5.4, Safety.

24.02 Contract Deliverable Requirements List

CDRL #	Title	Car Type
24-001	Software Systems Justification	All
24-002	Quality Control Plan	All
24-003	Software Plan	All
24-004	Software Quality Audits	All
24-005	Software Configuration Control Plan (SCCP)	All
24-006	Software Version Description (SVD)	All
24-007	Software Development Documentation	All
24-008	Unit Testing Report	All
24-009	Software Type Tests	All
24-010	Transfer of Software to Replacement Devices	All
24-011	Software Escrow	All

* End of Chapter 24*

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