Amtrak
Mechanical Department
Bureau of Rolling Stock Engineering

SPECIFICATION

for

PRIIA Single-Level Passenger Rail Car

PRIIA SPECIFICATION No. 305-003
AMTRAK SPECIFICATION No. 964

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Standardized Technical Specification

PRIIA 305 Next-Generation Equipment Committee
Single-Level Passenger Rail Cars

Chapter 1
Specification Summary
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1.0 Specification Summary

1.1 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 in medium- to long-distance intercity corridor service in North America. 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.

This specification has been developed by the Next Generation Corridor Equipment Pool Committee created to support Section 305 of the Passenger Rail Investment and Improvement Act of 2008 (PRIIA) Public Law 110-432. The goal of PRIIA is to create a single-level intercity corridor car specification that may be used by any state or agency to procure single-level rolling stock for intercity service.

1.2 Regulations

The PRIIA 305-003/Amtrak 964 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.

1.3 Concept

The Single-Level passenger rail cars are intended to be a single-level intercity car fleet for use in medium- to long-distance corridor service, based on the design concepts pioneered in the 1970’s by the Budd Company. Amtrak’s Amfleet I and Amfleet II fleets have established the design baseline for single-level inter-city and long-distance rail equipment. The new cars will be significantly different from the Amfleet cars but will include the following features:

- One or two large entry vestibule(s) for high-volume passenger loading and unloading, depending upon car type
- Trainline-controlled side entry doors
- Full compliance with all applicable ADA requirements
- Seat spacing for comfort as well as capacity
- Workstation tables
- A lounge car
- A cab control car and locomotive control trainlines for push-pull service
The PRIIA 305-003/Amtrak 964 Specification creates a new generation of the single-level intercity car design. In order to accommodate the needs and requirements of all potential users of this specification, this document was developed with the following ideologies:

- These cars shall be designed and built for use anywhere in the United States and Canada where their use may be desired, consistent with Amtrak’s clearance envelope (Drawing B-05-1355, rev E).
- All specifications shall reflect operational and environmental conditions that may be encountered anywhere the cars may operate, without requiring redesigning or modification. A nationwide perspective was used when specifying component performance.
- The Specification is heavily dependent on accepted industry standards, which have been referenced herein.
- 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 Amtrak train consists of all types of Amtrak 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 Amtrak diesel and electrical locomotives, and with all Amtrak single-level cars including Amfleet I, Amfleet II, Horizon, Cab cars and Viewliners. 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 Amtrak 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 Customer for approval as part of the design review Process.
- 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.
- Safety, reliability and maintainability are primary objectives of this specification. Because Amtrak is currently the operator for state-run passenger transportation in the United States, maintenance intervals and procedures are specified to match current Amtrak preventive maintenance programs. Use of specialized tools or equipment shall be limited. Ease of access for inspection, maintenance and repairs is a major design consideration.
- One goal of the PRIIA Specification is standardization. To meet this goal, 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 Customer.

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- Convenience outlets at every seat
- Sufficient space for trash and recyclables
- Exterior crew door control switches
- Accessible toilet room adjacent to the ADA-accessible vestibule
- Checked baggage compartment in the cab car
Various components have been specified by manufacturer and part number in this Specification. The Contractor may propose alternate manufacturers components but the use of alternate components or manufacturers must be approved by the Customer. Proposed alternative components must be interchangeable in form, fit and function with components called out herein.

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 Customer for approval.

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 Customer review include:

- Passenger seating area
- Café/lounge galley and lounge seating area
- Accessible toilet room
- Cab control compartment
- Side doors
- Enclosed overhead luggage bins
- Wheelchair lift

The mockups will allow the Customer, and those invited by the Customer, 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.

### 1.4 Summary of PRIIA 305-003/Amtrak 964 Car Specification

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

#### 1.4.1 Car Types and Arrangements

This technical specification provides for three distinct types of cars – a coach car, a cab/baggage car and a café/lounge car. See Chapter 9 for conceptual interior layouts.

The three types of cars are summarized as follows:

The coach car is a single-level car with revenue seating:

- Wheelchair access and an adjacent accessible toilet room.
- A smaller (non-accessible) toilet room.
- Enclosed overhead luggage bins are above each seat.
- Revenue seating includes several facing pairs of seats with workstation tables, and other seats with tray tables and footrests.
- All seating areas include carpeting and convenience outlets.
The cab/baggage car is similar to a coach car with the following exceptions:

- A full-width cab control compartment is located at the F-end to provide locomotive control for push-pull operation.
- The cab/baggage car includes a separate room for secure checked baggage storage.
- The forward end of the cab/baggage car conforms to all FRA structural and crashworthiness for cab car forward-facing ends.
- The forward end is fully equipped for push-pull operation, including a replaceable pilot (for protection from snow, ice, grade crossings and other debris).
- All seating is rearward-facing when the cab/baggage car is moving forward, except those seats located at workstation tables, to conform to the FRA’s crashworthiness and compartmentalization recommendations. All facing seat pairs shall have a workstation table between them.

The café/lounge car provides the train with food service and non-revenue lounge space as passenger amenities, as well as including revenue seating:

- The food service galley is located in the center of the car.
- The galley is equipped with all required food preparation appliances, including microwave ovens, toaster, freezer, ice well, coffee makers, chilled and dry storage, display case, point-of-sale terminal, hand washing and food preparation sinks and menu holders. A condiment station is located in the lounge area.
- Recycling and trash receptacles are located throughout the car.
- Commissary provisioning is via pre-loaded carts.
- Carts are loaded onto the car at the service vestibule.
- Refrigerated foods are loaded in pre-chilled carts that are kept cold while on board by self-contained chillers.
- One end of the car is dedicated to non-revenue lounge seating, with tables for 1, 2 or 4 passengers.
- The other end of the car is configured for revenue seating, which includes facing pairs of seats with workstation tables. This area could easily be reconfigured for business class or for additional non-revenue seating.

Business class may easily be developed and implemented on these cars through the use of a modular business class service station that bolts into existing seat and wall tracks:

- The business class service station includes a small refrigerator, storage for two service carts (stocked and supplied by the café-lounge car attendant), a holder for a coffee urn (brewed in the café-lounge car and brought to business class by the café attendant) plus counter space for newspapers and breakfast foods, and trash and recycling receptacles.
- This modular design allows flexibility as to the location of the business class section - it may be located in a coach or cab/baggage car, or in the revenue end of the café-lounge car.
- Seat pitch may be adjusted due to the seat mounting in wall and floor tracks, and overhead reading lights are mounted in adjustable-pitch units on the underside of the overhead luggage bins.
• The business class section is easily redeployed to other cars if necessary, including addition to existing cars in single-level fleets. Where there is a Business Class it will include accessible seating and wheelchair space.

1.4.2 Capacity and Consist Performance

1.4.2.1 Capacity

As specified, the PRIIA 305-003/Amtrak 964 cars are configured to have the following passenger capacities:

- Coach: 72 revenue seats maximum
  1 wheelchair parking location
- Cab/Baggage: 40 revenue seats, depending upon baggage room size
  1 wheelchair parking location
- Café/Lounge: 29 revenue seats
  1 wheelchair parking location
  21 lounge area (non-revenue) seats
  4 crew workstation seats

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 each customer.

1.4.2.2 Consist Performance

- Trains typically consist of 4 to 10 cars with all trainline functions operating normally.
- Maximum consist of 12 cars for all trainline functions to operate at reduced levels, as specified by the Customer.
- Maximum consist of 24 cars for brake system to operate properly.
- Cars are designed for continuous operation for up to 24 hours and 1200 miles per day.

1.4.3 Dimensions, Clearances and Track Geometry

1.4.3.1 Overall Carbody Dimensions

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

- Overall Length: 85 ft 0 in. (over pulling faces)
- Overall Height: 14 ft 6 in. above top of rail
- Overall Car Width: 10 ft 6 in. maximum (except at threshold)
- Truck Centers: 59 ft 6 in.
- Floor Height: 4 ft 3 in. above top of rail
- Minimum Side Door Openings: 2 ft 10 in. clear opening
The cars shall be designed and built to conform to the following overall dry weight limitations:

- **Coach:** 104,000 lbs
- **Cab/Baggage:** 108,000 lbs
- **Café/Lounge:** 111,000 lbs

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

- End-to-end balance within 5% (both at full supplies and no supplies)
- Lateral balance (side to side) within 30,000 inch-pounds (both at full supplies and no supplies)

### 1.4.3.2 Clearances

The cars shall fully conform to Amtrak’s Single-Level Clearance Drawing B-05-1355, rev E. Conformance to this clearance diagram will permit the PRIIA 305-003/Amtrak 964 cars to operate anywhere that Amfleets, Horizons and Viewliners are authorized to operate within the continental United States or Canada, on current Amtrak routes and elsewhere where clearance permits.

### 1.4.3.3 Track Geometry

- The cars shall be designed and tested for revenue operation at all speeds up to 125 mph, 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.
- The cars shall operate on standard gauge track. Standard gauge is 56.5 in.
- The cars shall be capable of meeting the S-603 braking distances.
- The cars shall be capable of negotiating a 250 ft radius (23 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.
- The cars shall be capable of negotiating a 1000 ft 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.
- The cars shall be stable at all design speeds and at 5mph above maximum design speed, including while stationary.
- The car shall have no more than 50% wheel unloading when stopped on 7 in. superelevation.
- The cars shall be capable of operating up to 5 in. cant deficiency according to 49CFR Section 213.329.
- 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 centers.

The cars shall be capable of negotiating a number 8 crossover between two tracks with centers 12 ft apart, coupled to other equipment, without damage.
1.4.3.4 Catenary Wire

The Amtrak Northeast Corridor and Harrisburg Line are equipped with an overhead catenary power supply system, operating at 3 voltage potentials. The minimum wire height is 15 ft for 11,500V, 25 Hz catenary and 15 ft 6 in. 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 insure 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 the Amtrak Clearance Drawing B-05-1355, Rev E.

1.4.3.5 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 insure 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 Amtrak Clearance Drawing B-05-1355, Rev E.

1.4.3.6 Passenger Stations

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

- Design height of high-level platform above top of rail: 4 ft
- Minimum distance of high-level platform edge to centerline of track: 5 ft 7 in.
- Design height of low-level platform above top of rail: 8 in.
- Minimum distance of low-level platform edge to centerline of track: 5 ft 1 in.

The Amtrak maintenance facilities and storage yards only have ground-level access at trackbed height. 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.

1.4.3.7 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.
1.4.4  Carbody (Chapter 4)

- Stainless steel carshell with Low-Alloy, High-Tensile (LAHT) end underframe and other primary structural components.
- The design of the carshell shall contain CEM features.
- Corrugated stainless steel roof for longitudinal structure and durability.
- Carshell shall be fully compliant with FRA’s requirements for structural strength, crashworthiness and testing per 49CFR Part 238:
  - Meets or exceeds 49CFR Part 238 Tier 1 structural requirements
  - Meets or exceeds APTA Standard SS-C&S–034-99 for the Design and Construction of Passenger Rolling Stock
  - Carshell tested to 800,000 lb buff load
  - 300,000 lb collision post load test
  - All components attached to withstand longitudinal/lateral/vertical accelerations of 8/4/4g
- Each car has two side entries, except the cab/baggage car may have only one for passenger use.
- All cars feature large picture windows with glass or Lexan panes. All cars will have emergency exit windows in full compliance with FRA regulations.
- The basic car design features two carborne powered wheelchair lifts.

1.4.5  Trucks (Chapter 5)

- The specification provides for either cast or fabricated trucks.
- All trucks will use standard Amtrak wheelsets, with 36 in. nominal new wheels, type F outside bearings, and tread and disc brakes.
- Primary and secondary suspension is provided through the use of steel coil springs, or air springs or chevrons as approved by the Customer.

1.4.6  Couplers (Chapter 6)

- All cars use energy absorbing couplers as specified in Chapter 6.
- Couplers, coupler carriers and uncoupling mechanisms shall be compliant with FRA standards and requirements.

1.4.7  Brakes (Chapter 7)

- Pneumatic air brake system uses conventional type 26C schedule.
- Truck-mounted air brake components shall use Amtrak standard brake shoes and pads.
- Locomotive supplies air for brake pipe and main reservoir functions:
  - 110 psi brake pipe operation (for train air brake control)
• 140 psi main reservoir operation (for auxiliary functions such as water pressure, toilet flushing, etc)

• Braking rates:
  • Full service: minimum of 1.35 miles per hour per second (mphps) deceleration from 125 mph down to 70 mph, then increasing to not less than 2.00 mphps average below 70 mph.
  • Emergency: minimum of 2.50 mphps below 70 mph.

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

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

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

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

• Cab/baggage cars are equipped with a pneumatic holding brake.

### 1.4.8 Door Systems (Chapter 8)

• All cars feature two side entry doors and sliding pocket body end doors.

• 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.

• 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.

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

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

• Body end doors are sliding pocket doors with upper and lower press plates (except the F-end door panel), 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.

### 1.4.9 Interiors (Chapter 9)

• All cars shall be equipped with reclining seats, energy-absorbing workstation tables, carpet, curtains and convenience outlets at every seat, and enclosed overhead luggage bins.

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

• Each car shall have two toilet rooms except the café/lounge, which will have none.

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

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

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

- Seats shall be selected at the discretion of each Customer in order to accommodate differences in operations and passenger preferences. 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 Customer.
- Reading light units shall be installed on the underside of the overhead luggage bin, and shall be track-mounted to permit different spacing based on seat pitch.

1.4.10 Heating, Ventilation and Air Conditioning (Chapter 10)

- The Heating, Ventilation and Air Conditioning (HVAC) system will use efficient scroll compressors, environmentally friendly R400-series refrigerants, microprocessor controls and multiple temperature sensors for system operation.
- The HVAC system shall be a hermetically sealed, packaged unit that is roof top mounted.
- Two identical HVAC units will provide cooling and overhead heat for each car.
- The HVAC system shall maintain the car interior, including the Engineer’s cab, to the specified temperature of 68°F to 76°F, with the car operating anywhere in the continental United States.
- The HVAC system performance requirements specify system operations under a variety of climatic extremes, from the hot and dusty California desert to the snow-packed Midwest.
- Maximum interior sound levels are specified to minimize blower and diffuser noise.
- Filters are easy to access and replace.
- Water system components are equipped with freeze protection.
- Side door thresholds are heated.

1.4.11 Lighting (Chapter 11)

- 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. Fluorescent lights can be used in Customer approved areas. Halogen lights are not to be used. Incandescent lights are not used anywhere on the car except for marker lights and cab/baggage car headlights and crossing lights.
- The normal and emergency lighting system meets all new APTA standards and FRA requirements for charging and emergency light levels.
- Emergency lighting relies on LED lamps and high-efficiency capacitors for power source.

1.4.12 Communications and Passenger Information (Chapter 12)

- All cars will feature a Public Address (PA) system, intercom and a passenger information system.
- PA and intercoms are compliant with FRA requirements for emergency communication.
Specifications Summary

- Specifications for passenger WiFi and on-train information systems will be consistent with Amtrak nationwide standards for these systems.
- On Board Train Information System (OTIS) provides an Ethernet-based data backbone for intra-car and car-to-car communication and data transfer. System capabilities include passenger wireless internet access, real-time ticketing and manifest generation, credit card transactions, component or system status monitoring and food inventory management.
- OTIS is compliant with ADA.

1.4.13 Electrical (Chapter 13)

- Primary power source is locomotive-provided 480 Volt Alternating Current (VAC) Head End Power (HEP).
- Power distribution system converts the HEP to 120VAC, 74VDC and 24VDC, (Cab/baggage car only) for use throughout the car.
- 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).
- All cars will be equipped with standard trainlines:
  - 480VAC HEP trainline (in compliance with APTA Recommended Practice RP-E-106-99)
  - 27-Point Multiple Unit (MU) Trainline (in compliance with APTA Recommended Practice RP-E-017-99)
  - 27-Point Communication (COMM) Trainline (in compliance with APTA Recommended Practice RP-E-017-99)
- 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).
- 120Vac utility outlets will be located in all toilet rooms, equipment rooms, the electrical locker, operating cab and utility rooms, for ease of maintenance and cleaning.

1.4.14 Food Service (Chapter 14)

The café/lounge car includes the following features, in addition to those listed above:

- Convenience outlets will be located in the revenue and lounge areas, for passenger use.
- PA and intercom located at the crew workstation, for convenience and passenger safety.
- The revenue seating area will include all elements of the seating area in a coach car, including overhead luggage bins and reading lights.
- The galley area of the café/lounge car will conform to all applicable requirements for a food preparation area, in accordance with Food and Drug Administration (FDA) regulations.
- A crew workstation will be located on the lounge side of the café-lounge car, and will be equipped with extra electrical outlets, secure storage, PA and intercom station.
- A secure storage area will be provided for café/lounge employee belongings.
1.4.15 **Water and Waste (Chapter 15)**

- Fresh water (112-gal storage capacity for cab/baggage and coach, 224-gal for café/lounge) will be used for toilet room functions such as toilet flush and hand washing.
- Particulate and antibacterial filtration will be used to provide potable water at drinking stations on both levels, as well as supply water for use in the galley of the café/lounge car (for coffee, hand washing and food preparation).
- All waste water will be captured and stored in a 225-gal waste retention tank at the B-end of each car.

1.4.16 **Cab and Controls (Chapter 16)**

- Each cab/baggage car will be equipped with a locomotive control cab at the forward end.
- The cab will be full width, and will provide seating for an engineer and an assistant.
- FRA Type 1 windshields will be provided on the end of the car for the engineer and the assistant. These windshields will be heated for defrosting and defogging. Opening windows will be provided on each side of the cab for sideways visibility.
- The Engineer will have access to all locomotive train controls and indicators to operate the train safely in push-pull service.
- Federally mandated safety systems such as an event recorder, alerter and Positive Train Control (PTC) shall be incorporated into the design of the cab.
- Secure cabinets will be located behind the cab for emergency equipment, storage of crew belongings and a refrigerator. A secure locker will be provided for data storage from the event recorder and PTC systems.
- The cab end of the cab/baggage car will include streamlined styling for reduced wind resistance, which reduces fuel consumption and enhances locomotive performance at high speeds when in push mode.

1.4.17 **Emergency Equipment (Chapter 17)**

- All cars will be equipped with emergency equipment as required by the FRA, including, but not limited to, fire extinguishers, pry bar, sledge hammer, first aid kit and light sticks.
- Signage for the emergency equipment shall meet all applicable FRA requirements.

1.4.18 **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.
1.4.19 Testing Requirements (Chapter 19)

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

Four major categories of tests are specified:

- **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.

- **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.

- **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.

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

1.4.20 Documentation and Training (Chapter 22)

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

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

1.4.21 Customer Variables (Chapter 23)

- This chapter describes those features of the car that change from one customer to another, such as exterior graphics, interior décor considerations, seats and interior layout, testing with existing fleets, and other aspects of the car design that may be exclusive or particular to a customer.

- Specific components may be called out here by the Customer, for example: trucks, HVAC units, couplers and windows.
1.4.22 Standard Keys

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, along with provisions in the café/lounge car for use of crew-supplied padlocks.

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. 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. from the face and protected by a fixed keyway spacer to prevent operation by a screwdriver or similar device.

The cab master controller key shall be used by the Engineer to activate the cab electrical controls and propulsion system master controller. It shall be a simple reverse-handle type design interchangeable with the current reverser handle used on the Amtrak AEM-7 electric locomotives. The Customer will supply details to the Contractor of the handle design.

Amtrak Lead Service Attendants (LSAs) will provide their own personal padlocks to secure the food service storage lockers and serving area of the food service car. The Contractor shall provide approved lock hasps for the application of padlocks by Amtrak crew. This shall include completely locking the galley area when closed and not in service.

The Contractor shall submit for approval, a matrix of the key type used in each lock or key switch.

* End of Chapter 1 *
Chapter 2

References and Glossary
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2.0 References and Glossary

2.1 Overview

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.

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

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

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.

2.2 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 an approved revision the 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 Customer 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.

2.2.1 Regulations

2.2.1.1 ADA (Americans with Disabilities Act)

36CFR 1192.99: Floors, Steps and Thresholds
36CFR 1192.113: Doorways
36CFR 1192 Appendix: Advisory Guidelines
49CFR Subtitle A, Figure 4: Intercity Rail Car (with accessible restroom)
49CFR 38.101: Lighting

Americans with Disabilities Act of 1990 and regulations promulgated thereafter, including 49CFR 27, 37 & 38.

2.2.1.2 DOE (U.S. Department of Energy)

Energy Policy Act (EPAct) of 2005

2.2.1.3 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
2.2.1.4 FAA (U.S. Federal Aviation Administration)
   AC 43.13-1B: Acceptable Methods, Techniques, and Practices – Aircraft Inspection and Repair

2.2.1.5 FDA (U.S. Food and Drug Administration)
   21CFR 1250: Interstate Conveyance Sanitation
   1250.41: Submittal of Construction Plans

2.2.1.6 FRA (Federal Railroad Administration)
   Title 49, 49CFR Transportation, Section II, Parts 200-299
   210: Railroad 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
   238.215: 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)
   238.303: 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

2.2.1.7 FTA (Federal Transit Administration)
   FTA-IT-90-5001-02.1 of February 2002: Quality Assurance and Quality Control Guidelines

2.2.1.8 USPHS (U.S. Public Health Service)
   U. S. Public Health Service Food Code 2005
2.2.2 Standards

2.2.2.1 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*

2.2.2.2 AHRI (Air-Conditioning, Heating, and Refrigeration Institute)

- 700: *Specifications for Fluorocarbon Refrigerants*

2.2.2.3 Aluminum Association

- AA-ADM-105: *Aluminum Design Manual: Specifications and Guidelines for Aluminum Structures*

2.2.2.4 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: *Specification for Sound Level Meters*
- S3.2-2009: *Method for Measuring the Intelligibility of Speech over Communication Systems*
2.2.2.5 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

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

730: Software Quality Assurance Plans

2.2.2.7 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
RP-C&S-001-98: Recommended Practice for Passenger Equipment Roof Emergency Access
RP-C&S-006-98: Standard for Attachment Strength of Interior Fittings for Passenger Railroad Equipment
RP-E-002-98: Wiring of Passenger Equipment
RP-E-006-99: Diesel Electric Passenger Locomotive Dynamic Brake Control
RP-E-007-98, Rev 1: Storage Batteries and Battery Compartments
RP-E-009-98: Recommended Practice for Wire Used on Passenger Equipment
RP-E-012-99, Edited 4-1-04: Recommended Practice for Normal Lighting System Design for Passenger Rail Equipment
RP-E-014-99: Recommended Practice for Diesel Electric Passenger Locomotive Blended Brake Control
RP-E-015-99: Head End Power Source Characteristics
RP-E-016-99: Recommended Practice for 480VAC Head End Power System
RP-E-017-99: Recommended Practice for 27-point Control and Communication Trainlines for Locomotives and Locomotive-Hauled Equipment
RP-E-018-99: 480 VAC Head End Power Jumper and Receptacle Hardware
RP-M-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
RP-M-001-98: Recommended Practice for Passenger Car Axle Design
RP-M-003-98: Recommended Practice for the Purchase and Acceptance of Type H-Tightlock Couplers
RP-M-009-98: Recommended Practice for New Truck Design
RP-PS-005-00: Fire Safety Analysis of Existing Passenger Rail Equipment
SS-C&S-002-98: Standard for Static Strength Attachment of Major Equipment to the Carbody Structure of Railroad Passenger Equipment
SS-C&S-004-98, Rev 1: Austenitic Stainless Steel for Railroad Passenger Equipment
SS-C&S-006-98, Rev 1: Attachment Strength of Interior Fittings for Passenger Railroad Equipment

SS-C&S-011-99: Standard for Cab Crew Seating Design and Performance

SS-C&S-012-02: Door Systems for New and Rebuilt Passenger Cars

SS-C&S-015-99: Standard for Aluminum and Aluminum Alloys for Passenger Equipment Carbody Construction

SS-C&S-016-99, Rev 1: Row-to-Row Seating in Commuter Rail Cars


SS-E-001-98: Standard for Insulation Integrity

SS-E-005-98: Standard for Grounding and Bonding

SS-E-010-98: Standard for the Development of an Electromagnetic Compatibility Plan


SS-M-006-98, Rev. 2: Standard for Parking Brakes for New Passenger Locomotives and Cars

SS-M-007-98: Conductor’s Valve – New Passenger Car and MU Locomotives

SS-M-011-99: Compressed Air Quality for Passenger Locomotive and Car Equipment

SS-M-012-99, Rev 1: Standard for the Manufacture of Wrought Steel Wheels for Passenger Cars and Locomotives

SS-M-014-06: Standard for Wheel Load Equalization of Passenger Railroad Rolling Stock

SS-M-015-06: Standard for Wheel Flange Angle for Passenger Equipment

SS-M-016-06: Standard for Safety Appliances for Rail Passenger Cars

SS-M-017-06: Standard Definition and Measurement of Wheel Tread Taper

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


SS-PS-003-98: Standard for Emergency Evacuation Units for Rail Passenger Cars

SS-PS-004-99, Rev. 2: Standard for Low-Location Exit Path Marking

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


2.2.2.9 ASME (American Society of Mechanical Engineers)

Boiler and Pressure Vessel Code

B1.13M: Metric Screw Threads: M Profile
2.2.2.10 ASTM (American Society for Testing and Materials)

A6: 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
A380-06: Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems
A488/A488M-07: Standard Practice for Steel Castings, Welding, Qualifications of Procedures and Personnel
A502-03: Standard Specification for Rivets, Steel Structural
A572, A 568, A 588, A 606, A 715, A 710: High Strength Low Alloy Structural Steel
A666: Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar
B32-08: Standard Specification for Solder Metal
B75-02: Standard Specification for Seamless Copper Tube
B85/B85M-09: Standard Specification for Aluminum-Alloy Die 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
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
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
E94-04: Standard Guide for Radiographic Examination
References and Glossary

E165-02: 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

2.2.2.11 AWS (American Welding Society)

AWS Welding Handbook
B2.2/B2.2M: Specification for Brazing Procedure and Performance Qualification
C7.2: 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

2.2.2.12 Boeing


2.2.2.13 Bombardier

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

2.2.2.14 British Railways Board Group Standard

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

2.2.2.15 CENELEC (European Committee for Electrotechnical Standardization)

EN 50128: Railway Applications - Communications, Signaling and Processing Systems - Software for Railway Control and Protection Systems
2.2.2.16 CSA (Canadian Standards Association)
   C22.2, No. 197-M1983: PVC Insulating Tape

2.2.2.17 EIA (Electronic Industries Alliance)

2.2.2.18 European Norms
   BS EN 50126: Railway Applications. The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS)

2.2.2.19 GSA (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, Concompliant (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)

2.2.2.20 IEC (International Electrotechnical Commission)
   60571: Electronic Equipment used on Rail Vehicles

2.2.2.21 IEEE (Institute of Electrical and Electronics Engineers)
   16: Standard for Electrical and Electronic Control Apparatus on Rail Vehicles
   1016: Standard for Information Technology-System Design-Software Design Descriptions
   1568-2003: Recommended Practice for Electrical Sizing of Nickel-Cadmium Batteries for Rail Passenger Vehicles
   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

2.2.2.22 IFI (Industrial Fasteners Institute)
   Inch Fastener Standards, 7th Edition
   Metric Fastener Standards, 3rd Edition
2.2.2.23  IPC (Association Connecting Electronics Industries)

2221: *Generic Standard on Printed Board Design*

2.2.2.24  ISO (International Organization for Standardization)

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

9001:2000: *Quality Management Systems-Requirements*


2.2.2.25  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-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*

2.2.2.26  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*
2.2.2.27 SAE (Society of Automotive Engineers)

AMS-T-81914/1: 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

2.2.3 Specifications

The Customer will provide copies of the following documents:

2.2.3.1 Amtrak

80-276: Specification for Composition Brake Shoes and Disc Brake Pads

315: Public Address/Intercom System

323: High Performance Wire and Cable for Use on Passenger Vehicles

352: Flammability, Smoke Emissions and Toxicity for use on Railway Passenger Cars and Locomotive Cabs

353: Vendor Maintenance Manuals

354: Builder Operating & Maintenance Manual Family

498: 480, 240, 208, 120 VAC and 72VDC Switchboard Panels

528: 480, 240, 208, and 120 VAC 72VDC Relay and Contactor Panel

685: Disposable Air Filter


697: Valve and Exterior Equipment Identification Tags & Labels and Operating Instructions

700: Schematic, Wiring and Piping Diagram Drawings

759: Replacement of Copper Waste Piping with Non-Metallic Pipe

962: Specification for PRIIA Bi-Level Passenger Rail Car

963: Operational and Environmental Conditions for Rail Rolling Stock

964: Specification for Truck Design Validation and Ride Quality Testing

967: Manufacture and Acceptance of Passenger Seating for Intercity Rail Cars

971: Linear Induction Motor Door Controllers

972: Plug Doors

S-603: Braking Distance Calculations

2.2.4 Drawings

2.2.4.1 Amtrak

A-63-7675-15: Trainline Standard: 27 Point MU System

A-63-7676-1: Trainline Standard 27 PT Communication System

B-066-00050, Rev A: Bi-Level Clearance Drawing

B-144: Standard Amtrak Coach Key (J.L. Howard Part No. 2555)

C-01-1498: 27-Pin Communication Jumper Cable

C-63-7422: 27-Pin MU Jumper Cable

C-63-7437: 27-Pin MU Receptacles

C-96-7591: Standard Trash Container (Amtrak Part No. 24-045-18737)
References and Glossary

D-00-1359: Speed Sensor and Cable Assembly
D-00-7075: Temperature Probe and Connectors
D-05-1355: Amtrak Clearance Diagram
D-08-2269: Axle Single Level Program
D-12-7191: 480 VAC Jumpers and Housing
D-63-7439: 27-Pin Communication Receptacle
D-63-7440: 27-Pin Communication Dummy Receptacle
D-65-7449, Rev A: Power Transformers
D 034-00014: Cab/Baggage Car F-end Pilot Assembly
D 035-00244: Seat Track Reference Dimensions
D 035-00245: Door System Equipment Location and Nomenclature
D 035-00246: Food Chiller Units
D-062-00108: Bi-Level Wheelset Assembly
E-140-2959: Emergency Equipment Cabinet Arrangement

2.2.5 Supplemental Documentation

http://www.volpe.dot.gov/sdd/pubs-crash.html
2.3 Definitions

The definitions and abbreviations defined below are used throughout this technical specification.

Wherever in the Contract Documents terms are used, the definition, intent and meaning shall be interpreted as follows:

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

**Amtrak** — The National Railroad Passenger Corporation.

**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 Customer. Customer approval in no way relieves the Contractor of meeting all requirements of the specification.

**Approved Equivalent** — The term "approved equivalent" shall mean an item, which is fully equivalent or superior in terms of form, fit, function, performance and properties, to the specified item.

**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 Customer.

**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.

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

**California Car** — Bi-level intercity corridor cars built by Morrison Knudson and Amerail for use on Capitol, San Joaquin and Pacific Surfliner corridor service. Car-to-car pass-through is on the upper level.

**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** — See Contractor.

**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.

**Contract** — The written agreement as executed between the Customer and the Contractor setting forth the obligations of the Parties, including all authorized changes to this Contract issued subsequent to the execution of the Contract.

**Contract Deliverable Requirements List (CDRL)** — List of documents and other deliverable items that the Contractor is required to deliver to the Customer. CDRL is also used to refer to a specific item on the list.

**Contractor or Carbuilder** — The prime Contractor solely responsible to the Customer for the construction, quality and proper functioning of the complete car and all of its components.

**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** — The organization, agency or party that is acquiring the vehicles from the Contractor through the administration of this specification and associated contract documents.

**Days** — Days shall mean calendar days unless otherwise specified. Business and working days shall be Monday through Friday, exclusive of federally designated Holidays.
Delivery, Delivered — The arrival of the completed vehicle at the Customer’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.

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.

Equal/Equivalent — Whenever the words "equal", "approved equal", “equivalent” or “approved equivalent are used in connection with a specified component, material, system characteristic or performance requirement, the Contractor shall prepare and submit for Customer 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 Customer. The reason for the variance request must be included in the analysis as submitted.

F-End (of the cab car or the locomotive) — The end of the cab/baggage car that is equipped with the locomotive control cab, per the requirements of 49CFR 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.

Field Modification Instructions (FMI) — Instructions for applying and installing engineering solutions to resolve fleet-wide defects and/or upgrade installations and/or systems to vehicles that have already been shipped from the factory.

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 Customer 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.

Fleet — All cars furnished under the terms of this Contract.

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 Documents.”

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.

Lowest Level Replaceable Unit (LLRU) — The lowest unit (component) of a system or subsystem, which is removable and replaceable from an installed position by standard attachments (e.g., bolts and nuts, quick-disconnects, etc.).

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 Customer’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 Customer.

**NTP** — A written notice from the Customer to the Contractor to officially start work on the contract.

**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.

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

**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 Documents, 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 Customer’s trains operate, and/or the property and/or improvements used in connection with such operating railroads, as defined by 49CFR 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** — To 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.

**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.
**References and Glossary**

**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.

**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.

**Subcontractor** — Provider to the Contractor of any services or materials for incorporation into the car design, car construction, spare parts, or other contract deliverable. The Contractor shall be solely responsible for the services or materials provided by the Subcontractor. The words “supplier”, “manufacturer” and “vendor” to have the same meaning.

**Subsystem** — A defined portion of a system.

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

**Superliner** — Bi-level Amtrak long distance passenger cars manufactured by either Pullman Standard or Bombardier. Cars have upper-level car-to-car pass-through.

**Surfliner** — Bi-level intercity corridor cars built by Alstom Transportation for Amtrak and Caltrans for use on Capitol, San Joaquin and Pacific Surfliner corridor service. Car-to-car pass-through is on the upper level.

**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 can not 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.

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.

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 15 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.

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.

Unisex Toilet Room (UTR) — The smaller of the two toilet rooms, to be located on the upper level of the passenger rail car, that is not required to be ADA compliant.

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.

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.

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 Customer 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 ft\(^2\) of clear floor space.

4. AW3: Car at crush load.
   • Crush Load is defined as seated load plus one standee per 1.5 ft\(^2\) of clear floor space.

Each passenger or standee is assumed to weigh an average of 180 pounds.

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 — See “No motion”.

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 Customer," "to Customer," "the Customer" 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."
2.3.1 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
- **ADA** Americans with Disabilities Act of 1990 as amended
- **AED** Automated External Defibrillator
- **AEI** Automatic Equipment Identification
- **AESS** Automatic Engine Stop Start
- **amp** ampere
- **ANSI** American National Standard Institute
- **APTA** American Public Transportation Association
- **ASHRAE** American Society of Heating, Refrigeration and Air Conditioning Engineers
- **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
- **ATS** Automatic Train Stop
- **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
References and Glossary

B.C.P. brake cylinder pressure
BP brake pipe
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
CDRL Contract Deliverable Requirements List
CDT Central Diagnostics Terminal
CEM Crash Energy Management
CFC Chlorinated Fluorocarbons
cfm Cubic Feet per Minute
CFR Code of Federal Regulations
CO Central Office
COMM Communication
COTS Clean, Oil, Test and Stencil
CPE Customer Premise Equipment
CPM Critical Path Method
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
DTN  Data Trainline Network
DVD  Digital Versatile Disc
DVD RW Digital Versatile Disc - Rewriteable
EAB  Electronic Air Brake
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)
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
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 49CFR Section 229.11)
°F   Fahrenheit (degrees)
FAI  First Article Inspection
fc   foot-candle
### References and Glossary

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<th>Definition</th>
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<tbody>
<tr>
<td>FCC</td>
<td>Federal Communication Commission</td>
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<tr>
<td>FDA</td>
<td>U.S. Food &amp; Drug Administration</td>
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<td>FDR</td>
<td>Final Design Review</td>
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<tr>
<td>FEA</td>
<td>Finite Element Analysis</td>
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<td>FEM</td>
<td>Finite Element Model</td>
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<td>FMEA</td>
<td>Failure Mode and Effects Analysis</td>
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<td>FMECA</td>
<td>Failure Modes and Effects Criticality Analysis</td>
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<td>FMI</td>
<td>Field Modification Instruction</td>
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<tr>
<td>FPM</td>
<td>feet per minute</td>
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<tr>
<td>FRA</td>
<td>Federal Railroad Administration (U.S. Department of Transportation)</td>
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<tr>
<td>FRP</td>
<td>Fiberglass Reinforced Plastic</td>
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<td>ft</td>
<td>foot</td>
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<td>ft²</td>
<td>square foot</td>
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<tr>
<td>ft³</td>
<td>cubic foot</td>
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<tr>
<td>foot-candle</td>
<td>Foot candle</td>
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<tr>
<td>FTA</td>
<td>Federal Transit Administration (U.S. Department of Transportation)</td>
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<tr>
<td>g</td>
<td>Acceleration due to gravity (386.1 inches per second per second)</td>
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<tr>
<td>gal</td>
<td>gallon</td>
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<tr>
<td>GB</td>
<td>Gigabyte</td>
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<tr>
<td>GFCI</td>
<td>Ground Fault Circuit Interrupter</td>
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<td>GHZ</td>
<td>gigahertz</td>
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<tr>
<td>gpm</td>
<td>gallons per minute</td>
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<tr>
<td>GPS</td>
<td>Global Positioning System</td>
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<tr>
<td>HAZ</td>
<td>Heat-Affected Zones</td>
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<tr>
<td>HBPS</td>
<td>Holding Brake Pressure</td>
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<tr>
<td>HDMI</td>
<td>High Definition Multimedia Interface</td>
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<tr>
<td>HEP</td>
<td>Head End Power</td>
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Hg  Mercury (pressure or vacuum – measured in inches)
HPPL  High Pressure Photoluminescent
hr  hour
HSR  High-Speed Rail
HVAC  Heating, Ventilation, & Air Conditioning
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
IGBT  Insulated Gate Bipolar Transistor
in.  inch
in²  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
ksi  1000 pounds per square inch (psi)
kW  kilowatt
LAHT  Low Alloy High Tensile
lb   pound
LDTS Local Diagnostic and Test System
LDVR Local Diagnostic and Test System
lbf  pounds of force
lbs/ft² 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
LLRU Lowest Level Replaceable Unit
LSA  Lead Service Attendant
lx   lux
LVPS Low Voltage Power Supply
m    meter
mA   milliampere
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
**References and Glossary**

- **MIG** Metal Inert Gas
- **MIL** Military Specification
- **min** Minute, minutes
- **mm** millimeter
- **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
\textbf{NO}  Normally Open
\textbf{NPT}  National Pipe Thread
\textbf{NSF}  National Sanitation Foundation
\textbf{NTP}  Notice-to-Proceed
\textbf{NTSB}  National Transportation Safety Board
\textbf{OCU}  Operator Control Unit
\textbf{ODBC}  Open Data Base Connectivity
\textbf{ODK}  Operator Display Keypad
\textbf{OEM}  Original Equipment Manufacturer
\textbf{OFE}  Oxygen Free Electronic
\textbf{OSHA}  Occupational Safety and Health Administration
\textbf{OTIS}  Onboard Train Information System
\textbf{oz}  ounce
\textbf{p/n}  part number
\textbf{PA}  Public Address
\textbf{PA/IC}  Public Address/Intercom
\textbf{PC}  Personal Computer
\textbf{PCB}  Printed Circuit Board
\textbf{PCMCIA}  Personal Computer Memory Card International Association
\textbf{PCS}  Pneumatic Control Switch
\textbf{PDF}  Portable Document Format
\textbf{PDR}  Preliminary Design Review
\textbf{PHS}  Public Health Service
\textbf{PIDS}  Passenger Information Display System
\textbf{PIS}  Passenger Information System
\textbf{PISCU}  Passenger Information System Control Unit
\textbf{PKO}  Power Knock/Out
References and Glossary

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
PTU  Portable Test Unit
PVC  Polyvinyl Chloride
PWM  Pulse Width Modulation
QA  Quality Assurance
QC  Quality Control
RAID  Redundant Array of Independent Disks
RAM  Random Access Memory
RFI  Radio Frequency Interference
RFP  Request for Proposal
RGB  red green blue
RH  Relative Humidity
rms  root mean square
S&I  Service and Inspection
SAE  Society of Automotive Engineers
SCFM  Standard Cubic Feet per Minute
sec  second
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIV</td>
<td>Secondary Impact Velocity</td>
</tr>
<tr>
<td>SNR</td>
<td>Signal-to-Noise Ratio</td>
</tr>
<tr>
<td>SQL</td>
<td>Structured Query Language</td>
</tr>
<tr>
<td>SSP</td>
<td>System Safety Plan</td>
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<tr>
<td>SSS</td>
<td>Sign System Server</td>
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<tr>
<td>t</td>
<td>Thickness</td>
</tr>
<tr>
<td>T/L</td>
<td>Trainline</td>
</tr>
<tr>
<td>T/R</td>
<td>Transmitter/Receiver</td>
</tr>
<tr>
<td>TB</td>
<td>Terabyte</td>
</tr>
<tr>
<td>TBD</td>
<td>To Be Determined</td>
</tr>
<tr>
<td>TCD</td>
<td>Train Communications Data</td>
</tr>
<tr>
<td>TFT</td>
<td>Thin Film Transistor</td>
</tr>
<tr>
<td>TIG</td>
<td>Tungsten Inert Gas</td>
</tr>
<tr>
<td>TLC</td>
<td>Trainline Complete</td>
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<tr>
<td>TMS</td>
<td>Train Monitoring System</td>
</tr>
<tr>
<td>TOR</td>
<td>Top of Rail</td>
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<tr>
<td>TSA</td>
<td>US Transportation Security</td>
</tr>
<tr>
<td>TTCI</td>
<td>Transportation Test Center</td>
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<tr>
<td>U.S.</td>
<td>United States</td>
</tr>
<tr>
<td>UL</td>
<td>Underwriter's Laboratories, Inc.</td>
</tr>
<tr>
<td>ULSD</td>
<td>Ultra Low Sulfur Diesel</td>
</tr>
<tr>
<td>UMLER</td>
<td>Universal Machine Language Equipment Register</td>
</tr>
<tr>
<td>USB</td>
<td>Universal Serial Bus</td>
</tr>
<tr>
<td>USDOT</td>
<td>United States Department of Transportation</td>
</tr>
<tr>
<td>USPHS</td>
<td>U.S. Public Health Service of the U.S. Department of Health and Human Services</td>
</tr>
<tr>
<td>USSC</td>
<td>United States Steel Corporation</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Full Form</td>
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<td>--------------</td>
<td>-----------</td>
</tr>
<tr>
<td>UTR</td>
<td>Unisex Toilet Room</td>
</tr>
<tr>
<td>UV</td>
<td>Ultraviolet</td>
</tr>
<tr>
<td>V</td>
<td>volt</td>
</tr>
<tr>
<td>VAC</td>
<td>Volt Alternating Current</td>
</tr>
<tr>
<td>VDC</td>
<td>Volts Direct Current</td>
</tr>
<tr>
<td>VDSL2</td>
<td>Very High Speed Digital Subscriber Line 2</td>
</tr>
<tr>
<td>VTI</td>
<td>Vehicle Track Interaction</td>
</tr>
<tr>
<td>W</td>
<td>watt</td>
</tr>
<tr>
<td>W/ft²</td>
<td>watts per square foot</td>
</tr>
<tr>
<td>WB</td>
<td>Wet Bulb</td>
</tr>
<tr>
<td>WCRS</td>
<td>Waste Collection and Retention</td>
</tr>
<tr>
<td>WiFi</td>
<td>Wireless Fidelity (Wireless Local Area Network protocol, IEEE 802.11b, 802.11g and 802.11n)</td>
</tr>
<tr>
<td>WLAN</td>
<td>Wireless Local Area Network</td>
</tr>
<tr>
<td>WMS</td>
<td>Work Management System</td>
</tr>
<tr>
<td>WPS</td>
<td>Welding Procedure Specifications</td>
</tr>
<tr>
<td>yr</td>
<td>year</td>
</tr>
<tr>
<td>Z</td>
<td>Impedance</td>
</tr>
</tbody>
</table>

* End of Chapter 2 *
Chapter 3
Project Management
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3.0 Project Management

3.1 Overview

These Technical Specifications, including the conceptual drawings, describe and illustrate the criteria to be used for the Contractor’s design and manufacture of the PRIIA 305-003/Amtrak 964 railcars.

The cars shall comply in all respects with the requirements of the applicable laws and regulations of the United States of America, especially 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.

The design criteria and constraints that are known to the Customer 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 Customer’s service conditions.

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 Customer. Material standards and specifications which are used by the Contractor, unless otherwise approved by the Customer, 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 Customer 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 Customer for any substituted documents.

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

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 Customer.

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 Customer.
3.2 Regulations, Standards, Specifications and Drawings

The Customer 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.

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

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.

3.3 Project Management

The Contractor shall submit to the Customer for approval no more than 45 days after Notice to Proceed (NTP) a program management plan. 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 program management plan shall have a live document status. All changes must be submitted to the Customer during the next monthly progress report covering the time period the change took place. Changes will be subject to approval by the Customer.

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 Customer. 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 Customer. 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.

In addition to the requirement for updated versions of the CPM plan to be submitted to the Customer, the Contractor shall submit to the Customer a monthly progress status report in the form of updated computer printouts and narrative reports. 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 Customer, 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.

3.3.1 Correspondence Tracking

Following NTP, the Contractor and the Customer 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 unmistakable identity. All correspondence shall readily display the Customer'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.

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 Customer and the specific identification of the material submitted in terms of drawing/revision numbers, document numbers, etc.

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

3.4 Quality Assurance (QA)

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.

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.

3.4.1 Quality Assurance Plan

A Contract-specific QA plan 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.

The plan shall illustrate how the Contractor intends to meet the quality assurance requirements of this Technical Specification.
Required elements of the QA plan:

- Overview of contractor’s QA program.
- 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.
- Organization chart for the QA unit, including names, duties and responsibilities, and contact information for QA unit personnel.
- 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.
- Role of the Customer in the QA process, including Customer design reviews, inspections and hold points, and the Customer’s authority to require corrective action to resolve quality problems.
- 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.
- 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.
- Process for auditing production to determine if QA policies and procedures are being implemented and maintained, and how problems are corrected.
- 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.
- Inspection process for monitoring quality during production, including flow chart and process for resolving defects and closing out nonconformances.
- Schedule for inspection and recalibration for all tools and devices used for measurement, testing or inspection.
- 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.
- 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. If a failure occurs on 10% of the component population fleet or three times on the same component within the warranty period a failure analysis will be completed and fleetwide field modification will be completed.
- The QA plan shall be submitted to the Customer for review and approval, no more than 90 days after NTP.

The approved QA plan and supplemental manuals, procedures and instructions shall be subject to regular scheduled and unscheduled audits by the Customer.
A quality organization chart shall be included to show the reporting relationships of all QA management staff. The responsibility for the quality assurance function shall be so placed in the Contractor’s organization that it is independent from production.

The QA plan shall clearly indicate that the Contractor’s QA representatives shall have sufficient authority and organizational freedom to insure that a nonconforming or discrepant product or service will not be delivered. The organization of the Contractor’s QA program shall report directly to the General Manager of the Contractor’s facility or the Contractor’s Project Manager. 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.

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. These records shall be made available to the Customer for review.

The Contractor shall, upon request, place measuring and control recordings at the disposal of the Customer 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 Customer.

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 Customer’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 Customer shall be established by the Contractor.

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

- 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.
- Introduction of required improvements and corrections, initial review of the adequacy of such measures, and monitoring of the effectiveness of corrective action taken.
- Analysis of trends in processes or performance of work to prevent nonconforming products.
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.

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.

3.4.1.1 Subcontractor Quality Assurance Requirements

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

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.

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.

3.4.1.2 Quality Assurance Assessments

The Customer 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 Customer 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.

For on-going assessments, the Customer shall have free access to the production facilities of the Contractor and his 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. Customer 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.

3.4.1.3 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 shall be made available to the Customer representative on demand, and a complete set of records shall be submitted to the Customer at the end of the warranty period.
3.4.1.3.1 Customer Audits

The Customer 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:

- During production of the first carshell (will include an audit of both the Contractor and major subcontractors)
- During manufacturing, installation of equipment, and testing
- Before acceptance of the first car

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

3.4.1.3.2 Contractor Audits

The Contractor shall perform periodic internal audits throughout the life of the project to verify that all aspects of the Customer-approved QA plan have been effectively implemented. The Contractor shall provide the Customer 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.

3.4.1.3.3 Subcontractor Audits

The Contractor shall audit subcontractors to assure compliance with the approved QA plan. As a minimum, the following audits of each subcontractor shall be performed:

- Prior to a subcontracted or purchased item being delivered
- Within 30 days of the scheduled First Article Inspection (FAI), qualification test or the Contractor’s acceptance of any supplies items or services

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

3.4.1.3.4 Audit Reports and Corrective Action

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

3.4.2 Initiatives that Promote Sustainability in the Manufacturing Process

The Contractor shall provide to the Customer documentation regarding initiatives the Contractor has undertaken to promote sustainability and reduce the amount of material and energy waste produced by the manufacturing process. This documentation shall extend to the strategies employed by the Contractor’s suppliers and vendors. 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.

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

- Creation and utilization of reusable packaging for the transport of materials and components between the facilities of the parts supplier and the Contractor;
- Use of recyclable materials for packaging;
- Use of recycled or renewable materials in the production process;
- Reuse or recycling of excess material created during the manufacturing process;
- Use of energy-efficient or low-emission vehicles and equipment for transportation and production purposes;
- Capture of reusable or recyclable materials such as office paper, cardboard, copier toner, beverage containers and other post-consumer recyclable material;
- Use of facilities that meet the standards of the Leadership in Energy and Environmental Design (LEED) program;
- Employee awareness campaigns that promote reduction of material and energy waste; and
- Strategies that promote the reduction of unnecessary use of materials and energy.

The Contractor’s waste reduction program shall provide to the Customer quarterly reports that document the status of the program and the level of success that the program is achieving.

3.5 Design Objectives

3.5.1 Reliability

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.

The Contractor shall prepare and submit at the Preliminary Design Review (PDR) for approval by the Customer a Reliability Program Plan which shall, as a minimum, contain the following:

- Program objectives
- Reliability program schedule
- Methodology to be used in reliability analyses
- Organization of personnel responsible for managing the reliability program
- Controls for activities of subcontractors and equipment suppliers to assure compliance with reliability program methods and objectives
- Preliminary reliability demonstration testing plans for verification of compliance when calculations and analyses are inconclusive, or when past performance records are incomplete or unavailable
- Reliability demonstration program
• Reliability demonstration procedures
• Reliability database in FileMaker Pro (current revision)

3.5.1.1 Reliability Objectives

The Contractor shall provide reliability objectives that identify the Mean Distance Between Train Delays (MDBTD) and the Mean Distance Between Component Failure (MDBC) performance levels to be met for its car design to the Customer for approval. The reliability of the cars shall be consistent with the requirements of this specification and the Contractor’s maintenance plan.

The reliability objectives shall be based on single car operation at an average speed of 80 mph (129 km/hr) and a utilization of 215,000 miles/yr (344,000 km/yr).

3.5.1.2 Car Reliability Requirements

The car shall achieve a car MDBTD of at least 150,000 miles (241,350 km).

A train delay shall be defined as a car-related failure causing a train in service to be:

• More than 15 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.

3.5.1.3 Component Reliability Requirements

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

<table>
<thead>
<tr>
<th>System</th>
<th>Mean Distance Between Component Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Friction Braking System</td>
<td>300,000 miles [482,700 km]</td>
</tr>
<tr>
<td>Side and End Doors</td>
<td>300,000 miles [482,700 km]</td>
</tr>
<tr>
<td>HVAC System</td>
<td>380,000 miles [611,420 km]</td>
</tr>
<tr>
<td>Couplers</td>
<td>300,000 miles [482,700 km]</td>
</tr>
<tr>
<td>Trucks and Suspension</td>
<td>750,000 miles [1,207,008 km]</td>
</tr>
<tr>
<td>PA Systems</td>
<td>600,000 miles [965,606 km]</td>
</tr>
<tr>
<td>Auxiliary Power Systems</td>
<td>360,000 miles [579,363 km]</td>
</tr>
<tr>
<td>Lighting (except bulbs)</td>
<td>1,000,000 miles [1,609,344 km]</td>
</tr>
<tr>
<td>Food Service Components</td>
<td>750,000 miles [1,207,008 km]</td>
</tr>
<tr>
<td>Toilet</td>
<td>750,000 miles [1,207,008 km]</td>
</tr>
<tr>
<td>Cab Control Systems</td>
<td>450,000 miles [724,204 km]</td>
</tr>
</tbody>
</table>

The Contractor shall provide records illustrating the product history and experience of existing systems and system components to verify that the specified MDBC requirements are achievable.

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.

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.

The MDBCF shall be defined by the following equation:

\[ MDBCF = \frac{d}{F} \]

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

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

- Failure due to documented instances of recommended preventative maintenance not being performed; or
- Failure due to accidents, vandalism or other physical mistreatment.

### 3.5.1.4 Reliability Demonstration Program

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 Customer at the preliminary design review.

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.

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

- Reliability program organization, showing personnel and their responsibilities over the entire program.
- Reliability demonstration schedule.
- Specific tasks shall be identified for schedule development with start and completion dates, illustrating integration with major program milestones for design, manufacturing and testing.
- 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.
- 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.
Establishment of a joint Contractor/Customer failure review board to classify failures, identify cause and propose corrective action, if required.

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

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 Customer 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.

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.

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 Customer 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 Customer.

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 Customer 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 Customer for such engineering and corrective work shall be at the Contractor’s expense. Any items replaced by the Customer during such corrective work will be disposed of by the Customer in the manner requested by the Contractor and at the Contractor’s expense. If the Contractor fails to furnish disposition instructions, the Customer will dispose of such items, at the Contractor’s expense, in such a manner, in the Customer’s sole judgment, is appropriate.

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.

3.5.1.5 Reliability Demonstration Procedures

The Contractor shall provide a set of procedures to be followed in the reliability demonstration. These procedures shall, as a minimum, contain the following:

- Method for all equipment failures to be reported during reliability testing, including forms and reliability database.
- The reliability program shall utilize failure data collected through the warranty failure tracking process.
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.

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.

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.

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 Customer within 60 days of the failed item or system.

3.5.1.6 Reliability Database

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

- Monitoring of overall car reliability on both a car and a component level
- Tracking of all component failures and identification of epidemic failures
- Tracking of all warranty claims
- Maintaining a configuration record for each car

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

- Customer car number
- Car acceptance date
- Detailed listing of all car system equipment and major components including description, supplier's name, Customer part number, supplier part number, serial number, revision level and date of installation on car

3.5.2 Maintainability

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:

- All systems and components serviced as part of periodic preventive maintenance shall be readily accessible for service and inspection.
- Removal or physical movement of components unrelated to the specific maintenance and repair tasks involved shall not be required.
• 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).

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

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

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

• 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), toilet system and food service equipment (chillers).

• 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.

• 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.

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

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

• 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.

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

• 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.

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

• Requirements for special tools and fixtures shall be minimized.

3.5.2.1 Maintainability Plan

The Contractor shall prepare and submit for review at the PDR, a maintainability program plan utilizing design standards that minimize Mean Time To Repair (MTTR), cleaning and maintenance costs throughout the car’s intended useful life.

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.

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.

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

- Maximization of car availability
- Minimization of maintenance costs, including cleaning
- Minimization of car down time
- Minimization of special and high skill levels for maintenance
- Minimization of special tools and fixtures

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

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.

3.5.2.2 Mean Time to Repair Requirements

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

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

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

3.5.2.3 Maintainability Demonstration

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

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

- Trucks
- HVAC
- Brakes
- Wheels and axles
- Auxiliary electric equipment (including battery charger and battery)
- Side and end doors
- Couplers
- PA and intercoms
- Water and waste system
- Emergency equipment and lighting
- Cab control equipment

The Contractor shall prepare and submit a maintainability demonstration plan for Customer approval at the PDR.

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

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.

### 3.5.3 Metrication

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 Customer 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.

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.

### 3.5.4 Safety

Safety shall be of primary importance in the design of the car. The car shall present a safe, hazard-free environment to passengers, crew members and the general public. Passage through the car shall be easy and safe. No sharp edges or corners or pinch points shall occur where passengers, crew, or maintenance personnel may come into contact with them. Adequate handholds shall be provided throughout the car. The operating cab shall be designed to minimize injury from impact against cab surfaces in a collision.
Passengers and crew shall not be exposed to tripping hazards, exposed electrical voltage, toxic materials or similar hazards. Location, illumination levels, colors, graphics and surface finishes shall be selected to maximize visibility of door thresholds, windscreens, controls and other objects with which the passengers and crew must interface.

Normal and emergency equipment and controls which the passenger or crew may operate shall be clearly identified, and operating procedures shall be presented in both text and graphic formats. Passenger emergency signs shall also be embossed in Braille raised typeface. Power capacitors shall self-discharge.

3.5.4.1 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.

- Only components with high reliability and predictable failure modes, and which have been proven in conditions similar to the projected service shall be utilized.
- All electronic circuits shall be assumed capable of failing in permissive modes.
- Software shall be considered capable of failing in an unsafe mode unless it is safety verified while operating in the proposed hardware.
- 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.
- Any component or wire becoming grounded shall not cause a permissive condition. Safety circuits shall be kept free of any combination of grounds that will permit a flow of current equal to, or in excess of 75% of the release value of any safety device in the circuit.
- Circuit 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.
- Commands that result in permissive conditions shall be propagated by no less than two independent signals, both of which must be present before the permissive condition can occur. The lack of either signal shall be interpreted as a restrictive command.
- Systems controlled by variable level signals shall be arranged such that zero signal level results in the most restrictive condition. At least one enabling signal, however, independent from the variable control signal, shall be present before the control signal can modulate the system to a more permissive level.
- Circuit breakers and fuses shall be guaranteed by the manufacturer to successfully interrupt rated currents. Circuit breakers and fuses shall be applied such that the maximum circuit fault currents cannot exceed the manufacturer’s guaranteed operating ranges.
- Systems that rely on structural integrity for safety shall have sufficient safety factors such that failures are not possible within the life of the car under all possible normal conditions.
- 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.

- Mechanical systems which apply force to achieve safe states shall not depend upon the application of fluid pressure or electrical energy, unless specifically approved.
- All locks, catches, and similar devices affecting safety shall be either self-engaging without application of power, or, if engaged by application of power, shall remain fully and safely engaged in the absence of power.
- All systems shall function safely under all combinations of supply voltages, fluid pressures, shock, vibration, dirt accumulation and the railroad environment.
- All safety related systems, and devices within those systems, shall be clearly identified in all operation and maintenance manuals, procedures, and training materials.
- Exposure of maintenance personnel to lethal or injurious voltages shall be minimized through compartmentalization, interlocks and similar measures.
- 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.
- No sequence of operations, or the simultaneous activation of any controls, shall result in unsafe conditions.
- All systems shall protect against unsafe conditions resulting from human error.

3.5.4.2 System Safety Program

The Contractor shall develop, implement and maintain a comprehensive System Safety Program (SSP) conforming to the guidelines and requirements of 49CFR Part 238 - Subpart B, the latest issue of the APTA Manual for the Development of System Safety Program Plans for Commuter Railroads, issued by the APTA Commuter Rail Safety Management Program. This SSP shall access, analyze and document the safety aspects of all components, systems, managements and materials used on the rail cars, and the operation, maintenance, repair and performance of those components, materials and systems, from the viewpoint of crews and passengers.

The SSP shall identify all hazards related to the car; and shall impose design requirements and management controls, in addition to those identified in this Technical Specification, to prevent unsafe conditions by eliminating hazards or reducing risk to levels acceptable to the Customer. The SSP shall be developed in the earliest phases of the Contract and shall be continuously maintained throughout, as design and construction evolves. The formats for reports, listings, analyses and other required submittals shall be jointly determined between the Customer and the Contractor.

The SSP shall include a software safety section which applies to any embedded or external software or firmware which controls or monitors safety-critical functions.

Software safety requirements shall treat software as an integral part of a hardware/software system. Functions accomplished through the use of software shall be considered safety critical unless an independent redundant hardware means is also provided to accomplish the same function.

Features of the software safety program shall include a description of how the following shall be accomplished: definition, implementation and oversight of the software design and
verification process, integrity of the documentation, software hazard analysis, software safety reviews, software hazard monitoring, reporting and tracking, and software integration with hardware at each stage of the design and testing process for components, subsystems, systems, cars, consists and trains incorporating software for safety-critical functions.

The completed SSP shall be submitted to the Customer for review and approval prior to acceptance of the first car.

### 3.6 Design Review

Within 30 days of NTP, the Contractor shall submit an engineering plan for accomplishing the engineering design functions and objectives. The engineering plan shall include at a minimum:

- Defining the relationship of the engineering team in the overall organization of the Contractor.
- Organization of the engineering department, with identification of the subgroups as organized by function or system.
- Critical path/workflow plan for completion of all engineering functions.
- 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.
- Oversight of vendor engineering functions and integration of supplier engineering into the Contractor's design.
- Manufacturing engineering plan, including assembly station work scope, parts flow and estimated labor hours/station staffing plan.
- Carshell engineering plan, including design, finite elements analysis, quasi-static and dynamic testing, measurement of critical dimensions, acceptance and shipment, and inspection/repair procedures.
- Completed car weight control plan.

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

The Contractor shall be responsible for the car design including all sub-systems and materials, with appropriate review by the Customer. 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.
The Contractor shall provide equipment meeting all specified performance levels and be compatible with all elements of the railway system on which the Customer will operate the equipment, for the useful life of the equipment.

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

The vehicle design and construction shall be subject to monthly progress reviews/program meetings.

The Contractor will record the minutes of the meetings, and shall provide, within one week of the meeting, a minutes package that shall include a copy of all documents presented/discussed at the meeting. Also included shall be matrices showing status of the following:

- System design reviews
- Schematics
- FAI and follow-up
- Master test plan, procedures and test schedule
- Manual status
- Training action plan
- Manufacturing status

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.

### 3.6.1 Customer Involvement

The Customer 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.

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

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 Customer of all comments and direction received from regulatory agencies regarding the project.
The Customer shall have the right to invite or permit to participate in any inspection, design review, audit or test anyone the Customer deems desirable or necessary. The Customer will give the Contractor reasonable notice of participants, but reserves the right to include participants with no notice.

3.6.2 Approval of Suppliers

The Contractor shall be responsible for pre-qualifying all proposed subcontractors to the Customer’s satisfaction and approval.

Within 30 days of NTP, the Contractor shall supply a complete list identifying each major supplier and their product proposed for use on the car. Along with this, a listing of names and addresses of other users of similar equipment from that supplier, including the two most recent customers, shall be submitted to the Customer. This list shall have been updated and approved prior to building of mockups.

3.6.3 Configuration Management

The Contractor shall develop and submit to the Customer for approval a configuration management plan within 45 days after NTP. The plan shall illustrate how the Contractor intends to meet the configuration management requirements and shall include as a minimum:

- Flow charts of paperwork for design changes prior to and following design reviews and drawing approvals.
- Forms to be used to convey, track and account for the design changes whether approved or not.
- 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.
- A description of the forms and methods to reflect the current modification status of every car.
- The method to be used to make required revisions to publications, drawings, education programs, photographs and any other program software.

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

The Contractor shall maintain accurate and current configuration records which shall be available to the Customer 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.
3.6.3.1 Engineering Changes

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:

- Interchangeability and availability
- Changes that require modifications to operating or maintenance manuals
- Changes that require modifications to periodic maintenance schedules
- Changes to parts manuals
- Mechanical or electrical form, fit, or function
- Reliability or maintainability
- Electromagnetic interference characteristics
- Safety
- Spares provisioning
- Sources of repairable items (source control drawing)
- Vehicles delivered
- Weight
- Wiring and or electrical function

All other changes shall be designated as Class II changes.

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 Customer for review prior to approval and implementation.

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 Customer 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 Customer's approval.

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 a 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.
3.6.3.2 Documentation Requirements

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

- 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.
- 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.
- Display the Customer's contract number on the title page.
- Display the originating company's name and address on the title page.
- Display the overall revision level on the title page and display the varying revision level on each consecutive page.
- Display the unique document number on each page of the document.
- 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.
- Record the revision levels of individual pages on a dedicated page for verification of proper document composition.
- Contain a table of contents and an itemized listing of tables and figures.

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

- Approved — The Customer concurs with the information in its submitted form. The material may be incorporated into the program.
- Conditionally Approved — The Customer 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 Customer approval.
- Disapproved — Means the Customer does not concur with vital details. The Contractor shall not incorporate the material into the program. The Customer's objections must be reconciled, and the material must be resubmitted in revised form for Customer approval as specified by the Customer.

An approval shall not be construed as:

- Permitting any departure from the Contract requirements; or
- Relieving the Contractor of the responsibility for any error including details, dimensions, materials and calculations.

Classification by the Customer 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 Customer in design review meetings or in travel to or from such meetings shall not be included in the 30 day figure.

After reviewing the submitted material, the Customer will provide to the Contractor its review comments on each submittal within 15 working days. 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 Customer 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 Customer in its review. At the conclusion of the meeting, the Customer 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 Customer and the Contractor.

The Customer 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.

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

3.6.4 Design Review Process

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). The requirements for these Design Reviews are as follows:

3.6.4.1 Preliminary Design Review (PDR)

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 Customer retains the right to redline, comment, and request changes to improve design and/or functionality.

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

- 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.
- 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.
- 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 Customer 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.
- 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 Customer for review and approval. Drawings shall show at a minimum:

- Overall dimensions, orientation, center of gravity, weight, points of normal support, and method of support during mounting and removal.
- Location of all doors, access panels and covers in relation to any enclosed equipment.
- Required space for opening of all doors and access panels.
- Location and space requirements for ventilation intake and exhaust openings and cable entrances.
- Location and space requirement for all major equipment.
- 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.
- Review Program — The Contractor shall submit to the Customer 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, and shall also include an update to the pre-award buy America submittal, indicating any revisions to the manufacturer of goods, country of origin, and cost data. After approval by the Customer, 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 Customer.
- 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 Customer 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.

3.6.4.2 Intermediate Design Review (IDR)

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 Customer 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.

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

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

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

At the IDR, the Contractor shall provide the finalized mockup review plan for Customer 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.

3.6.4.3 Mockup Development and Review

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; according to the drawings as reviewed and approved at the IDR, for Customer review and comment:

- A representative area of the passenger seating area shall be built, including:
  - Two facing 2-person passenger seats
  - Workstation table between the facing seats
  - Overhead luggage bin, including reading light unit
  - Wall panels, window and window mask
  - Convenience outlets
  - Heater grilles and diffusers

- A fully functional example of an enclosed overhead luggage bin 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.

- The wheelchair lift unit and installation shall be built to verify the function of the design.

- Café/lounge car:
  - A hard mockup of the galley area shall be constructed, and shall include all galley equipment and countertops and a full complement of simulated carts and chillers installed. Carts shall be functional to simulate circulation and loading of the carts in the galley area.
  - The lounge area booth seating on both sides of the lounge area shall be simulated.

- Complete side door and vestibule mockup.

- Cab/baggage 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.
• The bike rack/baggage room shall be mocked up for the purpose of evaluating ease of operation, quantity of bikes and baggage to be carried, and circulation.

• 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.

• Unisex toilet room:
  • A fully equipped Unisex Toilet Room (UTR) shall be assembled, for the purpose of evaluating layout, circulation and access to controls and appliances.

• Electrical locker:
  • 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.

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

All mockups shall be constructed of materials with sufficient strength so that they can be evaluated safely and thoroughly by the Customer. 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. The mockups shall include all finishings, colors, patterns, textures, fasteners and hardware as designed.

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 Customer at the final design review.

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

3.6.4.4 Final Design Review (FDR)

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 Customer retains the right to provide additional comments during this process as production progresses and concerns are brought to the Customer’s attention.

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

• 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.

- Detailed Drawings and Related Documents — The Contractor shall submit as a minimum the following detailed drawings and related documents to the Customer for review and approval:
  - All top and associated sublevel release drawings, properly dimensioned, detailed, to scale and in accordance with the approved drawing schedule.
  - 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).
  - 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.
  - Single line piping and flow diagrams for all pneumatic circuits, displaying all valves and control components. All test points shall be displayed.
  - Graphs and curves giving response and functional characteristics of the car, subsystems and major items.
  - Manufacturer’s data and specification sheets on all control items.
  - 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.
  - Stress Analysis — A stress analysis of the carbody shall be submitted to the Customer for approval.

### 3.6.5 Component Approvals

All vehicle components, except as listed in this document, shall be subject to approval by the Customer. The goal is to use, as much as possible, components known by the Customer 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 Customer.

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 Documents.
3.6.5.1 Component Substitution

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 Customer for approval in the form of a contract variance, and shall include, at a minimum:

- Identification and description of the specified part or material that is not available or not specification compliant.
- Reason the part is not available or not specification compliant.
- Part or material that is proposed for substitution.
- 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 Customer to determine the adequacy and equivalence of the proposed component.

3.6.6 First Article Inspection (FAI)

The Contractor shall perform First Article Inspection (FAI) of all major components, subassemblies and fully assembled cars. The Customer 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 Customer of an FAI.

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

3.6.6.1 FAI Process

Within 90 days of NTP the Contractor shall provide to the Customer, a list of assemblies and subassemblies subject to FAI along with their projected schedule. The FAI inspection plan shall include the following requirements at a minimum:

- A tracking system shall be developed and maintained which will identify each FAI subject and accurately reflect the present status of each inspection.
- 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.
- 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.
- 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.
- The Customer shall be given notice of an upcoming FAI at least 30 days before its schedule date.

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

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

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 Customer.

3.6.6.2 Systems Requiring FAI Approval

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

- Carshell (including all major subassemblies)
- Floor panels
- Door leaves
- Door hardware, latches
- Manual doors
- Power doors, operators and controls
- Wheelchair lift
- Windows
- Trucks-frame
- Trucks-fully assembled
- Wheel and axle assemblies
- Couplers and draft gear
- Air brake system
- Wheel slide control system
- Major fiberglass interior components and hardware
- Seats (including cab seat)
- Tables (workstation and lounge)
- HVAC system, controls and temperature controls
- All external and internal lighting systems
- Communication system
- Electrical lockers
- All electrical panels
• Batteries and charging system
• Food service equipment including refrigeration system
• Toilet room (modules)
• Waste collection and retention system

FAI for Cab Car Only

• Pilot
• Cab seat
• F-end frame door
• Alerter/speedometer/overspeed
• Event recorder system
• Positive Train Control (PTC) system
• Windshield wipers

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

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 Customer at least 30 days prior to the inspection.

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.

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 Customer’s representatives. Changes, modifications or adjustments to this baseline must be approved by the Customer and will be cause for initiating another FAI by the Customer.

Availability of the information in a timely manner is essential to ensure that the appropriate level of the Customer’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 Customer at least 15 working days before a scheduled FAI:

• A complete list of the equipment and its bill of materials to be inspected.
• Identify each completed assembly along with the configuration in which it is to be presented.
• A copy of the technical Specification for the equipment and the subcontractor’s scope of supply.
• 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.

- System schematics, electrical, fluid, pneumatic and piping, with current approvals. The schematics shall be sufficient to determine that the equipment will operate as intended.
- All instruction manuals, operating manuals, maintenance procedures and heavy repair shall be presented at the FAI for review.
- A report by a recognized independent testing laboratory certifying that all materials used in the equipment comply with the 49CFR Part 238 Appendix B requirements and NFPA 130, as applicable.
- A Customer-approved inspection and acceptance test procedure and a Customer approved qualification test procedure to which the equipment will be inspected. A functional test shall be required as part of the FAI.
- All pertinent calculations or analyses to show that the design is adequate for the purpose intended.
- The Contractor shall submit to the Customer a complete stress analysis and summary, in sufficient detail for the Customer 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 Customer to analyze, of the trucks shall be submitted at least 30 days prior to the beginning of the truck fatigue test.
- Should any of the above documents be incomplete or otherwise unacceptable to the Customer, this shall be grounds to delay the FAI until they are made right. The burden of any delay shall be with the Contractor.
- All manufacturing variations of specified materials that vary in color, texture, pattern, etc., shall be presented, for approval by the Customer, at FAI. Samples of acceptable variation extremes will be retained for reference in future inspections.
- The FAI sample shall be retained by the equipment manufacturer until the completion of production of all cars.

3.6.6.3 FAI Findings

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. The Contractor shall include an action plan to correct all deficiencies discovered during the FAI. The FAI will remain open until all action items are completed to the Customer’s satisfaction. Depending on the severity of the deficiency, follow-up FAI may be required.

The Customer shall provide an FAI report within ten days of the inspection. It shall include the findings of the inspection, tests and deficiencies.

The Contractor shall provide color photographs on 8.5 in. by 11 in. size paper and in a digital format within 30 days of the FAI, of each item subject to FAI. A second set of these photos shall be compiled into an album for the Customer’s reference for future car inspections and will be supplied to the Customer with the delivery of the first car.
3.7 Inspection

The Customer shall, at all times, have the right to inspect the work. The Contractor shall grant the Customer 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 documents. During these assessments, the Contractor, subcontractors and suppliers shall make every reasonable effort to assist Customer personnel.

Inspection or lack of inspection, approval or acceptance of any portion of the work by the Customer shall not relieve or release the Contractor from its obligations to fully comply with all requirements of the Contract documents.

The Contractor shall correct any portion of the work not meeting the requirements of the Contract documents at the Contractor’s expense to the satisfaction of the Customer.

The Customer at any time before issuance of final acceptance for any car may order re-inspection of any portion of the work.

3.7.1 Inspections and Tests

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 Customer 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.

The Customer 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.

The Customer 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.

If any portion of the car shall become hidden by subsequent work contrary to the specific request of the Customer, that portion of the car shall be made visible for Customer inspection by the Contractor at the Contractor’s expense.

The Customer 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 Customer’s right to supplement its on-site inspector with additional experts as necessary according to the particular nature of the test or inspection involved.

The presence of the Customer 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 Customer 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 Customer 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 Customer in writing that the problems have completely resolved.

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.

An Inspection and Test Log (Log) shall be maintained by the Contractor during equipment assembly. The Log shall be submitted to the Customer for review before each car will be released for shipment to the delivery site. All Contractor and Customer 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.

For those routine inspections and tests of components that are typically performed solely by the Customer, the Contractor shall give at least 72 hours notice of such inspections or tests to the Customer. The Customer 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.

The Contractor must maintain office copies of all records, and they must be accessible to the Customer, not more then five days after such notice is given.

3.7.2 Contractors Provisions for Customer Inspectors

From NTP continuously through production, the Contractor shall provide office facilities for Customer representatives at no additional cost to the Customer. 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 Customer. 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 Customer’s office or nearby (adjacent) area.

Reserved parking places shall also be provided for all Customer representatives assigned to the Contractor’s facility.

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 Customer 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.
### 3.7.3 Scheduling of Inspections and Tests

Inspection and testing activities by Customer staff will normally be conducted during normal daytime shifts and will not be conducted on Saturdays, Sundays or any holidays observed by the Contractor. Customer 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 Customer. This request will include compensation by the contractor to the Customer for this additional expense.

All inspection and tests shall be submitted to the Customer not less than 72 hours before that scheduled test or inspection. Inspections and tests outside of the United States and at subcontractors’ facilities are subject to the terms listed below.

For inspections and testing activities in the Contractor’s facilities, the Contractor shall present a written schedule of activities to the Customer’s inspectors at least 72 hours before the activities are to take place.

For inspections and testing activities at subcontractor’s facilities in the US, after written notice is submitted to the Customer 10 working days prior to the activities, the Customer will advise within five calendar days whether a representative will attend the inspection or test.

For inspections and testing activities at subcontractor’s facilities outside of the US, after written notice is submitted to the Customer 30 working days prior to the activities, the Customer will advise within 5 calendar days whether a representative will attend the inspection or test.

### 3.7.4 Receiving Inspection

The Contractor shall provide for the inspection of all incoming systems, subsystems, components, parts, equipment and materials to insure 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 Customer personnel.

### 3.7.5 Manufacturing/Assembly Inspection Hold Points

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 Customer’s representative of completed operations/installations or to inspect items that are about to be covered by succeeding assembly operations.

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:

- Each carshell section before painting
- Each carshell section after painting
- Each truck frame
- Each assembled truck, prior to installation under a car
- Each car underfloor area prior to receiving trucks
Each carshell watertightness test prior to installation of insulation and interior finishings
Each car final watertightness test
Each car interior wiring and components before being covered by panels
Each car underfloor area and connections prior to concealment
Each finished car interior
Each finished car exterior

The Contractor shall provide the Customer 72 hours advance notice of each such inspection.

The Contractor and Customer 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.

### 3.7.6 Car Pre-Shipment Inspection

After all work, including factory static and dynamic testing as per Chapter 19, is completed, the Contractor shall perform the car pre-shipment inspection according to a Customer approved procedure. All manufacturing or testing non conformance 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 Customer. The Contractor shall provide a qualified supervisor to accompany the Customer during inspection to assure that proper corrective action is taken. The Contractor shall provide the Customer 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.

The Contractor shall provide the Customer 72 hours advance notice of each such inspection.

### 3.7.7 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 Customer 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 Customer 72 hours advance notice of each such inspection. See Chapter 21 for additional shipping requirements.

### 3.7.8 Car Modification Inspection

The Contractor shall provide written procedures for Customer 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 Customer 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.

The Contractor shall provide the Customer 72 hours advance notice of each such inspection.
* End of Chapter 3 *
Chapter 4

Carbody
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4.0 Carbody

4.1 Overview

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 room components and access doors, wheelchair lifts and exterior graphics. The major structural elements of the carshell are described, and the requirements for the performance of the carshell structure are defined.

The carshell shall be manufactured of stainless steel, except for the end underframes which shall be constructed of Low Alloy High Tensile (LAHT) steel. The design of the carshell shall contain Crash Energy Management (CEM) features and 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.

4.2 General Requirements

The carbody shall be designed to the normal and expected base set of requirements established by 49CFR Part 238, APTA Standard SS-C&S-034-99 and this specification. The Crash Energy Management (CEM) recommended practice in Section 6 of APTA Standard SS-C&S-034-99, rev 2 shall be met with the crush-based approach specified in this Specification. Crash Energy Management (CEM) features are required as an overlay on the base set of requirements. CEM requirements are based on the results of FRA research to date as described in the various FRA technical papers and presentations that can be found on the Volpe Center website listed in Chapter 2.

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).

4.3 Arrangement

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 (reference Section 5.7 of APTA Standard SS-C&S-034-99, Rev. 2).

Apparatus requiring frequent inspection or attention shall be readily accessible and replaceable, including any element of the CEM system that requires periodic inspection to confirm serviceable condition. The frequency of required service shall govern the degree of accessibility. Apparatus requiring attention more frequently than every 120 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 Customer. 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 shall be submitted to the Customer for approval at the design review.
The general arrangement of the subcomponents shall be approved by the Customer during the mockup and design review process described in Chapter 3. 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.

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 Customer. 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 Customer.

All specified equipment on the car shall be arranged so that the maximum imbalance requirements in Chapter 1 are met.

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.

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:

- Car tare weight (AW0)
- Crush passenger load (AW3)
- Vertical, lateral and torsional dynamic load due to wheel/rail interaction
- Loads due to vehicle pitching caused by braking
- Snow or ice loads
- Aerodynamic load
- 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
- Buff load
4.3.1 Dimensions, Weights and Under Car Clearance

The completed car shall have the following overall dimensions:

- Length (over coupler pulling faces) 85 ft 0 in.
- Height (maximum) (ATOR) 14 ft 6 in.
- Overall Car Width (maximum) 10 ft 6 in.
- Carbody Width (excluding side handholds) 10 ft 2 in.
- Truck Centers 59 ft 6 in.
- Floor height (ATOR) 4 ft 3 in.

The completed car shall fully conform to Amtrak Clearance Drawing B-05-1355, rev E.

The final car dry weight shall not exceed the following weight restrictions:

- Coach Car 104,000 lbs
- Cab/Baggage Car 108,000 lbs
- Café/Lounge Car 111,000 lbs

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.

4.3.2 Physical Requirements

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 Amtrak Specification 963.

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.

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.
4.3.3 Carbody Materials

Materials used in carbody construction shall be in accordance with the provisions of APTA Standard SS-C&S-034-99, Rev. 2 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.

Where welded stainless steel fabrication is required, only austenitic stainless steel (AISI type 201 or 301 stainless steel) with a carbon content not exceeding 0.03%, or with proven weldability that resists atmospheric corrosion shall be used. Stainless steel parts attached to other parts by mechanical fasteners may be constructed of AISI types 201, 202, 301, 302, 304, 316, or 430 stainless steel.

LAHT shall be used for the end underframe assembly, irrespective of the carbody material - stainless steel or LAHT. The LAHT steel shall comply with all requirements of Chapter 18. Dissimilar metals shall not be used at connections requiring disassembly for removal and replacement of equipment.

Cross sectional views shall be provided on carshell drawings and must be submitted for approval at the design review.

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.

The Contractor shall submit for Customer approval the types of materials and their respective locations to be used in the components of the carbody.

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. At a minimum, each element shall include a drain hole.

4.3.4 Carbody Exterior Finish

Specifications and samples for all external surfaces shall be submitted for review and approval.

Stainless steel carshells shall be unpainted, except as specified for exterior graphics. Side sheets shall have a horizontal, 36 grit sanded finish. End sheets shall have a vertical, 36 grit sanded finish. All sanded surfaces shall have the same finish whether applied by hand or machine. Corrugated stainless steel shall have a 2B finish. 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.

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. and 0.0625 in. over a distance of 36 in. and 12 in., respectively, on the sides of the car and 0.1875 in. and 0.125 in. over a distance of 36 in. and 12 in., respectively, on the roof. The slope of any such deviation shall not exceed 0.1875 in. in 12 in. Dents, gashes or other surface imperfections shall not be permitted.
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:

- All exterior side and roof surfaces not hidden by covers or shrouds shall have a maximum 0.09375 in. variation (peak to valley) in 3 ft measured in any direction.
- Areas within 8 in. 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. from the side sheet contour.
- Exterior surfaces hidden by covers and shrouds shall have a maximum 0.3125 in. variation (peak to valley) in 3 ft measured in any direction.

4.3.5 Fabrication

The carbody structure shall be assembled by welding. Connections of LAHT 0.125 in. 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. Refer to Chapter 18 for structural welding practices.

Where the carbody structure must be assembled with mechanical fasteners, the fasteners shall be high-strength lock-bolts.

All weld, bolt patterns and bonds shall be identical on all cars, to the maximum extent practical.

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.

Sheet metal screws and self-tapping screws shall not be used to attach access panels or other frequently removed items.

Rivets, blind rivets and lock-bolts shall be set with power tools.

All holes for mechanical fasteners shall be clean and free of burrs.

Adequate drainage shall be provided in all body structure members. Enclosed structural cavities shall be vented to prevent condensate build up. Any enclosed structural cavities of steel members shall be treated with a rust-inhibiting coating as specified in Chapter 18.

The proposed construction tolerances of the finished vehicle shall be submitted for review and approval.

Where used, shims shall be permanently attached to the carbody structure.

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.

All bolts supplied shall be a minimum SAE J429, Grade 5, or approved equivalent, including markings. All nuts shall be per SAE J995 and shall match the strength of the bolts.
Tapping plates may be used if approved by the Customer, 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.

Intermittent fillet welds on tension members, or in the areas that experience fatigue are prohibited. Plug or slot welds on tension members, or in areas that experience fatigue are prohibited. 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.

4.4 Structural Design Details

4.4.1 Level

The difference in height Above Top of Rail (ATOR) of the four corners of the finished car shall not exceed 0.375 in. 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.

4.4.2 Camber

Carbody camber shall be defined as its vertical curved shape as viewed in side elevation, and shall be a smooth arc from end-to-end of the carbody. Camber shall be measured from a datum line drawn between the intersections of the arc with the centerline of the body bolsters to a line tangent to the arc midway between bolsters.

The car shall have a positive camber not to exceed 0.5 in. 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 maximum difference between the cambers of each side sill, measured at the location of maximum deflection, shall not exceed 0.125 in. The Contractor shall evaluate and submit camber values at AW0, AW1 and AW3 load for approval at the design review.

4.4.3 Carbody Strength

The strength of the carbody shall equal or exceed the requirements of 49CFR Part 238, Subpart C and APTA Standard SS-C&S-034-99. In addition, the carbody shall be designed with CEM features as specified herein.

The carbody structure shall be designed to absorb kinetic energy as specified to minimize passenger accelerations and preserve occupant volume.
4.4.3.1 Fatigue

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.

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.

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.

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 Customer.

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.

The dynamic factor shall be determined by the Contractor and shall not be less than 20%. The fatigue design shall be based on applied and allowable fatigue stress ranges at 10 million cycles.

4.4.4 Underframe Structure

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 or LAHT, except the end underframe which shall be constructed of LAHT steel.

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.
4.4.4.1 End underframe

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.

The coupler and draft gear carriers shall be included in the assembly. The end underframe shall be constructed of LAHT steel.

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. All welds in the end underframe assembly, where 100% penetration is desired, shall be non-destructively tested in conformance with AWS.

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.

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 Customer, 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.

If heat treatment is required for stress relief, the assemblies shall be heat treated after welding in accordance with AWS Standard D1.1.

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.

4.4.4.2 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.

4.4.4.3 Anti-climbing mechanism

The carbody design shall provide an anti-climbing arrangement at each end of each car designed in accordance with 49CFR Section 238.205 and Section 5.5 of APTA Standard SS-C&S-034-99. The analysis of the anti-climbing mechanism shall include an analysis of the attachment of the coupler/draft gear and draft gear carrier plate to the underframe.
4.4.4.4  Coupler carrier

A coupler carrier shall be provided as part of each end underframe assembly, and shall be
designed in accordance with the requirements of 49CFR Section 238.207 and Chapter 6. The
coupler carrier, and those portions of the carbody to which it is attached, shall 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.

4.4.4.5  Body bolster

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 bolster to limit the vertical and transverse
movement of suspended trucks when the carbody is lifted. The stops shall comply with APTA
Standard SS-C&S-008, Section 5.0.

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.

4.4.4.6  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. The draft sill shall be compatible with the CEM
design.

4.4.4.7  Side sill

Side sills shall be provided on both sides of the car and form a structurally continuous bottom
chord for the side frame.

4.4.4.8  Cross bearers, floor beams and floor pans

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.

A stainless steel floor pan shall be provided underneath the lower floor throughout the length
and width of the car and in the equipment room. 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 Customer. Between the carbody bolsters, the floor pan shall be
attached to the above mentioned members in a manner to allow for easy replacement of
damaged panels 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 moisture, dirt, dust and debris entry into the sub-floor for the life of the vehicle and shall be approved by the Customer.

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.

### 4.4.4.9 Subfloor and floor system

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 (to a maximum of 60 in. longitudinally and the car interior width laterally), shall not form part of the vehicle shell structural strength and shall have no joints in the doorways. To the extent possible, floor panels shall be interchangeable throughout the vehicle and between vehicles.

Under a dead load and a maximum passenger loading of AW3, the floor panels shall deflect by no more than 1/360 of the short span between members, up to a maximum of 0.0625 of an inch, without permanent deformation. Floor panels shall be attached to the carbody structure using an approved fastener system.

Plymetal panels 0.75 in. thick with butt joints shall be used for the floor. The sub-floor shall be aluminum honeycomb core or phenolic composite panels 0.75 in. thick. These panels will be constructed in a “clean room” to ensure adequate assembly quality and panel strength. The insulation core on each panel will be tested for dryness prior to hot pressing to insure proper bonding. Prior to installation each panel will undergo a thorough inspection to determine that no delamination has occurred. All exposed edges shall be waterproofed and sealed.

The honeycomb sub-floor and its attachments to adjacent structural members shall be capable of resisting the shear resulting from the specified compression loading without permanent deformation. All joints shall lie on supporting structure. The ends of the panel shall be sealed against moisture. Anti-squeak tape shall be applied between floor panels and supporting structure.

One-eighth inch elastomeric anti-squeak tape shall be applied between floor panels and supporting structure. Panels shall be attached to floor structure using approved flathead fasteners in formed countersunk holes. The floor material shall have shear strength not less than 400 pounds per square inch (psi) and shall be capable of passing ASTM E119 fire test. Tapping plates for above-floor equipment shall be suitably attached. Carpeting or composite floor covering, where specified, shall be installed over the top of the floor panel system.

### 4.4.5 End Frames

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. 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 Standard SS-C&S-034-99.
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.

The A and B-end sheets shall be of the same material as the side sheets and be securely framed to the car structure.

The F-end sheet on the cab/baggage car shall provide projective resistance equal to or greater than that specified for FRA Part 223 Type I glazing where adjacent to the cab control compartment.

The end sheets shall be of the same material as the side sheets and securely framed to the car structure.

4.4.5.1 Collision posts

The car end structures shall be provided with vertical collision posts 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.

The collision posts shall be continuous closed sections from the bottom of the end sill to the top of the roof.

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.

At a minimum, the cab end reinforcement shall be continuous from the bottom of the end sill up to at least 30 in. above the top of the underframe, then gradually taper to a point not less than 42 in. 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. and then taper to a point at 30 in. 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.

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.

Structural energy absorption capacity of the collision post and connecting structure as per the requirements of APTA Standard SS-C&S-034-99, Rev 2 shall be designed into the structure and shall be demonstrated to the satisfaction of the Customer. Compliance may be demonstrated as per Appendix F of 49CFR part 238, if approved by the Customer.

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.
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 Customer 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.

Lifting eyes shall be installed at the extreme top edge of each collision post.

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.

The stress analysis as required shall include an analysis of the collision posts and corner posts together with their connections and supporting structure.

4.4.5.2 Corner post

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.

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.

Structural energy absorption capacity of the corner post and connecting structure as per the requirements of APTA Standard SS-C&S-034-99, Rev 2 shall be designed into the structure and shall be demonstrated to the satisfaction of the Customer. Alternately, compliance may be demonstrated as per Appendix F of 49CFR Part 238, if approved by the Customer.

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.

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.

4.4.5.3 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.
4.4.6 Side Structure

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.

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 Standard SS-C&S-034-99 and shall comply with the requirements of 49CFR Section 238.217.

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.

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.

4.4.6.1 Side sheets

All the exterior surfaces of the carbody shall be stainless steel or LAHT steel. The required appearance of exposed welds shall be as described in Chapter 18. Three samples of all exterior finishes shall be submitted to the Customer for approval. 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.

Side sheathing shall be resistance spot welded to the outside of the side frame posts between the side sill and the roof. Smooth side sheets shall be stiffened by corrugations or similar sections resistance welded to the inside face of the side sheet. Weld spacing shall be in accordance to Chapter 18. Flat side sheathing shall be a minimum of 0.059 in. thick. Sheets under the windows, if corrugated, shall be of 0.042 in. thickness.

Horizontal lap joints shall be permitted where flat side sheets are connected to corrugated side sheets provided the direction of the joint sheds water and the joint is seam welded.

The ends of corrugations shall be permanently sealed against air and water by capping or controlled crushing. Additionally, they must be sealed with an approved sealing compound. Samples of the method must be submitted for approval at the design review, and maintained until notified otherwise by the Customer.

Side sheets below the windows shall be continuous sheets or longitudinal corrugated sections running the entire length of the car.
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.

Smooth side sheets stiffened with corrugations welded to the hidden surface shall be provided in the window area. All exterior surfaces shall be free of ripples and buckling. Flatness standards previously defined shall be met.

There shall be no less than two spot welds per node of corrugation or where attaching corrugated panels to framing members.

4.4.7 Roof

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.

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.

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 soldering. Horizontal lap joints shall be permitted where flat side sheets are connected to corrugated side sheets provided the direction of the joint sheds water and the joint is seam welded. No 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.

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.

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:

- Three concentrated loads of 250 lbs spaced 30 in. apart, each applied over a 3 in. by 3 in. area, such as might be applied by maintenance personnel working on the roof. The placement of the loads shall be such as to produce the worst-case condition for the roof structure without exceeding the yield strength, 80% of ultimate strength and critical buckling and,
- Meet the rollover strength requirement defined in 49CFR Section 238.215.
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.

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.

4.4.7.1 Emergency access “cut zone”

Roof emergency access shall be in accordance with FRA 49CFR Section 238.123 and APTA Recommended Practice RP-C&S-001-98. 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 Standard SS-PS-002-98.

4.4.7.2 Gutters and deflecting plates

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 when the car is stopped. Gutters shall also deflect water off the entire end of the car.

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.

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.

Alternative gutter designs that meet the Specification requirements shall require approval of the Customer.

4.4.8 Jacking Pads

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.

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.

The jack pads shall be a minimum of 32 in. ATOR. The jack pads shall be 8 in. wide and 5 in. deep (width is parallel to car’s side sheet) with a suitable surface to avoid slippage. The pads shall extend 0.50 in. to 1 in. below the bottom of the side sill.

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 0.50 in. below the bottom of the side sill.

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.

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.

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.

### 4.4.9 Lifting Eyes

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 and designs shall be submitted to the Customer for approval during the design review of the car. 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.

The collision post lifting area may have a suitable removable cover sealed to prevent ingress of water. It shall not require special tools to remove the cover.

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.

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:

- Car upright
- Car lying on left hand side
- Car lying on right hand side

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.

### 4.5 Truck–to-Carbody Attachment

An approved truck safety mechanism and truck rotation stops shall be provided in accordance with 49 CFR Section 238.219 and APTA Standard SS-C&S-034-99.

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.
Distance between truck centers shall be 59 ft 6 in.

### 4.6 Bolster Anchor Rods and Brackets

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.

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.

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.

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.

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.

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 Customer.

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.

### 4.7 Doorways and Passageways

#### 4.7.1 Side Doorway Framing – Coach Cars

All doorways shall be in accordance with 49CFR Section 38.93. All coach 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- and low-level boarding at these four side door locations.
Carbody

- Two baggage doors (one per side) at an appropriate intermediate location, with high-level access only.

Location and dimensions of these doorway frames shall be in accordance with Chapter 1. The actual number of doors desired at the above six framed locations will be a Customer 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.

4.7.2 Side Doorway Framing – Cab Cars

All doorways shall be in accordance with 49CFR Section 38.93. All cab cars shall be structurally framed to allow:

- Two sets of side passenger entry doorways (one per side) at the non-cab end of the cars. This framing shall permit high- and low-level boarding at these two side door locations.
- Two sets of side crew entry doorways (one per side) at the cab end of the cars, outboard of the trucks. This framing shall accommodate only high-level boarding, with ladder access from the lower-level.
- Two baggage doors (one per side) at an appropriate intermediate location, with high-level access only.

Location and dimensions of these doorways shall be in accordance with Chapter 8. The actual number of doors desired at the above six framed locations will be a Customer 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.

4.7.3 Carbody End Doorways

Each coach 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. 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.

4.7.4 Passageways

All passageways shall be in accordance with 49CFR Section 38.93. The passageways shall have a minimum width of 32 in. and shall allow for the passage of food service carts and wheelchairs between cars under nominal operating conditions.

4.8 Diaphragm

A non-metallic modular, maintainable diaphragm shall be provided at each end of each 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 Customer during design review.
Easily replaceable wear plates shall be provided on diaphragm faceplates. A minimum clear horizontal opening of 32 in. through the diaphragm parallel to the end door panel shall be provided when the car is at rest on level tangent track.

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.

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.

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.

Retractable curtains with restraining devices shall be provided on either side in the diaphragm passage. The curtains shall be directly interchangeable, without adapters, with existing curtains on single-level equipment identified in Chapter 1, and shall include an "automatic retraction or break away” feature. Diaphragm size, arrangement and installation shall be compatible with other single-level equipment as required.

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.

4.9 F-End Pilot

A pilot which meets the requirements of 49CFR Section 229.123 shall be provided at the F-end of the cab car. See Chapter 16 for details.

4.10 Safety Appliances

4.10.1 Exterior

Railroad safety appliances shall be in accordance with 49CFR Part 238 and/or 49CFR Part 231. The Contractor shall be responsible for obtaining from the FRA a determination of compliance with all applicable FRA safety appliance regulations. All car types should have the same safety appliances.

Handrails shall be provided on the exterior of the carbody on each side of each entrance doors to assist passengers when boarding or alighting from the car. Design and assembly of handholds and handrails shall be submitted to the Customer for review and approval at the design review.

Sill steps shall be provided near each end on each side of the car.

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 Customer approval.
End handholds shall be provided near each side on each end of the car.

Suitable warning signs shall be provided where appropriate.

All safety appliances shall be within the specified clearance envelope.

The Contractor shall arrange for an FRA sample car inspection of the safety appliance applications and shall provide the Customer with a copy of the FRA “no exceptions taken” letter prior to release of the first car of each type.

4.10.2 Interior Passenger Grab Handles

Passenger grab handles shall be provided as follows:

- At the side of the entrance area to allow crew to stand safely in the open doorway; and
- 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 Mobility Aid Accessibility

4.11.1 Wheelchair Lift

The structure of the carbody shall be designed to accommodate two permanently mounted powered wheelchair lifts, one for each side of the car located adjacent to the B-end side doors. The performance requirements for these wheelchair lifts are defined in Chapter 9.

4.12 Underfloor Equipment, Equipment Rooms and Access Doors

The high-speed intercity nature of Amtrak 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 outboard 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.

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 equipment boxes and mounting supports shall meet the requirements of APTA Standard SS-C&S-034-99.

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.

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.

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.

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.

No apparatus over 25 lbs shall be supported by bolts in tension. The Contractor may submit to the Customer, 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. in 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.

Bolted connections shall be designed with a factor of safety of 1.5 using bolts of not less than 0.375 of an inch 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.

Final dimensions and arrangement of all equipment compartment accesses shall be subject to approval by the Customer.

4.12.1 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.

4.12.2 Equipment Boxes

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.
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. 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.

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.

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. clearance from interior surfaces of enclosures or covers.

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.

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.

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 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 Customer. 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.
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.

All covers more than 3 ft 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. All gaskets shall be of a closed cell elastomeric material that will insure 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.

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. 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 Customer approved, simple drain clearing mechanisms.

Each cover shall have the car number stenciled in black paint in 2 in. high numerals at the top left inside corner of the cover.

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

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.

Glazing assembly (frame, rubber and glazing material) shall not leak during carbody water tests. The glazing material shall show no physical damage or degradation of optical qualities when exposed to the environment encountered in rail passenger service.

Construction shall be a double-glazed side window with the exterior light to be tinted laminated safety glass, and the inner light to be untinted.

All glazing assemblies shall meet all applicable requirements of 49CFR Part 223. They shall meet any applicable APTA requirements.
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.

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.

### 4.13.1 Glazing Materials

Glazing material shall conform to the requirements specified in Chapter 18.

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.

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.

Markings are to be in accordance with current ANSI Standard Z26.1 and 49CFR Part 223. Location of these markings must be visible for identification after installation.

### 4.13.2 Side Windows

Side windows shall conform to the requirements specified in Chapter 18.

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. Aluminum tape shall be applied to the perimeter of the glazing assembly.

The window frames shall be extruded aluminum 6063-T5 alloy. The carbody side of the window opening shall be reinforced to keep the opening flat.

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.

The window opening in the carbody shall be reinforced to keep the opening flat. A leak proof seal shall be provided.

### 4.13.2.1 Emergency side windows

A two part "Emergency" handle shall be provided at designated "Emergency" windows for removal of the window from inside of the car. 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.
4.13.2.2 Rescue access windows

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.

Identification and removal instructions shall be provided in accordance with 49CFR Part 223, 49CFR Section 238.114, APTA Standard SS-PS-002-98 and ASTM Standard D 4956-07 for Type I material sheeting.

4.14 Insulation

4.14.1 Acoustical Insulation

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). 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.

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.

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:

- 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.
- 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. The compound shall be applied wet to the supplier’s recommended thickness.
- Structural members under the floor of the carbody shall not be coated.
- 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. The compound shall be applied wet to the supplier’s recommended thickness.
- Duct splitters (if used) shall not be coated.
• The underside of the main air duct, top/bottom of floor beams and inside door pockets shall not be coated.

4.14.2 Thermal Insulation

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 1200 Btu/Hr/°F under the environmental conditions specified in Amtrak specification 963 while carbody is stationary. Contractor to supply thermal analysis of completed car for approval at the design review.

As much as practicable insulation shall have an acoustic barrier and shall not settle in long service under vibrating conditions.

The roof insulation shall be retained by insulation pins of the same metal as the car structure attached to the carlines. Side and end wall insulation shall be retained by insulation pins. On the inside of the end and side powered door pockets the insulation shall be retained by stainless steel sheets.

Side wall insulation located near heater assemblies shall be metal-backed with metal side facing the heater.

A vapor barrier shall be provided between all interior linings and the carbody insulation.

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.

4.15 Exterior Finish

Generally the stainless steel car exterior will not be painted, however some painting shall be required for aesthetic as well as branding purposes. Refer to the Customer exterior graphics requirements, as specified in Chapter 23 for details.

Painting of the car serves two primary purposes: 1) to protect the metal 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.

Soon after fabrication, all carbon steel portions of the carbody shall be prepared for painting and immediately thereafter painted with the first coat of primer, utilizing the paint supplier’s written procedures with trained technicians.

The surface preparation and graphics applications shall ensure that the car can operate at least eight years between major exterior finish repairs or replacement.

All exterior surface treatment plans and specifications shall be submitted to the Customer for review and approval.
4.15.1 Painting-Exterior

The carbody exterior shall be painted in accordance with the Customer instructions as specified in Chapter 18 and Chapter 23.

Care in painting application shall ensure freedom from runs, sags, orange peel and other unsightly paint deficiencies, utilizing the paint supplier's written procedures with trained technicians.

4.15.2 Post Painting

Allow the car to remain inside for a minimum of 8 hours unless outside temperatures are above 60°F, utilizing the paint suppliers written procedures with trained technicians.

4.16 Graphics and Labels

4.16.1 Exterior Graphics

All exterior graphics, lettering and signage, including vehicle numbers and reporting marks, shall be applied to the vehicle in accordance with Customer specifications as identified in Chapter 23.

4.16.2 Labels

Exterior equipment shall be labeled in accordance with Amtrak Specification 696.

4.17 Automatic Equipment Identification (AEI) Tags

Each car shall be equipped with an Automatic Equipment Identification (AEI) transponder tag on each side, located in conformance with Universal Machine Language Equipment Register (UMLER) dimensional and securement requirements and programmed with the reporting marks of the owner, road number of the vehicle and all other technical data required by UMLER.

The Contractor is responsible for ensuring the following:

- Tags are properly installed in accordance with UMLER requirements;
- Tags are properly programmed with all data required by UMLER; and
- The UMLER system is updated with the data for each vehicle as required for shipment.
4.18 Summary of Load Cases for Structural Design Requirements

The following load conditions must meet the requirements as stated in this Specification, as well as those identified in CFR and APTA:

- Fatigue
- Side structure load
- Floor load
- Roof load
- Jack pad loads
- Jacking loads
- Lifting loads
- Anchor rod loads
- Anchor rod bracket loads

Where there is a conflict between this Specification, Federal requirements and APTA standards the Federal requirements shall prevail, then the APTA standards and then this Specification.

4.19 Stress Analyses

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 in accordance with APTA Standard SS-C&S-034-99, Section 7.0. Stress analyses for supports for safety related items weighing less than 150 lbs shall be included in the analysis. For non-safety related items, stress analysis may be requested for review at the discretion of the Customer.

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.

The approved stress analyses, including crashworthiness analysis, shall be a prerequisite for approval of the structural test procedures and structural drawings required by this Specification and shall be used as an aid in determining strain gauge locations during the tests.

The stress analyses shall indicate the calculated and allowable stresses and margins of safety for all elements, for all specified load conditions. The stress analyses shall, as a minimum, include Finite Element Analyses (FEA) using recognized computer programs, supplemented as necessary by manual or computer calculations of stresses at joints.

The initial stress analyses shall require assumptions as to configurations, weights, and the method of manufacture. All of which may require re-evaluation and change as the designs are developed. As changes are made to the original assumptions, the stress analyses shall be
revised and submitted for review. The final submitted and approved stress analyses shall be for the car and truck in the as-built configuration.

All stress analysis reports shall conform to the requirements specified herein.

The meanings described in the following section shall apply in performing the analyses.

Permanent Deformation — A member shall be considered as having developed permanent deformation if any one of the following conditions is met:

- The minimum yield strength as published by ASTM for the specified material and grade is exceeded. For materials or grades not covered by an ASTM 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.
- The material has buckled or deformed and does not return to its original shape or position after the load is released.

Ultimate Load Carrying Capacity — The ultimate load carrying capacity of a member is the maximum load that the member can support before it separates at its ultimate strength or completely fails as a column.

Margin of Safety (MS):

$$MS = \frac{\text{Allowable Stress}}{\text{Calculated Stress}} - 1$$

The calculated stress shall include the applicable load factors. MS shall be a minimum value but a positive number.

Load Factor — Load factor is 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.

4.19.1 Stress Analyses and Test Plan

A Carbody and Truck Stress Analysis and Test Plan shall be submitted for approval no later than 120 days after NTP. The Plan shall address the requirements of Section 6.0 of APTA Standard SS-C&S-034-99, Rev. 2 regarding a CEM and Survivability Plan. It 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 no more frequently than monthly. Each revision shall include revision level indications.

The Stress Analyses and Tests 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:

- A listing of all load conditions to be used during analysis and test, including load magnitudes and points of application, with Specification references.
- A description of the analysis to be used for each load condition.
- Acceptance criteria for each load condition.
Diagrams displaying loads applied externally to the carbody and truck and points of support for each load case for each analysis.

Diagrams displaying loads applied externally to the carbody and truck and points of support for each load case for each test.

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.

A description of all the major assumptions used in the stress analyses.

A description of how analyses results shall be correlated with test results.

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.

A list of all structural tests to be conducted on carbody and truck along with acceptance criteria.

Diagrams displaying all boundary conditions including symmetry and asymmetry boundary conditions.

An introduction page referencing all the related stress analysis documents to be submitted.

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.

4.19.2 Finite Element Model Report

The Contractor shall submit Preliminary and Final reports outlining the FEA work. Solid elements shall be used for major structural areas of the truck frame and bolster.

The element mesh, all assumptions, loads, boundary conditions summed totals of reactions forces and moments, area properties and material properties, and units used shall be included as part of the preliminary submittal and again as part of the complete report. A key to all symbols and colors shall be included. Boundary reaction forces of the carbody and truck at AW0 shall be included. Each load condition submittal thereafter shall also include diagrams of areas of mesh refinement.

The FEM Report 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 APTA Standard SS-C&S-034-99, Rev. 2, Section 7.2. 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.

The FEM Report shall include a list of drawings, with revision levels, used to develop the model. As drawings are revised, the 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.

4.19.3 Carbody and Truck Stress Analyses

The stress analysis shall show the calculated and allowable stresses and Margins of Safety for all elements, for all specified load conditions.

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.

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.

4.19.3.1 Finite element analysis

As part of the stress analysis, a linear-static finite element analysis (FEA) of the complete carbody and truck shall be performed. 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.

The submittal input and output shall have each page numbered and columns of data shall be clearly labeled on each page using terms, symbols, abbreviations, and units defined in the analysis report.

At the discretion of the Customer, Finite Element Models (FEM) and results shall be reviewed during the conferences conducted within three weeks after each submittal.

Color plots shall be prepared showing the following:

- Deflections in all three axes
- Von Mises or other approved combination stresses
- Maximum and minimum principal stresses
- Direction of maximum and minimum principal stresses
- Meshing accuracy index
- Maximum shear stress
All plots shall show the maximum and minimum values and all values which are greater than 80% of the specified maximum value. Each drawing or plot shall include a triad showing the direction of the global axes. Plots at high magnification shall be keyed to a plot showing the structure to an extent sufficient to orient the high-magnification plots.

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.

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.

4.19.3.2 Connections

The Report shall include analyses of all critical connections of major structural elements under all specified load conditions.

Critical connections which cannot be adequately analyzed shall be prototyped and tested to demonstrate compliance with the requirements of the design and the Specification.

The Report shall include analyses of all critical and highly loaded connections, showing that the joint is stronger than the weakest member being joined.

The FEA shall be supplemented as necessary by manual or computer calculations of stresses at joints.

4.19.3.3 Buckling

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.

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.

4.19.3.4 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.

4.19.3.5 Fatigue

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.
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 Customer:

- For carbon and low alloy steel members, the stress range shall be obtained from AWS Standard D1.1.
- 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.
- 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.
- The Contractor shall conduct fatigue tests to determine allowable fatigue stresses for materials or joint designs not covered by the above requirements.

The fatigue stress range and acceptance criterion for the trucks is detailed in Chapter 5 and Chapter 19.

The fatigue analysis section of the stress analysis report shall include table(s) showing the minimum static and fatigue strengths of single and multiple spot welds. Values shall be given for each material, temper, weld size and thickness combination used in the carbody. The source of the data shall be provided.

4.19.3.6 Manual analysis

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, Rev. 2, Section 7.3. 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.

The following are examples of stress calculations for which manual analysis may be used:

- An analysis of the critical connections of the major structural elements and the critical loading conditions
- An analysis of the strength of the connections of the trucks to the carbody including calculated vertical and horizontal connection load limits
- An analysis of the truck equalizer beams
- An analysis of the axles
- An analysis of the coil springs
- An analysis of primary and secondary suspension
- An analysis of equipment hangers
Validation of Stress Analyses

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.

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.

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, the analytical stress value, the percent difference between the two values, and a space for annotation. The report shall include a graph plotted in MS Excel comparing the stresses calculated from test strain gauge readings with analytical stresses from FEA.

The percent difference between the two values shall be within 20% for 75% of the compared values of the test results and analytical results.

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.

For any of the remaining 25% of the compared values, if the analytical values disagree with the test value by more than 20% and the test value is equal to or greater than 35% of the yield strength of the material, a detailed explanation of the reasons for the excessive variance shall be included in the carbody and truck test report. This explanation may include supporting manual calculations.

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.

Stress Analysis Report

The Stress Analysis Report shall be prepared and submitted for review and approval not later than 60 calendar days prior to commencing manufacture of any carbody and truck structural parts. 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 Customer, 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.

The report shall demonstrate that all structural members satisfy the requirements of this Specification on 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 Customer 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 Customer.

A summary of the results of calculations of stresses in all structural framing members and shear panels 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.

The report shall include detailed calculations of stresses with Margins of Safety (MS) in all structural framing members and sheathing. 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:

- The identity of the member
- Its location
- The load condition
- The MS
- The page on which the analysis can be found
- The material of that member
- The allowable stress of the members

In addition to the body of the analysis, the stress analysis report shall include, at a minimum, the following:

- A Table of Contents
- 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.
- Units with all quantities.
- 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.
- Each page, including all stress analysis sheets, shall be numbered, 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.
- Particular reference to, but not limited to, the following:
  - Side sill
  - Body sills (if used)
  - End sill
  - Anti-climber
  - Draft sills
  - Coupler supports
  - Side frame rails
  - Side frame posts
• Transverse and longitudinal sections at doorways
• Body bolster
• Floor and floor beams
• Collision posts
• Corner posts
• Structural shelf
• Roof structure
• Equipment supports
• Connections between structural elements
• Truck frame
• Truck bolster
• Truck equalizer beam
• Axle
• Bolster anchor rod and bracket
• Pilot
• Truck and attachment

• 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.

• A table listing and defining all symbols and abbreviations used in any analysis shall be included.

• 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.

• 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 Crash Energy Management (CEM) Design

The carbody shall be designed with Crash Energy Management (CEM) following the guidelines in APTA Standard SS-C&S-34-99, Section 6 Crash Energy Management (CEM). Scenario analysis as described in APTA Standard SS-C&S-034-99 shall not be required.

A CEM and Collision Survivability Plan shall be submitted to the Customer for review and approval in accordance with APTA Standard SS-C&S-034-99, Section 6.2.
4.20.1 Protected Operator Cab Space

In addition to APTA Standard SS-C&S-034-99, the cab shall be designed with a protected operator cab space for the Engineer’s and Assistant’s cab control compartment.

![Figure 4-1: Operator Seat Clearance Zone](image)

For the Cab Car Interaction Evaluation required by this Specification, at the point when the design energy absorption has been reached, each seat in the operator compartment shall have a survivable space where there is no intrusion, and there shall be a clear exit path for the cab occupants. The clear exit path shall be free of debris, obstructions, deformed panels or hazards, and the cab door shall function as an exit path without hindrance.

The protected operator cab space shall be maintained at a minimum of 30 in. in length, 30 in. in width, and 63 in. in height. The outboard plane of the protected operator cab space shall be 12 in. from the front surface of the operator seat adjusted to its median fore and aft position. The outboard side of the protected operator cab space shall be at the lateral extremity of the seat defined by the side arm rest adjacent to the side wall of the carbody. The cab console may extend into the protected operator cab space as necessary for satisfactory ergonomics, but shall remain upright and at the same distance from the mounting of the operator seat to the floor throughout crushing.

The deformation of the structure shall not cause any vehicle equipment or parts (e.g. console, window screens, etc.) to encroach into the designated survival spaces. The structure immediately outboard the Operator’s survival space shall be designed in a manner that does not create sharp-edged fracture surfaces, crippled structural members with sharp bends and similar injurious features.

The front windscreen shall be supported by the structure of the Operator’s cab in a manner that resists the windscreen as a whole, whether or not damaged, moving into the Operator’s survival space. Operation of the cab end CEM system to exhaustion shall not result in any condition that interferes with ready egress from the cab. The seat attachment shall meet the requirement of APTA Standard SS-C&S-011-99.
4.20.2 Sequence of Operation of CEM Functions

The sequence of operation of the CEM functions shall be as follows for the condition of a cab car colliding with a locomotive. Approved equal functions and sequences will be considered subject to demonstration of satisfactory performance resulting from the application of the design, analysis, and testing requirements of this Specification.

- Coupling mechanisms of cab car and locomotive contact,
- Coupling mechanism initiates energy absorption,
- Structure(s) involved in principal load path engage,
- Crush elements initiate, and
- Crush zone operates to extent necessary to absorb required energy.

The sequence at coupled-car interfaces is the same except that the initial condition is with couplers mated.

The coupling mechanisms shall meet the requirements in Chapter 6.

4.20.3 Cab Car Interaction Evaluation

The cab end shall be analyzed to show that during a collision with the standard FRA collision-simulation locomotive, the geometry of which can be found on the Volpe website listed in Chapter 2. The ends of the vehicles shall engage and the sequence of operation of the CEM function as stated in Sequence of Operation of CEM Function (above), and all requirements within this Chapter shall be met, including the protected operator's space, energy absorption of the cab end and the acceptance criteria. (See Cab End Crush Zone, Non-cab Crush Zone, Analysis of Pass Volume Strength).

In addition, compliance with the requirements of this chapter at a coupled interface of a cab end with a non-cab end, and with another cab end shall be demonstrated by test and analysis as required by the Plan and this specification.

4.20.4 Cab End Crush Zone

Requirements for energy absorption at each cab end is as follows:

- Not less than 2,000,000 ft-lbf including coupling mechanism energy absorption
- Length of plastic deformation by crushing shall not exceed 24 in.
- For crush zone, best-fit straight line approximation of crush load vs. crush distance data has zero or positive slope
- Trigger, frangible, and fuse elements shall be designed to not interfere with operation of the crush zone

Contractor shall submit the force-crush characteristic curves for the actual car design to the Customer for review and approval.
4.20.5 Non-cab End Crush Zone

Requirements for energy absorption at each non-cab end is as follows:

- Not less than 1,500,000 ft-lbf, including coupling mechanism energy absorption
- Length of plastic deformation by crushing shall not exceed 24 in.
- For coupler and crush zone, best-fit straight line approximation of crush load vs. crush distance data has zero or positive slope
- Trigger, frangible, and fuse elements shall be designed to not interfere with operation of the crush zone

Contractor shall submit the force-crush characteristic curves for the actual car design to the Engineer for review and approval.

4.20.6 Analysis of Passenger Volume Strength

For the length carbody structure occupied by passengers, stresses shall not exceed yield under the action of loads applied by the crush zone to exhaustion.

Highly localized areas of stress exceeding yield (“hotspots”) may be permitted provided:

- Plastic analysis of the model shows the affected areas to be small with plastic strain not exceeding 1%;
- With removal of the simulated load there is no permanent set in the overall dimension of the occupant volume; and
- The function of the structure is not compromised.

4.20.7 CEM System Validation, Analysis, and Testing

CEM system design validation shall be provided according to separate CEM System Tests Plan and CEM System Analyses Plan that shall be integrated into the Carbody and Truck Tests and Analyses Plan. The CEM System Tests Plan shall include as a minimum the tests included in Chapter 19 and the CEM System Test Matrix shown in Chapter 19. The CEM System Analyses Plan shall include as a minimum the analyses included in Chapter 19.

Validation of the analysis models shall be by testing of crush elements and fuse elements. The validated models of these elements shall be assembled into a model of the crush zone on the end of the car. The assembled model shall be used to perform a full 3D explicit analysis of the car (flat wall for coaches, into a locomotive for cabs) to prove compliance with this specification.

Full scale whole car testing will not be required. Also, elements previously validated may be used as-is without re-test.

* End of Chapter 4 *
Standardized Technical Specification

PRIIA 305 Next-Generation Equipment Committee
Single-Level Passenger Rail Cars

Chapter 5
Trucks
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5.0 Trucks

5.1 Overview

Each car shall be equipped with two four-wheel trucks. Trucks shall be designed for operation at all speeds up to 125 mph. 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.

5.2 General Requirements

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 Customer) and instrumented testing at an approved test track facility. The car must meet the requirements of 49CFR Section 213.329 (c) and (d) and 49CFR 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. of cant deficiency. Overall curving performance shall be demonstrated to be at least as good as the existing Viewliner type rail car at maximum design speeds over a range of curvatures in comparative testing.

Truck wheelbase shall be 8 ft 6 in. Truck centers shall be spaced 59 ft 6 in. apart, equal distance from the car's lateral center line. Trucks shall be designed to operate under the environmental and operating conditions identified in Amtrak Specification 963, including track configurations. All truck-mounted equipment shall conform to the clearance requirements of Amtrak's Single-Level Standard Clearance Drawing D-05-1355, Rev. E. 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.

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.

Unsprung mass (between the track and the primary suspension) shall be as low as practical.

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 Section 238.219 and APTA Standard SS-C&S-008-98. 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 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. 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.

Provisions shall be made for use of a 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.)

All truck assembly parts shall be designed to withstand maximum stresses as called out in APTA Recommended Practice RP-M-009-98. See Chapter 19 for stress analysis requirements.

Truck components shall be designed to have sufficient clearance but no less than 1.0 in. 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.

**5.3 Ride Quality and Performance**

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 Customer. Some or all portions of the required design validation tests may be waived at the sole discretion of the Customer if design adequacy can be proven by submittal of existing engineering analysis and demonstration of successful service history of the truck design.

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 0.032g and a crest factor less than 9. Weighted rms acceleration and crest factors shall be calculated according to ISO 2631.

**5.4 Truck Design**

**5.4.1 Truck Frame**

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. Critical areas of all welds and castings shall be magnetic-particle inspected per ASTM E709-01, radio-graphically inspected per ASTM E94-04 or ultrasonically inspected per AWS D.1.1.

Rotational 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.

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.

This truck design shall provide sufficient restraints to prevent hunting of the truck at all speeds up to 125 mph, with worn wheels and other components at their condemning wear
limits, in accordance with 49CFR Section 213.333, 49CFR Section 238.227 and APTA Recommended Practice RP-M-009-98.

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.

A centering bearing or pivot shall be located between the truck bolster and the truck frame at its center.

5.4.2 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 Amtrak Specification 963. At the Customer’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.

5.4.3 Suspension

Primary and secondary suspension arrangements must be of proven arrangement for application on a single-level car.

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 five 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.

At the Customer’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 Customer’s request, yaw dampers may be proposed in lieu of the anchor rods for damping swiveling motion.
Vertical $P_2$ forces shall not exceed 68,000 lbs with a $1^\circ$ dip angle using the Esveld equation.

\[ P_2 = P_0 + 2\alpha \sqrt{\frac{m_u}{m_u + m_{T2}}} \left[ 1 - \frac{c_T \pi}{\sqrt{k_{T2}(m_u + m_{T2})}} \right] \sqrt{k_{T2} m_u} \]

Esveld Equation:

The parameters in the $P_2$ force calculation are:

- $P_0$ is the nominal static vertical wheel load (pounds)
- $2\alpha$ is the total dip angle at a joint, weld dip or other rail discontinuity (radians)
- $v$ is the speed (inches/sec)
- $m_u$ is the unsprung mass of the wheelset (pounds-sec$^2$/inch)
- $m_{T2}$ is the equivalent track mass (pounds-sec$^2$/inch)
- $C_T$ is the equivalent track damping (pounds-sec/inch)
- $K_{T2}$ is the vertical track stiffness (pounds/inch)

The assumed values of selected parameters are:

- $2\alpha = 0.017$ rad, (1 degree) with half of this ($\alpha$) on either side of the dip.
- $m_{T2} = 1.1335$ pounds-sec$^2$/inch, for nominally stiff concrete tie track
- $C_T = 671$ pounds-sec/inch, from literature for nominal track conditions
- $K_{T2} = 330,000$ pounds/inch, for nominally stiff concrete tie track which corresponds to a track modulus of 4000 pounds/in/in (assuming a track deflection of 0.10 inches under a wheel load of 33,000 pounds)

A safe ride shall be provided in the event of a broken spring, inoperative damper or collapsed or over-inflated air spring (if used).

A minimum of 0.75 in. 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.
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.

Coil springs, if used, shall be thoroughly shot-peened after grinding and then coated in accordance with a Customer-approved paint type.

Unless otherwise noted, all coil springs shall meet the latest revision of AAR Standard M-114.

5.4.4 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 car body to 1.5 in. in either direction. Stops that limit truck over-rotation shall be equipped with a replaceable liner to prevent metal-to-metal contact.

5.4.5 Hand Brake Linkage

Truck-mounted hand brake 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 hand brake linkage as specified in Chapter 7.

5.4.6 Adjustments

Provisions shall be made for adjusting the carbody height up to 0.75 in. in either direction from nominal (1.5 in. total adjustment range), in increments of 0.25 in., 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.

5.5 Wheel and Axle Assembly

The wheel and axle assembly shall consist of an axle, two wheels, two outboard journal bearings, two inboard brake discs, 104-tooth 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.

5.5.1 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) elongation of 20% in 2 in. minimum, reduction of area at 50% minimum, yield strength of 80 ksi (1000 psi) 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...
Trucks

5.5.2 Wheels

The wheels shall be 36 in. diameter (nominal) Class B, multiple-wear type, conforming to AAR Standard M-107-84 and APTA Standard SS-M-012-99, and shall have a 1 in 40 tapered tread.

5.5.3 Brake Discs

Brake discs shall be of self-ventilated "mono-block" construction, 28 in. diameter as specified in Chapter 7.

5.5.4 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. by 12 in., with HDL seals (or equivalent). The service life of the journal bearing shall be at least 1 million miles under AW3 loading. The Contractor shall provide design analysis to verify the use of the type "F" roller bearing.

5.5.5 Journal Bearing Housings

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.

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 detector, per Amtrak Drawing D-00-7075.

5.6 Shock Absorbers and Shock Mounts

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.

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.

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 Customer for approval as part of the Contractor’s proof of design testing (see Chapter 19).

The shock absorbers shall be appropriately rated for a service life of no less than five years.
5.7 Electrical Wiring

5.7.1 Speed Sensor

A speed sensor cable shall be provided on each truck to provide a signal from the 104-tooth gear located on each axle to the wheelslip control system (see Chapter 7). The speed sensor cables shall be attached to the truck frame using 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.

5.7.2 Grounding

An electrical ground path using highly flexible cables or straps shall be provided from each journal bearing to the car body. Grounding paths shall be run from each journal box to the truck frame, from the truck frame to the truck bolster and from the truck bolster to the car body. Grounding cables or straps shall not restrict the movement of truck components, and shall remain slack under all operating conditions.

5.8 Painting

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.

Final coat of paint will be applied in accordance with exterior graphics requirements in Chapter 23.

* End of Chapter 5 *
Chapter 6

Couplers and Draft Gear
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6.0 Couplers and Draft Gear

6.1 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 Recommended Practice RP-M-003-98. Push back couplers with energy absorption shall be used as a component of an integrated crash energy management system.

6.2 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 49CFR Section 238.207. All components shall be designed to operate properly under the operational and environmental conditions defined in Amtrak Specification 963. 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.

6.3 Performance Requirements

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 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.

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 Amtrak specification 963. Coupler swing shall be such that a car shall be able to negotiate a 250-foot 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.

The centering mechanism shall maintain the coupler on the vehicle center line when in the uncoupled condition.

Car-to-car and coupler-to-carbody air connections shall be designed in conformance with APTA Recommended Practice RP-M-001-97. See Chapter 7 for details regarding car-to-car air connections.
6.4 **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 Standard M-201 grade C or better high tensile steel, or better. Couplers shall comply with the requirements of APTA Recommended Practice RP-M-003-98.

6.5 **Draft Gear**

Draft gear characteristics shall be compatible with twin-cushion WM-6-DP draft gear packs and the pockets shall allow for the implementation of pushback couplers.

6.6 **Coupler Carrier**

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. Above Top of Rail (ATOR) height (as measured at the center of the coupler) when uncoupled. The coupler carrier shall be designed to accommodate the complete push-back motion of the coupler without interference with the energy absorption function. During coupler pushback, contact between the coupler head and the coupler carrier will not result in unintentional activation of the coupler uncoupling mechanism and therefore cause car separation.

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.

The coupler carrier shall provide for adjustment of coupler height of 1 in. in either vertical direction from the nominal 34.5 in. ATOR coupler height standard. The coupler carrier shall comply with the vertical force requirements specified in 49CFR Sections 238.205 and 238.207.

6.7 **Uncoupling Mechanism**

All uncoupling levers and hardware shall meet the safety requirements of 49CFR Part 238. An uncoupling mechanism shall be installed at each end of each car, in conformance with section 5.10 of APTA Standard SS-M-016-06. Minimum clearance of 2 in. 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.

The uncoupling mechanism shall be designed to accommodate the complete push-back motion of the coupler without unintentional activation of the coupler lock mechanism and therefore car separation.

6.8 **Mounting Arrangement**

The proposed mounting arrangement of the coupler assemblies (cab and non-cab ends) will be submitted for customer approval during design review.
Both ends of all cars shall be equipped with push–back, energy absorbing coupler assemblies. A higher capacity coupler shall be provided on the cab-end of the cab car.

The push-back energy absorbing coupler assemblies shall meet the requirements shown in Table 6-1, Push-Back, Energy Absorbing Coupler Requirements.

**Table 6-1: Push-Back, Energy Absorbing Coupler Requirements**

<table>
<thead>
<tr>
<th>Application</th>
<th>Minimum Initiation Load, Pounds</th>
<th>Minimum Energy Absorption, Ft-lbs</th>
<th>Minimum Push-Back Stroke, Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>All, except cab-end of Cab Car</td>
<td>600,000</td>
<td>200,000 @ 4 in.</td>
<td>9</td>
</tr>
<tr>
<td>Cab-end of Cab Car</td>
<td>600,000</td>
<td>700,000 @ 14 in.</td>
<td>20</td>
</tr>
</tbody>
</table>

The slope of the force during push back shall be greater than or equal to zero.

The coupling system must be capable of transferring a 150,000 pounds draft load at any time during the push back sequence to ensure that cars remain coupled during and after an impact.

Indicators shall be provided that shall be visible from outside the car to indicate full or partial activation of the energy absorption unit and the need for its replacement. The activation of the energy absorption unit shall be readily apparent when performing periodic inspections.

* End of Chapter 6 *
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Chapter 7

Brakes
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7.0 Brakes

7.1 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 a conventional pneumatic system for service and emergency brake applications for all cars in the train, control equipment to be installed on the cab/baggage car to provide braking control for the train brakes and a pneumatic parking brake for the cab/baggage car, a wheel slide control system and a mechanical hand brake.

7.2 General Requirements

A conventional pneumatic brake system shall be provided on all cars unless specified otherwise by the Customer.

All air brake equipment shall be completely compatible with Type 26C/26L air brake equipment, currently in use in intercity rail passenger service. The air brake system shall be capable of running in conventional service in graduated release or direct release mode.

Nominal air pressures in the air brake system shall be:

- Main Reservoir: 140 psig
- Brake Pipe: 110 psig
- Brake Cylinder: 100 psig maximum

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 AAR Standard S-4200, and particularly AAR Standard S-4210, for redundant implementation of ECP cable-based system in this Specification. The installation shall include a terminal box at each end of the car (for installation of the inter-car jumper cables), 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 installation, servicing and removal of ECP modules. The Contractor shall provide a wiring diagram showing connections of brake controls with the two car end junction boxes to implement ECP braking.

The cab car shall be equipped with provisions for installation of a Positive Train Control (PTC) system consistent with 49CFR Part 236, Subpart I – Positive Train Control Systems.

7.3 Performance

The system shall be designed for operation at all speeds up to 125 mph in train consists of up to 24 cars with any combination of intercity rail passenger locomotives and single-level cars as specified.
The air brake system shall be designed for operation and maintenance in conformance with all applicable Amtrak air brake rules.

Braking performance shall be in conformance with the braking performance curve as identified in Amtrak Standard S-603.

A train consisting of five single-level cars built to this Specification (in any combination of car types) and one P42 locomotive (or equivalent) shall have a minimum full service braking rate of 1.35 miles per hour per second (mphps) at 125 mph increasing to and maintaining an average of 2.00 mphps at speeds of 70 mph or less. The instantaneous full service deceleration rate shall not exceed 2.75 mphps nor be less than 1.25 mphps. The emergency brake rate shall not be less than 2.50 mphps at speeds below 70 mph. 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 Amtrak Specification 963. Locomotive dynamic braking shall not be used to determine compliance with specified brake rates.

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) under all normal conditions. There shall be no jerk limit for emergency brake applications.

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 Customer during the brake system design review. 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.

### 7.4 Design Review

Preliminary 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:

**Concept:**
- Concept and operation of friction brake system
- Thermal capacity of brake system
- Calculations showing that the system’s performance requirements will be met
- Graduated release setting of control valve
- Direct release setting of control valve
- Graduated release mode of automatic brake valve operation
- Direct release mode of automatic brake valve operation
- Lead/trail (cut-in/cut-out of automatic brake valve)
- Feed valve setting
- Safety control interface (cab signal, overspeed, alerter, PTC)
- Forestall pending restriction – positive and accurate interlock with suppression
  - Penalty application
Brakes

- Recovery from penalty
- Compliance with Amtrak daily and periodic test requirements
- Power knockdown: brakes and traction
  - Penalty
  - Emergency
- Wheel slide control
- Parking brake interface with brake system, both before and after parking brake application/release, penalty application and automatic brake application

Operating:
- Push-pull operation with locomotive in either leading or trailing position
- Stopping on a grade
- Starting on a grade
- Penalty brake application
- Engineer-initiated emergency brake application
- Conductor- or passenger-initiated emergency brake application
- Train separation (break-in-two)
- Operation of short trains (three cars or less)
- Operation of long trains [six to 24 cars including the locomotive(s)]
- Dead engine movement (with and without Main Reservoir (MR) to cab car)

Design and performance analysis will be evaluated during design review, First Article Inspection (FAI) and proof of design testing.

7.5 Car Body Components

7.5.1 Piping and Fittings

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 both lines shall be extra-heavy steel pipe in accordance with ASTM Standard A-53.

Brake pipe trainline must pass AAR Standard S-471.

Piping practices shall conform to AAR Standard S-400.

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.

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 Standard SS-M-011-99 for compressed air quality for passenger locomotive and car equipment.

### 7.5.2 Angle and Cut-out Cocks

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.

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 down stream. The vent port of the cut-out cock shall be tapped for 0.25 in. National Pipe Thread (NPT).

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.

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 or plastic tags.

### 7.5.3 Hoses and Couplings

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 Standard SS-M-001. 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 Recommended Practice RP-M-001-97.

Two dummy couplings, one "F" type and one "E&L" non-insert 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.

### 7.5.4 Emergency (Conductor) Brake, Application and Vent Valves

Manually operated conductor’s valves, Wabtec B-3-B emergency brake valve, or approved equivalent, shall be provided as follows:

- 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/baggage cars).
- On the F-end of the cab/baggage 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.

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.
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 Amtrak Specification 697.

A Wabtec emergency brake valve p/n 535026, or approved equivalent, shall be located in the cab on the Assistant's console.

Vent valves shall be provided along the BP in accordance with air brake system design requirements.

Ready access shall be provided to all valves to facilitate inspection, replacement and maintenance.

The valves shall meet the requirements of APTA Standard SS-M-007-98.

### 7.5.5 Air 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 FRA 49CFR 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.

### 7.5.6 Control Manifold and Valves

The control valve shall be a Type 26C service portion and pipe bracket. Control valves shall use stainless steel springs and spool valves where appropriate. The control valve shall include the control reservoir charging cable.

The air brake control valve and cab control manifolds shall be located inside the carbody, above the level of brake pipe. 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.

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.

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.

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.
Brakes

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.

Brake cylinder pressure shall be supplied and maintained by a relay valve with a 1:1 ratio, or approved equivalent.

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.

Full service brake cylinder pressure shall be nominally 60 – 65 psi. Emergency brake cylinder pressure shall be nominally 75 – 78 psi.

7.5.7 P-2-A Application Valve

A Wabco P-2-A penalty application valve portion and pipe bracket, or approved equivalent, shall be used to initiate a full service brake application when actuated by the alerter, overspeed or PTC.

7.5.8 Auxiliary Air Equipment

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. 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/baggage car shall be supplied from the first main reservoir.

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.

7.6 Truck Components

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.

The truck-mounted components as specified have been identified for the purposes of interchangeability with other intercity bi-level cars. The Contractor may propose alternate components for Customer 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.
7.6.1 Disc Brake Actuator

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 be a 3-point position type that permits caliper to follow lateral movement of the wheel assembly without restriction. Automatic slack adjusters shall maintain a 0.03 in. to 0.06 in. clearance between the pad and the disc when brakes are released.

The disc brake system shall use pads compliant with Amtrak Specification 80-276. 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.

Pad holders and disc pads shall be UIC Type for 400 cm² with an approved locking device. 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.

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.

7.6.2 Brake Discs

Two self-ventilated 28 in. maximum, 27.5 in. nominal diameter brake discs shall be provided per axle. 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 Amtrak.

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, whichever is greater.

All brake discs must be cast within a facility located in either North America or Europe, unless approved by the Customer. The disc shall comply with the following requirements in this Chapter during design review. The brake disc supplier shall initially investigate if the brake disc currently used by Amtrak for a G-size axle is suitable for this application.

7.6.2.1 Design Criteria

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 Amtrak Specification 963. The discs shall be designed to withstand the mechanical loads arising from track-generated accelerations defined in Appendix A 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.

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 Appendix A, and from the thermal loading measured from the dynamometer testing performed pursuant to the requirements of Chapter 19, and submitted to the Customer for approval. 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.

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.

### 7.6.2.2 Brake Disc FEA Report

The brake disc supplier shall submit a brake disc FEA report, for approval by the Customer. 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 Customer. 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:

- Introduction
- Table of Contents
- Summary
- Physical properties of each material used for the disc. This table shall include, but not be limited to:
  - Yield strength
  - Ultimate strength
  - Elongation
  - Tension modulus
  - Compression modulus
  - Shear modulus
Minimum values shall be used, and shall be selected from ASTM (or equal) material specifications, as approved by the Customer. The brake disc supplier may propose alternate material specifications for Customer approval.

- 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.

- 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.

- The complete test report must be submitted including procedure, raw and reduced data, and summary of results, including:
  - 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.
  - Diagrams displaying externally applied loads and boundary conditions.
  - Color plots of the stress under each load condition for critically stressed areas.
  - Natural Frequencies of the disc.

### 7.6.3 Tread Brake Units

A truck mounted air actuated tread brake unit, with integral single acting 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.

Composition brake shoes 2 in. thick, of a size and type in general use by Amtrak and conforming to Amtrak Specification 80-286 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 49CFR Part 238. 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.

The design of the tread brake shall accommodate a new wheel with a diameter 0.625 in. greater than nominal wheel diameter.

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 2.0 in. brake shoe against a new wheel.

One tread brake unit on each axle of the B-end truck shall be equipped with hand brake linkage. Tread brake units shall be provided with spring applied parking brakes, integral to the tread brake unit which is compatible with APTA Standard SS-M-006-98, if specified by Customer.
7.7 Wheelslide Control System

The wheel slide 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:

- System unit/controller with pre-wired connector plugs
- Modulation type dump valves (two per car)
- Molded T-harness cable, or equivalent protected cable type (two per car)
- Speed sensors (one per axle)
- Download any diagnostic software for a Portable Test Unit (PTU) (test unit itself is not required)
- Adapter cable to connect a PTU to the wheelslide control unit

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.

The wheelslide system components, including controller and dump valves shall be equipped with an identification plate or tag which includes:

- Vendor
- Vendor part number
- Date of manufacture
- Serial number
- Car type

7.7.1 Control Unit

The control unit shall be mounted in the electric locker.

The wheelslide control equipment is subject to the following conditions:

- 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.
- The system software shall be designed to account for the rotational inertia properties of the wheel set assembly.
- 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 slip and instantaneous deceleration rate shall be submitted for review and approval.
- The system software/control electronics shall possess features to prevent inappropriate wheel slip 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.

- 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.
- 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.
- The system shall utilize software that is at the current revision at the time of installation.

### 7.7.1.1 Auxiliary Functions

The system shall supply two auxiliary zero speed signals, provided for door control, as described in Chapter 8, as follows:

- A zero-speed switching device shall close below 3 mph, and shall open above 3 mph.
- A 20 mph speed switching device shall close below 20 mph and shall open above 20 mph.
- Logic shall be fail-safe, such that zero-speed and 20 mph 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 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.

### 7.7.1.2 Diagnostics

The wheelslide control unit shall include integral diagnostic indications (at a minimum) of the following system states with the vehicle moving:

- Open, shorted or grounded speed sensor circuit
- Open, shorted or grounded dump valve circuit
- Electronics fault identified at card level
- Power loss/low supply voltage during car deceleration
- Software logic fatal error or program lockup
- Time out of safety timer
- Weak/missing speed sensor signal

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:

- Ability of magnet valves to release and apply brake cylinder pressure
- Ability to test magnet valve time-out
- Ability to exercise zero-speed relays
7.7.1.3 Faults

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:

- Be able to identify defects down to printed circuit board, individual speed sensor or magnet valve level.
- Include transient faults detected while the car is in motion.
- 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.

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.

7.7.1.4 Circuit Boards

All circuit boards shall be identified with:

- Vendor name
- Vendor part number
- Date of manufacture
- Revision level
- Serial number

7.7.1.5 Test Equipment and Software

The Contractor shall provide five electronic copies of wheelslide system diagnostic software to be used on a PTU. Operating instructions for this software shall be included in the vehicle maintenance manuals.

The Contractor shall provide 10 cables to connect a PTU to the wheelslide control unit to allow on-car troubleshooting.

7.7.2 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. The manufacturer must provide a pre-wired mating plug connector for each dump valve. The wire pigtail must be molded construction and sealed at the plug.
7.7.3 Speed Sensors and Wiring

Axle speed shall be determined from a passive magnetic speed sensor mounted on a journal bearing adapter and a 104-tooth gear mounted on the end of the axle. The sensor shall detect speeds of 2.5 mph or more. Nominal sensor gap shall be 0.020 in. to 0.035 in. 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.

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.

7.8 Brake Indication Devices

7.8.1 Pneumatic Indicators

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, with the plunger extended away from the carbody when the brakes are applied, and retracted under the carbody when the brakes are released. The indicators shall be readily visible from station platforms as well as track level, and from both ends of each side of the car.

7.8.2 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 engineer’s console in the locomotive or cab/baggage car (via pins 19 and 20 of the 27-point communication trainline) to display brake system status (applied or released). Trainline function is as follows:

- Brake released: continuity when brake cylinder pressure on both trucks is less than one-half of a minimum service application, and handbrake is released.
- 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.
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:

- Green: All brakes released and handbrake released
- Yellow: Brakes applied and handbrake released
- Flashing Yellow: Handbrake applied (with air brakes applied or released)

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/baggage car via pin 20 of the 27-point communication trainline. The switch shall be weatherproof to prevent damage from environmental conditions.

### 7.9 Handbrake

#### 7.9.1 Handbrake or Spring Brake Units

A handbrake with lever-type handle shall be provided at the B-end of each car accessible from the passageway between collision posts. Spring-applied parking brakes may be provided in lieu of a handbrake if requested by the Customer. The handbrake or spring brakes shall be compliant with APTA Standard SS-M-006-98.

#### 7.9.2 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. This section applies only if handbrakes are utilized.

### 7.10 ECP Brake Control System

All cars shall be equipped with mounting provisions to facilitate the future conversion to an Electronically Controlled Pneumatic (ECP) Brake System. The cars shall be equipped with discrete conduit and wiring configured per AAR Manual of Standards and Recommended Practices Specifications S-4200 and S-4210, to facilitate the future installation by User of an ECP cable based brake system. This shall include the installation of trainlines, an electrical terminal box at each end of the car (for future installation of the intercar jumper cables), 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 future installation, servicing and removal of ECP modules. The end of car arrangement shall include provision for the ECP trainline cable and junction connections. 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 Customer approval during design review.
In lieu of a purely pneumatic friction brake control system, the Contractor may propose the use of an electronically controlled brake system with the following functionality:

- The ECP system shall be powered by the vehicle low voltage power system.
- The ECP controller shall interface with the above denoted communications trainline for transmission of brake demand signals.
- The ECP 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 ECP controller is utilized for BP response control, the controller shall emulate 26C response for compatibility with legacy cars in the same consist.
- 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.
- The ECP controller shall have provision to provide wheelslide control as in Chapter 7.
- The ECP system shall incorporate interior mounting of pneumatics and electronics within a single module.
- The ECP system shall incorporate component standardization in accordance with current PRIIA Requirements documents.
Brakes

7-17

Table 7-1: Communication Acceleration Summary: Washington, DC - New York
City - Boston

PRIIA 305-003/Amtrak 964 Technical Specification Initial Release
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**021998-06 Newark to New York Penn Station**

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### Brakes 7-20

#### ACCELERATION SUMMARY – WAS-NY

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### Acceleration Thresholds

- **Vertical (Vertical):** 50 g
- **Lateral (Lateral):** 30 g
- **Bump (Bump):** 50 g
- **Tilt (Tilt):** 50 g

### Acceleration Summary -- NY-80S

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- **LBOXVERT:**
  - 2012
- **RBOXVERT:**
  - 2012

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- Copyright 2011 Amtrak All rights reserved
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* End of Chapter 7 *
Standardized Technical Specification

PRIIA 305 Next-Generation Equipment Committee
Single-Level Passenger Rail Cars

Chapter 8
Door Systems
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8.0 Door Systems

8.1 Design Objectives

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:

- Unsafe conditions for passengers or crewmembers;
- Train delays from malfunctioning side door equipment;
- Poor system reliability in adverse operational and environmental conditions;
- Accumulation of dust and dirt that affects system performance and cause failures;
- System complexity that increases the time and effort required for troubleshooting and repairs; and
- Requirement for frequent adjustment and component replacement.

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.

8.2 Door Construction

8.2.1 Exterior and Vestibule Doors

Each vestibule end of each carbody shall have two exterior side entrance doors (with stepwell and vestibule trap door at each, except at the cab end of the cab car), an exterior body end door to close off the intercar walkway, and a vestibule sliding end door between the vestibule and the passenger seating area. The general arrangement shall be as shown in the conceptual drawings in Chapter 9. All doors shall have minimum clear dimensions of 32 in. All side doors and vestibule sliding end doors shall be power operated. The side doors shall be arranged for passenger entrance or exit from both high-level and low-level station platforms, except for the cab end of the cab car, which will have a crew only door, which shall be configured for high-level station platforms only.

A side door arrangement which is improved from the current Amfleet cars is of great importance to Amtrak, in order to properly address ADA accessibility, improve winter performance, increase reliability and provide improved maintenance access. Each side door, except at the cab end of the cab car, shall be of single door panel construction from the door header down to the bottom step of the stepwell. A vestibule trap door shall be located inboard and separate from the door panel, arranged so the trap door may be raised or lowered when the door is either opened or closed.

A sliding stainless steel high-level walkway threshold shall be located outboard of the door panel, and function as a walkway extension at high-level station platforms. This high-level threshold shall be mounted on a separate roller track from the door panel, and connected to the door panel trailing edge by a simple mechanical latch controlled by the trap door position. When the trap door is raised exposing the stepwell for low-level station boarding, the high-level threshold shall be mechanically linked to the door panel, and be moved open or closed across the doorway by the door panel, thus providing a clear opening for low-level boarding. When the trap door is lowered for high-level station boarding, the high-level threshold shall be...
Door Systems

Disengaged from the door panel and be locked in the closed position, and shall function as an additional walkway surface outboard of the trap door edge.

Proposals utilizing an alternative technique (such as an automatic footboard) are also permitted, with Customer approval.

The side door at the cab end of the cab car shall be of similar construction, but arranged for only high-level station platform access, and shall not have a stepwell or a vestibule trap door. The side door arrangement used on the New Jersey Transit multilevel cars demonstrates an acceptable application of this design concept, and its features shall be considered in developing the design for this vehicle. Alternatives can be proposed for review and approval. All details and components must be submitted to the Customer for approval during design review.

The doors and their hardware shall be of a design related to prior successful North American rail passenger service. The Contractor's design for all doors must comply with the requirements of 49CFR Part 37, 49CFR Part 38 Subpart F, 49CFR Part 238 and APTA Standard SS-C&S-034-99. A minimum number of door panel types shall be used. It is desired that all doors provide the maximum safety and ergonomic ease of use by train crew and passengers, especially the elderly and those with reduced vision acuity. Contrasting yellow color stripes shall be provided at all edges, thresholds and steps. Handholds recessed in the side walls (preferably on each side of the passageway) with generous hand clearances shall be provided in all doorways, for both high-level and low-level platform height, in accordance with 49CFR Section 38.115. Hand-operated latches and handles shall provide clearance for operation by a gloved hand. All doors shall be solidly mounted, of lightweight construction, vibration free, open or close positively, and not rattle or make noise in service.

Each carbody side door, end door and vestibule sliding door panel shall be of stainless steel construction with a phenolic foam core. Minimum thickness of exterior sheathing shall be 0.030 in. for side and vestibule sliding doors, and 0.050 in. for end doors. The design shall match the carbody profile, meet the environmental requirements of Amtrak Specification 963, 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. The interior surface finish of the doors shall be faced to match the interior finish material and color of the surrounding panels as approved by the Customer, similar to the interior finish treatment used on the Acela trainset doors. If door panels shall be painted, an alternative design using aluminum door panels is permitted.

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. If aluminum door panels are used, a service-proven bonding process must be employed (welding of sheets to frame is not permitted). Each door leaf supported only at the top and bottom shall not deflect more than 0.25 in. under a 200 lb load applied perpendicularly over an area of 4 in. by 4 in. 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.

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.

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. The design of the nosing shall meet the requirements of Chapter 18, and shall be easily removable to allow for maintenance and replacement. 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. The doors shall be constructed so that all 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. 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.

The car sides shall have minimum projections which could trap snow. Door operation shall be unaffected by snow, ice or freezing rain. A positive means of mechanical locking each powered door when closed, not dependent on continuous electrical power, shall be provided as part of the door control system. Refer to Chapter 8 for manual locking and emergency door release requirements.

Hanger assemblies and door tracks for all sliding doors and side door sliding thresholds shall be of the lubricated ball bearing type, consisting of a track with a ball bearing cage, and installed with an adjustable locking arrangement. The track and ball bearing must be metal. T-shaped hanger members for sliding engagement, with tapped holes to accept fasteners, shall be provided to secure the door panel to the hanger. Alternative guide systems, such as service-proven plastic roller-guiding are permitted, with Customer approval. The hanger member shall mate to the inside, inboard surface of the upper door channel. The door shall be fastened to the hanger with approved fasteners and lock washers, arranged to provide adjustability of door panel position. Hangers shall be protected from the weather, but shall be completely accessible for inspection, adjustment and removal of doors by means of approved access doors and removable panels. Rubber stops shall be provided at both top and bottom of door open positions to prevent undue noise and skewing of doors.

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. 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. 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 particular applications require the use of adhesives this has to be approved by the Customer. 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.

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 Customer.

8.2.1.1 Weather sealing

Amtrak will operate the cars in 125 mph intercity service throughout the continental United States. Side door operation will be much more infrequent than typically encountered in commuter rail operations. It has been Amtrak's experience that this combination allows a great amount of snow and ice to accumulate on the side door panels and seals during winter train operation, which results in many door failures. The very high operating speeds of the
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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. This must be beyond the level of design normally applied to North American commuter rail equipment.

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. 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. Sliding plug doors fulfilling the general operating requirements in lieu of sliding doors are permitted, with Customer approval.

Heavy duty brush type seals or a Customer-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. 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.

8.2.1.2 Maintenance access

Ease of maintenance access to all components of the door system is of significant importance to Amtrak, 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. 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. 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. 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 Customer's satisfaction.

8.2.1.3 Vestibule side doors

Each end of each car, except for the cab end of the cab car, shall be equipped with a sliding or sliding plug type side door on each side, arranged for both high-level and low-level station platform access. The door shall be a single panel, and shall extend from just below the roof rail to a threshold installed flush into the lowest step, and its design shall be coordinated with the
interior vestibule trap door features, and the exterior sliding high platform threshold. The side doors shall be mounted as close to the outside of the car as construction permits.

The cab end of the cab car shall be equipped with a similar sliding/sliding plug type side door on each side, but arranged for only high-level station platform access. The door shall be otherwise similar to the high-level/low-level door type, and shall use similar parts.

The side doors must be robustly weather-stripped for 125 mph intercity service in harsh winter storm conditions. 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.

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.

8.2.1.4 Vestibule trap door

Each end of each car, except for the cab end of the cab car, shall have a trap door in the vestibule covering the side door stairway to permit passenger loading at high-level station platforms. The trap door shall be constructed of stainless steel materials. Lightweight composite materials with similar corrosion resistance and durability may be proposed for approval by the Customer. When open, the trap door shall be fully recessed into the thickness of the adjacent wall partition. A nonskid synthetic floor covering with stainless steel protective edges shall be applied to the top surface of the vestibule trap door; the lower surface shall match the finish of the adjacent wall partition. The trap door shall be as light as possible, have smoothly rounded corners and edges, and be thermally and acoustically insulated.

The trap door shall be designed for manual operation with the side door either open or closed. The trap door shall have a coil spring, or equivalent, and hinge arrangement which shall allow the trap door to open (lift) approximately 20° when the trap door closed latch is released. The spring shall also assist in lifting the trap door to the open position. Once installed and after initial adjustment, the trap door spring shall require no further adjustments.

A foot operated, ice breaking, slam latch on the vestibule floor shall be provided to secure the trap door in the lowered position. This latch shall also be connected to a remote handle which is recess mounted on the exterior of the car at the doorway or just inside the stepwell, convenient for operation by train crew standing on the trackbed. A hand operated slam latch with bumper to prevent rattling shall be provided to secure the trap door in the raised position. Neither latch shall infringe into the accessible clear opening passage through the vestibule. The underside of the trap door shall be equipped with a smoothly shaped handle arrangement to assist in fully opening the trap door. A stainless steel passenger handhold shall be applied to the bottom face of the trap door, for use when the trap door is raised. The trap door must lock positively in the open and closed position without rattling, using robust, corrosion resistant railroad proven hardware.

The trap door shall be covered with rubber sheet flooring having the highest level of anti-skid properties. Its edges, and the edges of the vestibule floor opening, shall have an integral contrasting yellow color stripe. A stainless steel zee molding of minimal width shall cap the outer edge of the rubber sheet to positively prevent lifting. The design of the vestibule steps

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and vestibule flooring shall use similar materials compatible with operating and maintenance practices. An environmentally sealed proximity switch shall be used to detect the closed status of each vestibule trap door (see Chapter 8).

The trap door and side door shall provide for the minimum increase in gap between a high-level platform and the trap door edge and comply with the ADA requirements of 49CFR Parts 27, 37 and 38. The design of the trap door assembly shall be submitted to the Customer for approval.

8.2.1.5 Vestibule steps

Each side doorway equipped with a trap door shall have a stainless steel fixed stepwell, consisting of three steps, and designed for maximum ease of use by elderly and mobility-impaired passengers. The step dimensions shall be in accordance with ADA requirements, with maximized tread width. The top surface of the lowest step shall be a nominal 1 ft 5 in. above the top of rail. The tread depth shall be a minimum of 10 in., and all riser heights shall be equal. The stepwell shall be designed as a unitized assembly installed with stainless steel fasteners to the carbody, arranged for ease of replacement of a damaged stepwell with a new unit. The use of open risers is prohibited. The step treads shall be the anti-slip rubber sheet material used for the trap door floor covering. To provide contrasting colors for passengers of low visual acuity in compliance with 36CFR Section 1192.99 and 49CFR Section 38.117, the front edge of each step shall have a minimum 3 in. yellow stripe on the foot plate surface and 1 in. yellow stripe on the vertical surface visible by people boarding or exiting the vehicle. The stepwell shall be insulated and have deicing forced air heating provided using an approved arrangement per Chapter 8. The steps shall be sloped for drainage. The bottom step shall have a flush mounted door threshold coordinated with the door panel design.

8.2.1.6 Side door threshold

Each side door shall have a threshold 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. The threshold and door track shall be equipped with a protective heater per Chapter 8 to prevent snow and ice accumulation. 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 shall be provided on the car exterior 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.

8.2.2 Hinged End Door

Each end of each car at the intercar passageway shall be equipped with a stainless steel, single leaf, full height, piano hinged, inward swinging end door panel. The clear opening of the doorway shall meet the requirements of Chapter 4. The exterior contour and surface finish of the door at the cab end of the cab car shall match the profile and finish of the car end, and shall be mounted flush with the car end profile. The door at the non-cab end of the cab car, and at all other car types, shall be a flat panel, and when opened shall swing through an arc of 180°, similar to the current Amtrak Amfleet car, and be latched in the open position into a recess in the carbody vestibule wall lining. 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 be made to match the door profile and shall fully support the door when closed. The 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. The door exterior surface shall include a diagonal hand rail, so that when open and secured to the carbody end wall the hand rail may be used by passengers using the adjacent low-level platform stairwell.
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The end door shall be equipped with an approved weather seal arrangement which shall be applied to the door perimeter. Dual weather seals shall be applied 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. 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 insure continuity of the seal.

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. 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. No heating element is 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 Customer.

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. 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 Customer.

8.2.3 Vestibule End Sliding Doors

An electrically powered bi-parting sliding door shall be located between the passenger seating area and the vestibule at each end of the car, as shown in Chapter 9. Its arrangement shall be similar to that used on the current Amtrak Acela trainsets, with maximized window panes. Doors shall be vibration free and well insulated against heat and sound transmission as approved by the Customer. A recessed stainless steel handle shall be provided on either side of the door panels to allow manual opening or closing of the door. The doors shall be hung on ball bearing hanger assemblies having the carrier or stem members designed to be fastened to the door, and have provision for accepting mounting hardware. 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.

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. The trailing edge seal shall be attached to the door leaf rather than the
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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 Customer approval.

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 thresholds shall be compliant with ADA requirements. 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.

The following alternatives may be proposed:
- Single piece sliding door
- Obstruction detection without using sensitive edge
- Alternative door opening switch and sensor arrangements

8.2.4 Side Doorway Heaters

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. The system shall consist of 120VAC automatic self-regulating heating cable cut from bulk rolls, 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 jams. All connections shall be made using the manufacturer's watertight splicing kit, and each individual length shall be terminated with the manufacturer's Light Emitting Diode (LED) power indicator light, consistently orientated on all cars so as to be easily inspected from the side or interior of the car. The heat tape shall be of a design that can withstand the application of live steam at 212°F without damage, as this is often the only method available in the Amtrak maintenance facility for thawing a frozen car. It is desired that the heat tape be identical to that used for freeze protection of the water system for standardization.

The heating cable shall be secured by metallic clips; adhesive tapes shall not be used. All cable and electrical terminations shall be environmentally sealed to withstand exposure to cleaning chemicals, deicing salts, brine, etc. present in the door area. 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. 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. Access shall be provided for ease or replacement and to all electrical terminations for maintenance. The heater system shall be approved by the Customer.

8.2.5 Vestibule Trap Door Gap Filler Provisions

Due to US regulatory wayside clearance requirements, there is a gap between a high-level station platform and the outer edge of the side door vestibule of approximately 7 in. As part of the preliminary design review, the Contractor shall investigate and report to the Customer on the feasibility and costs of providing a gap filler mechanism to the vestibule trap door or sliding high-level threshold. This gap filler would be a device which would extend from the side of the car at the high-level side door when the door is commanded to open, and retract after the door has been closed. [Note: Such a device will have to be mounted on the trap door, therefore it will not be possible for it to extend before the door is opened. In sliding plug applications, this
device can start moving as soon as the door is unplugged and before it starts to open. The device must retract before the door closes.] Such a device would need to incorporate a high-level of safety into its design for the use of passengers and train crew, account for misalignment of platform heights, have a high-level of reliability and have simple manual override capabilities. It is expected that this system would be power operated, be capable of remote trainline operation as part of the operation of the high-level side doors by the train crew, and suitable for use by foot passengers, wheelchairs and food service carts. As information, a high-level station platform gap filler system is used by the San Francisco Municipal Railway on its light rail vehicles, and on the GMB Class 71 electric multiple unit cars used by Flytoget for the Airport Express Trains on the Gardermo Line of Norway. Amtrak would determine during the preliminary design review if the Contractor should then proceed, on an extra work basis, on the final design and installation of a gap filler device onto the cars.

8.3 Door Control

This section describes the operation and control of the power operated side doors and sliding end vestibule doors on the car. The mechanical details of the door panels are described in Chapter 8.

Each end vestibule of all car types, except for the cab end of the cab car, shall be equipped with a combination high-level/low-level platform power-operated side entrance sliding pocket door on each side of the car. The cab end vestibule of the cab car shall be equipped with a power-operated side entrance sliding pocket door on each side of the car, for service to only high-level platforms. Each side door shall be individually electrically powered, use a single piece door panel, and low-level platform doors shall have stairway trap door. The vestibule sliding end door shall be power operated and controlled as described in Chapter 8. Human factors, ergonomic criteria and ADA requirements shall be incorporated into the design, operation, installation and maintenance of the door system.

It is required that the door control system for the side doors be designed and operate with complete interoperability with the existing Amtrak Amfleet I cars, as detailed in Chapter 1. The existing Amtrak door control/communications trainline shall be used between all cars, as detailed in Chapter 13. The car must successfully accept and properly respond to door control commands originated by an Amfleet I car, and must likewise originate door control commands for high-level station platforms which can be successfully accepted and responded to by the doors on the Amfleet I cars.

Each powered side and end door panel shall be provided with a service-proven obstruction detection feature.

On a per door basis, the door control shall be arranged so that any obstruction, as defined in APTA Recommended Practice RP-C&S-012-99, shall be sensed throughout the closing cycle until the door is fully closed and locked. If an obstruction is sensed by the door or door post, that door shall recycle to the fully open position and immediately reclose. Recycling shall continue as long as an obstruction is detected. 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 it’s mating edge.

Door operators and controls shall be considered to be safety critical functions. They shall be designed to operate at a nominal voltage of 74VDC over a voltage range of 55VDC to 80VDC at the door control panel, and shall continue to operate in standby mode. The power supply for door controls shall be electrically isolated from the 74VDC supply. All door pocket wiring shall be installed in rigid conduit. Exposed wire bundles or flexible conduit are not permitted. 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 Customer for approval.

All electrical and mechanical components of the door system shall be fully accessible for ease of maintenance, trouble shooting, repair and adjustment. The doors shall be controlled by a service-proven electronic door controller.

A door shall not change position under any circumstances other than when specifically commanded to do so. This shall include car all power-up and power-down conditions, application or removal of battery or HEP, intermittent HEP, intermittent command signals, abnormal sequences of commands, etc, as single conditions and in combination. This shall be considered a design fundamental. The door control circuit logic shall be carefully reviewed in detail during design review with the Customer 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.

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.

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 Customer for approval during design review. 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.

The detailed design of the door system, door operators, controls and installation shall be submitted to the Customer for review and approval during the design review process. The Contractor during design review shall establish a logic table to be approved by the Customer listing every possible combination of door control station and crew key switch status within a train, including consists with and without existing Amfleet I 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.

### 8.3.1 Side Doors

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 the Amtrak standard coach key per Chapter 1, (unless specified differently in Chapter 23) and shall have the tumbler set back at least 0.5 in. from the face to prevent unauthorized operation. The door control commands and indications shall be transmitted through discrete hard-wired trainlines to be compatible with the existing Amtrak Amfleet I cars. 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. An environmentally sealed proximity switch shall be used to detect when each vestibule trap door is not fully lowered and locked.
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 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 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 Customer approval during the design review process.

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.

Zone control switches shall be provided in each car to permit breaking the door control trainline at either end of each car with the car at any point in the train, to permit cars to be deadheaded in a train and their side doors kept closed at station stops. The proper functioning of the trainline door status signal circuitry shall not be affected.

8.3.1.1 Side door operators

Each side door shall be actuated by an electrically powered door operator system with successful previous North American transit or commuter rail experience. The operator shall be overhead mounted, readily accessible for maintenance and well protected from wind-driven snow, rain, dirt and other environmental factors. Use of electro-pneumatic, belt or cable driven door operators is prohibited. 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. Door operator access shall be provided by an access door at the intersection of the ceiling to the door pocket, located at a 30° to 45° angle to the ceiling. It shall not be necessary to dismantle any seat to gain access to the door operator. Emergency manual operation of the door system shall comply with the requirements of 49CFR Part 238 and APTA Recommended Practice RP-C&S-012-99. Details of the access and operation of the door operator and emergency release shall be submitted to the Customer for review and approval.

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

If sliding plug doors are used, the operating timing shall be defined as follows:

Opening: 4.0 seconds – Adjustable 4.0 to 5.0 seconds
Closing: 4.0 seconds – Adjustable 4.0 to 5.0 seconds

In this case, 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 shall be between 20 and 36 lbs, through the entire cycle.
A cutout switch shall be provided at each side door operator so that in the event of failure, the operator may be bypassed, made inoperative, and not affect the trainline operation of any other door. This switch shall have two positions, NORMAL and CUTOUT. In the NORMAL position the door control and signal light circuitry shall function in the normal manner. In the CUTOUT position the door operator shall be cutout, but the output to the door closed signal light circuitry shall function normally. The switch shall not be visible to passengers and shall be accessible with minimum disturbance to passengers. A positive electromechanical lock, integral to the door operator cutout switch, shall be provided to secure the door in the closed and locked position when the operator has been cutout. This electromechanical lock shall be mounted on the door operating mechanism. When the door has been mechanically locked, the switch shall remove power to the door operator motor.

Each door operator shall use a service proven motor with a service lifetime of at least 20 years.

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 with the door operators disconnected.

### 8.3.1.2 Side door control panels

At each carbody side door location, a watertight master side door control switch panel with a stainless steel cover shall be flush mounted recessed on the interior face of the vestibule, for a total of four per car. The panel shall have a flat face plate with a Customer-approved orientation, functionally equivalent to that provided for the existing Amfleet I cars. All side door control circuits for one side of the car shall be separate and distinct from those for the other side of the car. There shall be no shared components unless specifically called for herein. One trainline circuit shall be momentarily energized to command doors to unlock and open. Doors shall be commanded to close and lock by momentarily energizing another trainline circuit. The door control trainlines shall be configured as detailed in Chapter 13. Means shall be provided in the design to permit Amtrak to easily revise the door circuitry in the future such that an open low platform side door will automatically close when its vestibule trap door is lowered and locked.

The door control system shall be designed to allow the car doors to be operated with the cars coupled in any end-to-end orientation, and with other existing Amtrak cars (including Amfleet I cars) in the train consist. Cars shall be capable of the proper function of all systems including the door system with cars coupled A-end to A-end, or B-end to B-end, or A-end to B-end of another car. Circuits shall be arranged so that a locomotive or cab car can be used on either end of the train. Details of the design and operation of the door control system shall be submitted to the Customer for review and approval.

The door control circuitry shall be arranged so that the doors on a given side of the train are controlled only from door control panels on that side of the train. At each door control position, provision shall be made for independent control of doors forward and rearward of that position, of the door at that position, and of doors for either low-level or high-level platforms.

The methodology of providing separate control of high-level and low-level platform door operation using the existing Amtrak communications/door control trainline specified in...
Chapter 13 shall be presented to the Customer for approval. The door control system shall be arranged so that an Amfleet I car will only recognize received trainlined door commands from a new car for only high-level platform door operation. Likewise, any trainlined door commands issued from an Amfleet I car will only be recognized by a new car for high-level platform door operation. The new car shall not generate any low-level platform trainlined open door control commands that may be recognized by an Amfleet I car; such trainlined commands shall be configured to pass through the Amfleet I car and only be recognized by other new cars in the consist. No modification to the existing Amfleet I cars shall be required. Spare trainlines are available on the Loco Control 27-pin jumper for this purpose.

The door control panels shall be fitted with a key switch required to activate the panel, ten recessed watertight push buttons and three door signal LED lights. Nine push buttons shall be arranged in three vertical columns of three push buttons each. One indicator light shall be located above each vertical column of buttons. The left vertical column of push buttons shall control doors forward of the control station, the center vertical column shall control the local vestibule door and the right vertical column shall control doors rearward of the control station. Forward and rearward shall be based upon a train crew member standing in the vestibule and facing the door control panel. Note that the forward and rearward columns are reversed for opposite vestibule locations. The top horizontal row of three push buttons shall be used to open the appropriate door(s) at high-level station platforms. The middle horizontal row of three push buttons shall be used to open the appropriate door(s) at low-level station platforms. The bottom horizontal row of three push buttons shall be used to close the appropriate door(s) at both high-level and low-level station platforms. The tenth push button shall be located in the inboard side of the door control panel, and used for the Conductor's signal buzzer.

The section of the train (forward, local or rearward) which is controlled by each set of push buttons shall be clearly indicated by permanent engraved faceplate labeling such as arrows and the word LOCAL, or other appropriate approved wording. The HIGH-LEVEL OPEN, LOW-LEVEL OPEN and CLOSE doors push buttons shall be clearly indicated.

The key switch shall be an electric, non-mechanical type switch. Insertion and rotation of the standard coach key shall activate the door controls without physically moving a switch contact. A photoelectric sensor or equivalent device shall identify the uniqueness of the standard coach key so that non-standard keys cannot operate the doors. Alternate mechanical designs that are functionally equivalent may be submitted for approval by the Customer. The key shall be captive while the door control panel is active.

The position of the each side door stairwell trap door shall be interlocked with the door control at each location so that the side door can only open when its corresponding trap door is in the proper position for the door opening command requested for that side of the train. If a HIGH-LEVEL PLATFORM OPEN push button is operated, the trap door must be latched in the down position for that side door to open. If a LOW-LEVEL PLATFORM OPEN push button is operated, the trap door must be in the latched up position for its corresponding side door to open. Positive detection of the trap door position for the push button operated must be available for the corresponding door to operate.

For maximum train crew familiarity, the door control panel shall be arranged and dimensioned to the greatest extent practical in a manner similar to those of the existing Amfleet I cars, recognizing the additional functions of the multilevel door controls. The door control panels are exposed to exterior weather conditions when the doors are open, so they must be of a weather resistant design. The switches, indicators, seals, panel and all compartments shall be watertight and chemical resistant to exclude moisture, carwash solution and dirt during cleaning of vestibules.

It shall require use of the Amtrak standard coach key to activate a door control panel. It shall be possible to remove the key after the doors have opened, and the doors shall remain open; and to close the doors from a different energized door control panel, with zoning re-established.
at the panel used to close the doors. Activation of a door control panel shall zone the door commands from the door control panel activated.

Door control switches shall be of the momentary contact type, and circuitry shall be arranged so that when a button is pressed, the operating cycle shall be completed even if the button is immediately released. Door control switches shall be watertight and chemical resistant incorporating an approved, easily replaceable and durable elastomer seal between the panel and switch button to prevent entry of moisture, dirt and contaminates. The switch assembly on the panel may be of the membrane type that is completely sealed, waterproof, chemical proof, dirt proof and completely replaceable as a unit. The door control panel shall have a stainless steel faceplate, be gasketed against weather and dust entry, and use stainless steel fasteners and top hinge. The faceplate shall be mechanically attached to the hinge for ease of replacement.

The circuitry shall be so arranged that pressing the door open button in the active door control panel will immediately stop the door closing operation at any time and cause the doors to reopen. If the door close button is pressed before the doors are fully open, the doors shall close without going through the signal and timing cycle. After the doors are fully open, the signal and timing cycle shall be restored to its starting point.

### 8.4 Exterior Crew Switches

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 separate high-level platform and low-level platform key operated crew access switches. The high-level platform crew switch panel shall be flush mounted to the carbody approximately 3 ft 2 in. above the interior floor line and located adjacent to the door, for a total of four per car. It shall open the adjacent door in the high-level platform mode, and close the door. The low-level platform crew switch panel shall be located under the side sill adjacent to the door, preferably near the manual exterior release for the trap door latch, for a total of four per car. It shall open the adjacent door in the low-level platform mode, regardless of the trap door position, and close the door. 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. The door shall immediately reverse direction during the opening or closing cycle if so commanded by the crew switch. The crew switches shall be speed interlocked on a local car basis except for when the car is placed in layover or storage mode with the car battery switched off.

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 insure 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.

After operation of a crew switch from outside the car, it shall be possible to remove the key with the door in either the open or closed position. When a door has been opened by operation of a crew switch and the key is removed from the crew switch, it shall be possible to close the open door by means of any door control switch panel on that side of the train; thereafter, the door shall operate normally. Likewise, when a door has been opened at a door control switch panel, 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 Customer during design review.

### 8.5 Emergency Door Release

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. This shall be achieved by manual release of the door operator. The emergency door release handle shall unlock and release the adjacent door by means of a pull cable or other approved mechanism. Low-level or high-level door opening shall take place in accordance with the raised or lowered status of the vestibule trap door.

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.

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. 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.

### 8.6 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 at 30 to 95VDC. The indicator lights shall be extinguished when the master battery switch for the car is in the OFF position.

#### 8.6.1 Exterior Door Open Indicator

One red LED indicating light shall be mounted on each side of car exterior at each end vestibule, 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. 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.
8.6.2 Side Door Control Panel Signal Lights

Each vestibule side door control panel shall be equipped with three green LED signal lights, visible in bright sunlight, to indicate the door closed status of all cars in the train, including Amfleet I cars. The lights shall be of the push-to-test type, or a separate test button shall be provided. One light shall be located in line with each vertical column of push buttons controlling the forward zone, the rearward zone and the local door, and shall indicate the closed condition of the doors under the control of the appropriate push buttons. The circuitry shall be arranged so that when the door control panel on one side of the vestibule has been activated, the appropriate signal light shall be illuminated green when all side doors in its zone are closed and locked.

A green LED signal light shall be provided in the operating compartment of the cab car to indicate door closed status of all cars in the train, including Amfleet I cars. The circuitry shall be arranged so that the light is illuminated when all side doors on the train are closed and locked. The light shall be tested by a common test switch in the Engineer's light panel. The signal light shall continue to perform its normal function when the traction interlock bypass switch is activated. This signal light shall also be located in each crew office location in the café/lounge car and the cab car.

8.6.3 Interior Signal Lights

A small unobtrusive amber LED shall be located in the ceiling of each end vestibule adjacent to each exterior side door, for a total of four per car. They 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.

8.7 Door Closing Signal System

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 36CFR Section 1192.113(c) and 49CFR Section 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. 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 rated for 30 to 95VDC input and shall have an adjustable 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 Customer for approval during design review.

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.

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
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door, and shall be user-adjustable. The details of the system shall be submitted to the Customer for approval during design review.

Each car may be equipped with a Conductor communicating signal buzzer system as detailed in Chapter 23, at Customer request.

8.8 Vestibule End Sliding Doors

An electrically powered sliding door shall be located between the passenger seating area and the vestibule area at each end of the car. Each door leaf shall incorporate a service-proven obstruction sensing system. No door closing warning shall be given.

At Customer request, each door shall be passenger operated on each side by both a ceiling mounted infrared proximity sensor, and a side door frame mounted push plate electrical switch, identical to the end door arrangement used on the Amtrak Acela trainset. The proximity sensor shall have an adjustable detection range suitable for the railroad environment, and shall not open the door for typical nearby passenger movements (such as accessing nearby luggage racks, etc.) when doorway passage is not intended. It shall easily permit future adjustments in sensitivity and detection zone by Amtrak. Details must be submitted for approval. Approved LED back lighted push plate switches shall be used. The switches shall be back lighted when the door operator is in Normal mode.

A backup local manual control shall be provided. The door panels shall not use kick plate control switches as currently used on the Amtrak Amfleet cars. The doors shall be labeled for emergency egress in accordance with APTA Recommended Practice SS-PS-002-98.

Each 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. Each door operator shall include a maintenance switch which will remove power from the motor to prevent operation while maintenance work is in process. All functions will be available, including diagnostics.

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.

8.8.1 Door Operator

An electrically powered overhead door operator system shall be supplied. The door operator shall be an electric motor and shall drive the bi-parting doors through the necessary drive train or linkage. Use of electro-pneumatic, belt or cable driven door operators is prohibited. 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. Thermal cutouts shall not be used nor required for motor protection. The drive mechanism shall be constructed to minimize torque applied to door panels during operation. The operator shall hold the door, without oscillation, in either a fully open or closed position during all train operating conditions, including stationary on 7 in. of track superelevation. Door closing speed shall not exceed 1 foot per second at any point in the closing cycle nor shall the closing time exceed 5 seconds. Regardless of the condition of the door track, the door shall have equal opening and closing speeds.

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.

8.9 End Door Control

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 Amtrak.

In normal mode, the end door shall automatically open fully within 2 seconds after the infrared sensor or 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 sensitive edge obstruction system is activated during closing, both door panels shall automatically fully open and remain open for 8 to 10 seconds before reclosing.

In door open mode, the door will automatically open and remain open.

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. The door shall be held in either the open or closed position with the vehicle subjected to track superelevation up to 7 in.

8.9.1 End Door Cutout Switch

Each sliding end door shall be equipped with an approved Amtrak type waterproof door cutout toggle switch, similar to that used on the present Amtrak Amfleet cars, 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 in Chapter 8. A red toggle switch guard shall be provided, which shall fully close only when the switch is in NORMAL position.

8.9.2 End Door Mechanical Lock

An approved positive mechanical lock, operable from the vestibule side of the door using the standard coach key, shall be provided to secure the door panels in the closed position. When the door is key locked closed, it shall disable door operator power. The door shall continue to be operable from the passenger seating side of the door, to prevent trapping passengers behind a locked doorway. The door system shall be designed so that no damage shall result to any system components should the door be activated when it is locked or otherwise prevented from operating.

* End of Chapter 8 *
Chapter 9

Interior
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This chapter defines the interior design and configuration for the revenue seating areas of the coach, café/lounge and cab/baggage cars, including vestibules, toilet rooms, stairways and overhead luggage storage bins.

All cars shall be equipped with an accessible toilet room, seating areas with overhead luggage bins, workstation tables and convenience outlets. Cab/baggage cars shall be equipped with a baggage/bicycle storage area. Coach and cab/baggage cars shall have a unisex toilet room. Café/lounge cars shall have a revenue seating area at the B-end of the car and a lounge area at the A-end of the car. For details regarding the lounge area, galley and food service equipment on the café/lounge car see Chapter 14. Cab/baggage cars shall have a locomotive control cab at the F-end (see Chapter 16).

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, task lighting, and individual work trays or tables.

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. If curtains are provided, they shall be provided on a track located above each window. Visible fasteners shall be minimized.

The cars will have designated crash energy management crush zone of 24 in. at the end of each coach and café/lounge car, and the B-end of the cab/baggage car. Coach and café/lounge cars, and the B-end of the cab/baggage cars shall not have any passenger seating or restrooms located closer than 24 in. to the car end exterior walls. This area should be used for trash and recycling receptacles, door opening equipment, luggage towers, HVAC supply or return ducts, utility lockers and other crushable components that allow energy absorption requirements to be met in the available space.

All systems requiring maintenance shall be easily accessible and removable for cleaning and repair.

A conceptual floor plan for all car types is provided for use by the Contractor as guidance to design the general layout of the car on both levels. These conceptual interior layouts shall serve as general guideline for the development of the interior of the cars. Final interior layouts shall be reviewed and approved by the Customer during design review.
9.3 Basic Features of All Car Types

Whenever possible, common components shall be used in all car types.

Strength of all interior fittings and their attachment to the carbody shall meet APTA Standard SS-C&S-006-98 and 49CFR Section 238.233.

All car types shall include the following:

- Accessible Toilet Room (ATR)
- Wheelchair parking location
- Wheelchair storage area
- Accessible transfer seat
- Mechanical wheelchair lift – B-end (one on each side). All structural and mechanical fittings and electrical connections needed for the wheelchair lift are required.
- Single and pair standard coach seating, facing seat pairs with workstation tables
- One Unisex Toilet Room (UTR) (except café/lounge car) - Optional
- 120 Volt Alternating Current (VAC) electrical outlets adjacent to each seat or seat pair on the sidewall (see Chapter 13)
- Trash receptacles and recycle bins at both ends of the cars
- Emergency tool locker
- Electric locker
- Public Address (PA) system (See Chapter 12)
- Passenger Information System (PIS)/Onboard Train Information System (OTIS) (see Chapter 12)
- Heating, Ventilation and Air Conditioning (HVAC) system (see Chapter 10)
- Lighting system (see Chapter 11)
- Low-Level Emergency Path Markings (LLEPM)
- Emergency lighting (see Chapter 11)
- Emergency and non-emergency windows (see Chapter 4)
- Passenger information signage and service markings
- Window treatments – curtains or shades
- Drinking water station (except café/lounge car) (see Chapter 15)
- Racks for promotional materials
- Enclosed overhead luggage bins
- Two vestibules with side entry doors
- Two end doors/passageways

The above configuration will represent the “basic” coach car for this Specification.
Refer to Figure 9-1 through Figure 9-4 for car interior conceptual drawings.

### 9.3.1 Coach Car

Whenever possible, identical components shall be used in all car types.

Features valid for all car types:

- Passenger Information System (PIS) and Public Address (PA) system
- Lighting system including emergency lighting
- Closed overhead luggage bins above the windows suitable for a standard airline suitcase
- One entrance area per 45 passengers seated (maximum 2 entrance areas)
- Partition walls with an automatic sliding door between entrance areas and passenger areas
- Passenger compartment aisle no less than 19.5 in. wide (495.3 mm)

The business class shall include the following features:

- Clearing between armrests no less than 19.5 in. wide (495.3 mm)
- All seats equipped with tables suitable for the use of laptops
- One 120VAC electrical socket per seat, suitable for the charging of laptops or mobile phones
- Trash bins in every entrance area (min. capacity of 500 in.³) and at all seats (min. capacity of 90 in³ per seat)
- Average capacity per car of at least 40 seats
- Nominal seat pitch of at least 39 in.
- One luggage rack/tower
- For coaches equipped with wheelchair spaces, one accessible toilet room is obligatory.

#### 9.3.1.1 Crew space

The coach car shall have an option for a crew office. This will comprise of a seating area with a table for two persons enclosed with full height wall glazed pocket door, lockable with a standard coach key lock, and shall be located on the A-end for crew to use. An extra pair of duplex outlets shall be provided for the crew to use for charging radios, cell phones and other equipment.

The overhead bin above the conductor’s workstation shall be fitted with a standard coach key lock.
9.3.2 Cab/Baggage Car

The cab/baggage car shall be configured as the basic coach with the following differences:

- The cab area of the car shall be located at the F-end (the end opposite the B-end) of the car and shall be a full-width control cab for push/pull operations. (See Chapter 16)
- A checked baggage storage area shall be located at the F-end of the car.

The baggage storage area shall be configured with a partition at the B-end. This partition shall contain a lockable door of sufficient durability to provide security for passengers’ checked baggage. The size of the baggage room shall be at the option of the Customer, and thus the car shall be designed to permit this door and partition arrangement to be located at any carline between truck centers. An optional secure area for package/express service/gun storage locker may be specified by the Customer.

A baggage door using the same hardware as the side passenger doors shall be provided immediately behind (towards the center of the car) the F-end truck. The clear opening of this door shall be no less than 60 in.

Standard sill steps and handholds complying with FRA “safety appliance” requirements shall be provided at the latch edge of this door. Passenger access will not be provided at this location.

In the case of a full length cab/baggage car, provision shall be made for a second pair of doors to be located behind the B-end truck, or for one pair only located between the side posts nearest the center of the car.

The room shall contain folding baggage shelves on both sides of the central aisle that allows converting individual sections into bicycle racks. The baggage room floor shall be made of 2 in. by 4 in. hardwood on edge with an appropriate non-skid finish. If this flooring construction results in a floor higher than that in the passenger (and cab) sections, every effort should be made to minimize the height difference. Stainless steel thresholds with an appropriate angle shall be employed to mitigate any tripping hazard.

The general seating in the remainder of the car will follow the coach configuration except for the space needed for the cab control area and the baggage area.

The baggage doors shall be designed to be operated via trainline, allowing passengers to self-load bikes or luggage at high-level platforms; or isolated and operated locally only, allowing checked baggage to be loaded by employees. See Chapter 8.

The partition between the coach section and the baggage room shall be equipped with a door that can be locked from the inside, to deter passenger entry to the baggage room when it is being used in checked baggage service. This door shall be capable of remaining unlocked when the baggage room is used for bicycle loading by passengers. The door, along with the structure supporting it and the piano hinge used to secure it to the partition, shall be robust to endure rough service by passengers and crews. The structure on the free-end of the door shall be robust to successfully sustain the impact of the door slamming closed. A latching bumper shall be provided to cushion the door at the full-open position, and when desired, to hold it there. The door shall use a self-latching latch to secure it when closed. This latch shall...
include a deadbolt operable by a standard coach key. Neither the door nor its hardware shall
rattle when latched in either the open or closed position. A commercial duty door closer shall
be applied on the baggage room side of the door to control its motion.

The Contractor shall design the intermediate carbody (non-cab car or coach) to accommodate a
similar range of possible floor plans.

**9.3.3 Business Class Car**

At the discretion of the Customer, a business class car may be configured out of a coach car or
a cab/baggage car that may provide some or all of the following features:

- Seat and reading light pitch greater or less than that provided in basic coach;
- Business Class module where snacks, beverages and other provisions may be made available;
- Appropriate interior and/or exterior signage identifying the car as Business Class; and
- Other features and amenities as specified by the Customer.

**9.3.4 Americans with Disabilities Act (ADA) Provisions**

- Each car shall be fully compliant at the time of manufacture, with all rules and
  regulations of 49CFR 38, Americans with Disabilities Act (ADA) Accessibility
  Specification for Transportation Vehicles, and no part of these 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 Customer as part of the mockup review.
- Each car shall include at least one accessible wheelchair parking location, which shall
  allow the wheelchair passengers to remain in their wheelchairs while on board the car.
  Segway restraints will be provided at the Customer’s request. A storage area for an
  unoccupied, folded wheelchair, 48 in. long by 20 in. wide and 40 in. high, in close
  proximity to the wheelchair parking location and to accessible seating, shall be provided
  on each car.
- Each wheelchair-accessible coach which includes revenue seating shall also include an
  accessible toilet room. The toilet room door may operate manually and shall be of the
  sliding type. Requirements for the toilet and associated equipment are included
  elsewhere in this Chapter.
- 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. 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.
- Each car shall include a wheelchair lift on each side of the car’s vestibule. For cars
  having two vestibules, only one vestibule is required to have the lift equipment. At the
  Customer’s option, this on-board equipment (as specified in the following articles), may
  be superseded by wayside-located portable lift equipment.
  - Basic Parameters: The lowest station platform height for the purposes of the lift’s
    upper and lower reach shall be assumed to be the top of rail. Movement of the lift
    shall allow a wheelchair occupant or other disabled rider to be lifted from platform
    height at the top of rail to the car floor height. The lift design shall allow for an
    uneven station platform plane with platform slope in both the lateral and
longitudinal directions. The lift design shall also allow for operation when the car is on a curve with up to 7 in. of lean, due to super-elevation. As part of the installation review conducted with the Customer, cross-sectional views showing the lifts deployed on each side of the car on level, tangent track and on curve with the maximum specified super-elevation shall be provided. These shall depict the anticipated effects for both an unloaded and a fully-loaded (at least 600 lbs per 49CFR Section 38.159) wheelchair lift.

A fold-down barrier shall be mounted on each side of the vestibule, across from the lift, to prevent a wheelchair from rolling down the vestibule steps of the opposite side. Design of the barrier shall be subject to the Customer’s approval.

The lift shall be of modular, compact design to facilitate removal and replacement for servicing/repair. These requirements also extend to the hydraulic pump (or other operating technology, such as electro-mechanical) and controls associated with the lift. The installation review with the Customer shall also consider the location and accessibility to the pump and other controls. Weather resistant stainless steel enclosures with provisions to drain any accumulations of moisture shall be provided to protect undercar components. The back of the enclosure shall have a drain of sufficient size to discharge dirt and water when cleaning the lift with a pressure washer.

The lift and associated equipment shall be suitable for sustained operation under all ambient conditions through which these cars are expected to operate (see Chapter 3).

- Lift Controls: Controls for each lift shall be adjacent to the lift they control and shall allow a train crewmember to readily supervise all aspects of the lift operation and movements of the wheelchair occupant to/from the lift without obstructing or impacting the occupant’s movements.

In the event of lift failure or a power failure, it shall be possible to manually operate the lift to or from any position in the raising/lowering cycle, regardless if the lift is loaded or unloaded, and to stow and deploy the lift platform. Operation of the lift in manual mode shall not damage the lift or its components.

A standard Amtrak coach key shall be required to operate the switch for each lift. The location and design details of this switch shall be approved by the Customer. When in the ON position, the lift controls shall be enabled and the brakes on the car with an activated lift shall be applied. This status shall be communicated to the active control position on the train, whether in a locomotive or a cab car. These events shall also be triggered when the switch is in the OFF position and the lift is being manually deployed. Each lift control position shall have separate switches to control the deployment of the lift, the stowing of the lift and the raising and lowering of the lift platform. Each of these switches shall be clearly labeled as to function.

The controls for the operation of the on-board lifts shall be interlocked with the car’s air brake system and with the locomotive control system to prevent train motion.

- Optional Lift Control Provisions (Not required by 49CFR part 38):
  - An indicator LED shall illuminate on both sides of the car when a wheelchair lift is energized, regardless of the position of the lift. An audible signal shall also sound when the wheelchair lift is being deployed and when it is being stowed.
  - Lift controls shall be local and side-specific. Lift controls shall not be co-mingled with side door controls.
  - A top-hinged, spring-loaded cover (to hold in the open position) shall be provided over the lift controls. When the cover is in the “open” position, that set of controls shall be enabled.
- **Lift Movement:** The wheelchair lift shall stow such that it does not prohibit or otherwise impact the use of the fixed steps or the vestibule on that side of the car by able-bodied persons. Pinch points shall be kept to a minimum with suitable warning marking provided.

The wheelchair lift shall stow such that the accessible entryway, at a high-level platform, is not restricted by the wheelchair lift for a wheelchair user.

- **Lift Capability:** The design load of the lift shall be at least 600 lbs, per 49CFR Section 38.159(b).

- **Optional Lift Capability Provisions (Not required by 49CFR Part 38):** Under power operation, the complete cycle of deploying the platform, lowering the lift to platform height, raising the lift to car floor height and stowing the lift platform shall require no more than between 30 and 60 seconds.

- **When being manually operated, the sequence of events required to complete the lifting or lowering cycle shall require no more than three times the maximum time allowed for the sequence under power operation (see previous paragraph), when operated by a 90 percentile female person.**

- **Anti-Roll Barrier Design (Not Required by 49CFR Part 38):** The barrier may be constructed of stainless steel and covered with alternating stripes of a combination that achieves maximum visibility (on vinyl film) to clearly denote the barrier when deployed.

- **Lift Movement:**
  - The wheelchair lift shall stow such that it does not prohibit or otherwise impact the use of the fixed steps or the vestibule on that side of the car or unit by able-bodied persons. Pinch points shall be kept to a minimum with suitable warning marking provided.
  - The wheelchair lift shall stow such that the accessible entryway, at a high-level platform, is not restricted by the wheelchair lift for a wheelchair user.

- **Lift Capability (not required by 49CFR Part 38):**
  - Under power operation, the complete cycle of deploying the platform, lowering the lift to platform height, raising the lift to car floor height and stowing the lift platform shall require no more than 45 seconds, plus or minus 15 seconds.
  - When being manually operated, the sequence of events required to complete the lifting or lowering cycle shall require no more than three times the maximum time allowed for the sequence under power operation (see previous paragraph), when operated by a 90 percentile person.

- **Lift Capacity:**
  - The design load of the lift shall be at least 600 lbs, per 49CFR Section 38.159(b).

- **Anti-Roll Barrier (not required by 49CFR Part 38):**
  - A fold-down barrier shall be mounted on each side of the vestibule, across from the lift, to prevent a wheelchair from rolling down the vestibule steps of the opposite side. The barrier shall be constructed of stainless steel and covered with alternating stripes of black and yellow (on vinyl film) to increase visibility when the barrier is deployed. Design of the barrier shall be subject to the Customer's approval.
The coach 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 mockup process to be approved by the Customer.

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.

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.

9.4.1 Vestibules

- Each car or carbody (if part of a trainset) shall have vestibules located at each end. The vestibule shall include the following elements:
  - Side entrance doors (one on each side of the car) – specified elsewhere
  - Fixed steps with trap door (one on each side of the car)
  - Door control panels – specified elsewhere
  - PA system panel – specified elsewhere
  - Wheelchair lifts (one on each side of the car) – specified elsewhere
  - Lockable compartment for bridge plate (one per vestibule)
  - Bridge plate
  - Recycling and trash receptacles – specified elsewhere
- The minimum clear width of the vestibule (exclusive of side and end doorways) shall be 3 ft 6 in.
- 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).
- The vestibule floor and steps 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.
- 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 Customer’s approval. All installations shall be free of rattles and squeaks and shall comply with APTA standards for the attachment of interior fittings.
- All stair risers in the vestibule shall have the upper 4 in. covered by Fluorescent Yellow, 3M Scotchlite No. 680CR-71 or approved equivalent, warning material. The warning material shall be applied to resist peeling.
• All vestibule step treads shall have a full-length 3 in. wide yellow strip on their outer edge. Step treads shall be covered with a skid resistant material subject to the Customer’s approval.

• A stainless steel WATCH YOUR STEP sign shall be applied to the top riser of the side entrance steps on both sides of the car. Letters shall be etched and filled with black paint.

• Anti-freeze protection shall be provided under the bottom step of each side entrance door and shall have sufficient capacity to prevent ice formation at these locations under the severest of winter operating conditions these cars are likely to encounter.

• A retractable trap door shall be provided on each side above the vestibule steps to facilitate boarding/alighting at both low- and high-level platforms. The width over the trap door (outer edge-to-outer edge) shall be at least 36 in. The trap doors shall be constructed of stainless steel covered with plates having a plasma spray anti-slip treatment applied. The travel of the trap doors shall be regulated by torsional springs, which provide a maximum lift of 12 in. and a minimum of 6 in. when released from the down position. The door shall assume a position of between 10 and 20 degrees from the horizontal when released from the up position. Spring tension shall be incrementally adjustable. When in the full up position (stairs clear for boarding/alighting) the trap door shall be retained by a latch – Adams & Westlake No. 760 or approved equivalent. The latches shall be installed to prevent the development of rattles when in service. The trap doors shall be equipped with sheet heaters, RTR Technologies No. 302096, or approved equivalent.

• A recessed enclosure, with suitable keyed lock, shall be provided to contain the bridge plate. The location of the enclosure shall not interfere with the operation of the side doors, the trap doors, wheelchair lift or the vestibule bulkhead door. The enclosure shall have provisions to drain any moisture accumulation. A safety chain shall prevent the bridge plate from dropping to the floor when unlocked. Rubber bumpers shall be provided inside the enclosure to minimize rattling of the bridge plate when in the stowed position.

• A bridge plate shall be provided. The bridge plate 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. The bridge plate shall not weigh more than 50 lbs.

• 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.

• Each vestibule shall have at least three fluorescent or LED ceiling-mounted fixtures, with one fixture located over each of the side door areas in the vestibule. A double 24 in. fixture, Trans-Lite No. S-7593-12 F, or approved equivalent (for a fluorescent fixture), shall be located over each stairway, as close to the side of the car as practical. This same fixture shall be located over the center aisle in the vestibule. All vestibule fixtures shall be moisture-proof, operate on 120VAC and shall utilize 0°F rapid-start ballasts, if utilized. Emergency light fixtures shall also be installed in each vestibule, with the quantity and location subject to the Customer’s approval.

9.4.2 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.

9.4.3 Side Walls

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. 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).

Wainscot fabric, if specified, shall be a woven loop pile weave using 100% wool face yarn incorporating static control and have a synthetic backing material. An approved stain resistant chemical shall be applied to the wainscot carpet material. Wainscot fabric shall be applied to the wainscot panel using a manufacturer-approved adhesive. Wainscot fabric shall comply with the following requirements:

- Pitch: 216 P. O. B.
- Rows per Inch: 10.5
- Pile Height: 0.14 in.
- Weight: 20.0 oz/square yard
- Width: 12 ft, slit to 6 ft

9.4.3.1 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.

9.4.3.2 Sidewall heat

Passenger seating areas as well as the café/lounge car passage at the galley 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.

9.4.4 Diffusers and Grilles

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.

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.

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 engineer's cab, baggage
room and galley (when it is secured). 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.

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 at nominal supply voltage.

9.4.5 120V Outlet Strip

Convenience outlets utilizing duplex 120VAC receptacles shall be located between the window
mask and wainscoting. 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. forward from the front of the seat back, 16
in. forward of the seat back for those seats located at tables. Two duplex receptacles 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, in accordance with Amtrak Specification 697, shall be installed on
the conduit cover at each outlet location, 0.50 in. 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.

9.4.6 Central Ceilings

The central ceilings shall cover the main lighting and the blow out of the air conditioning. 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.

The ceilings shall be made of a wear resistant and easy to clean material, preferably coated
metal sheets.

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.
9.4.7 Drinking Water Stations

Each car shall be equipped with a drinking station at the A-end of each car. Each station will consist of:

- Chilled water cooling unit (see Chapter 15);
- Recessed chilled water dispenser with drain;
- Recessed cup dispenser for 100 - 4 oz paper cups, with durable springs to secure cups in the unit;
- An access side panel secured with quarter-turn fasteners for access to the water cooler for maintenance;
- ADA compliant design; and
- Clearly marked trash container for disposal of used cups.

9.4.8 Electrical Locker

The electrical equipment and switch locker shall be located as appropriate near the cab or at the end of the car.

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.

The door lock shall be a coach key style lock with interior release latch.

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. 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.

The locker shall include a metal pocket or rack to hold the car defect report book, which is approximately 8.5 in. wide by 11 in. tall by 1 in. thick. Likewise, an 8.5 in. wide by 11 in. tall metal surface shall be provided on the inside face of the door for FDA inspection form and stickers.

9.4.9 Recycling and Trash Receptacles

Recycling and trash receptacles shall be provided on both ends of each car type as close as practical to the end of the car interior. They shall meet all FDA and NSF requirements for trash containers and their materials. Each set of receptacles shall include two separate openings and respective bins: one for trash, and one for recyclables (cans, bottles and newspapers). Openings for these receptacles shall be designed to encourage passengers to use the proper receptacle for disposing of trash and recyclables, through the use of distinctive opening designs and signage. The recycling and trash receptacles shall be either side-by-side in a row or directly across the aisle from one another. To the extent possible, these receptacles shall be designed to accommodate the Amtrak standard trash container, per Amtrak Drawing C-96-7591. The receptacles shall be labeled with an icon for type of contents, in accordance
with Amtrak Specification 697. The locker shall include appropriate brackets and/or guides to properly index the containers with the openings, and as required, to keep them upright. The containers shall be rounded to protect staff handling the containers or servicing the end door from injury.

Toilet rooms shall only contain a trash receptacle, sized to provide the maximum trash capacity and receptacle opening permissible by the toilet room design.

Recycling and trash receptacle lockers shall be of panel construction with substructure as appropriate to support components. Panel construction shall be the same as bulkheads when transverse walls serve as bulkheads. Longitudinal walls shall be of the same construction as the bulkhead walls except that there will be no wainscot carpeting.

Trash and recycling locker door panels shall have melamine or factory-applied laminate. Alternatively, panels may be constructed of honeycomb or plymetal wall materials. The door shall be secured closed with a pencil latch and shall include a knob or handle to be used to pull the door open when unlatched.

Visible hardware and fasteners shall be minimized to aid cleaning, reduce build-up of contaminants and provide for pleasing aesthetics.

Vertically-oriented recycling and trash receptacles shall include a hinged self-closing door flap, shall be a touch-free design and shall be as large as practical. These flaps shall be held closed by gravity without requiring the use of springs. Horizontally oriented recycling and trash receptacles shall have clear openings without flappers.

The inside of the trash locker shall be easy to clean and be sealed at all joints for good sanitation and to meet FDA requirements.

9.4.10 Enclosed Overhead Luggage Bins

Enclosed overhead luggage bins shall be provided above all revenue seating. The Customer may specify open luggage racks in lieu of enclosed bins and if so will provide a specification in Chapter 23. The luggage bins shall consist of modular units bolted to the sidewall and roof car structure and extend the entire length of the passenger-seating compartment. The bins shall accommodate carry-on luggage of up to 13.38 in. by 18 in. by 22 in. in size. The door opening shall provide at least 14 in. open vertical clearance. Length of bin modules shall match the window pitch so that the bin dividers are located centered on the pillar between windows. Design of the bins shall include as few obstructions as possible for manipulating luggage into and out of the bin.

The bin shall incorporate a raised lip along the longitudinal edge of the luggage support surface. The lip shall be of a sufficient height to mitigate the potential of any luggage resting on the bottom surface of the bin from sliding out of the bins when the doors are opened.

Luggage bin doors shall be robustly hinged at the top with a stainless steel piano hinge. Doors shall contain a positive latching device to secure the door in the closed position and retain luggage inside the bin in accordance with FRA securement requirements specified in 49CFR Section 238.233. Under no conditions shall the door latch self-disengage during train operation. The doors shall be self-opening when the door latch is released. The mounting of hinges, latches, keepers, dampers and self-opening mechanisms shall be via steel tapping plates, which are integral with the rack and door structure, so that hardware does not work loose or cracks develop in the parent material. Design of the bins shall take into account the
likely rough handling by passengers in the course of normal service life, including repeated loading and unloading of luggage. The luggage bins shall be designed, manufactured and installed to prevent rattles resulting from car movement at any speed. Reliability and robustness of the luggage bin system shall be demonstrated to Customer satisfaction. A 50,000-cycle endurance test shall be conducted on the door and all associated hardware (latch, hinges, self-opening mechanism, etc.) to demonstrate reliability and freedom from wear. See Chapter 19.

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. The luggage bin fascia shall be fiberglass faced or approved alternative. The underside of the luggage bin fascia shall integrate the upper curtain track above the side windows.

The bin structure and attachment to carbody shall have sufficient strength to support a load of 250 lbs, applied over a 10 in. by 10 in. area, midway between adjacent supports with a deflection not to exceed 0.25 in. (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 an angle of approximately three degrees. The complete and fully-loaded luggage bin and its attachment to the carbody shall be designed to resist loads, without failure or door opening, due to accelerations of 8g longitudinally, 4g laterally and 4g vertically, acting on the mass of the luggage. The Contractor shall demonstrate the strength and luggage retention capability of the luggage bins during the design review.

Track-mounted reading light assemblies, as described in Chapter 11 shall be mounted on the underside of the bins, with the entire installation conducted from the bottom side of the bins. The design shall allow the light fixture units to be moved in small increments longitudinally along the luggage rack so as to allow it to be centered above each passenger seat pair, regardless of seat pitch. The luggage rack shall be equipped with a wiring chase or equivalent that provides the flexibility in wiring to achieve this.

A means to retain conductor seat checks shall be provided on the luggage rack. This may be individual parts, a continuous strip or part of the reading light assembly. The seat check holders shall hold seat checks in plain view of the conductor, looking along the length of the car. Seat check holders shall be positioned so that seat checks are not easily struck by passengers using the luggage rack edge to steady themselves. The design of the seat check holders shall be integrated into the design of the luggage bins.

9.4.11 Luggage Racks/Towers

A luggage rack/tower shall be provided at both ends of the car. It shall be of robust tubular brushed stainless steel construction and include shelves. Bumper guards shall be mechanically attached to the wall panels within the luggage rack/tower to prevent damage to walls or luggage.

The racks shall have sufficient strength to support a load of 250 lbs midway between adjacent supports with a deflection not to exceed 0.25 in. and without permanent deformation. The load-bearing surface shall be not less than 24 in. wide and shall be inclined upward from the horizontal toward the center of the car at an angle of approximately three degrees.
9.4.12 Baggage Room

A separate area shall be provided in the F-end half of the cab/baggage car for storing checked baggage and passenger-loaded bicycles. This storage room shall be approximately 32 ft long (including the F-end vestibule) from the transition bulkhead at the F-end to the interior partition wall separating the baggage room from the seating area. The baggage room shall consist of four sets (two on each longitudinal wall) of flip-up luggage shelves, similar to those used in the A-end vestibule luggage rack/bike rack on coach cars. Each set of shelves shall consist of two shelves that can flip up to access a wall-mounted bike rack. The shelves in the F-end vestibule shall be identical to those in the A-end vestibule of coach cars. The baggage room shall be designed to hold a minimum of 10 bicycles. The bicycle racks used in the baggage room shall be identical to those used in the A-end vestibule of coach cars.

The side entry doors in the baggage room shall be operated using a Door Control Panel-Local, and shall have the capability of being controlled via a trainline command, or only from the local door control panel. The Door Control Panel-Local and Trainline/Local switch shall be located adjacent to door 7. See Chapter 8. The side baggage door openings shall be a minimum of 60 in.

9.5 Toilet Rooms

9.5.1 Accessible Toilet Room (ATR)

The Accessible Toilet Room (ATR) shall be located on the right side of the A-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:

- The restroom shell shall be constructed primarily of FRP or thermoformed plastic with a high gloss gel coat finish on surfaces exposed to the public. All corners of the shell shall have a minimum 2 in. radius to eliminate the accumulation of debris and aid in cleaning.
- Trash bins shall be sized to use Amtrak standard 30 gal trash liners and have a large bin opening.
- 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.
- A tempered safety glass or polished stainless steel mirror with a minimum 20 in. by 30 in. 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.
- A water-resistant, LED light fixture shall be mounted over the toilet vanity mirror.
- A high velocity motion-activated hand dryer/blower.
- A sliding pocket door with lock shall be provided. The lock shall be operable from the outside with a standard Amtrak coach key. An LED TOILET ROOM OCCUPIED indicator light shall be provided on the outside of the toilet room, and 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 (see Chapter 11). A decal shall provide door lock operation instructions.

- All controls, switches and amenities shall be readily accessible and operable by
  passengers with disabilities.
- Stainless steel, anti-slip grab bars shall be provided in accordance with 49CFR Part 38
  Subpart F, Section 123(a)(3).
- Minimum ATR dimensions shown by 49CFR Part 38 Subtitle A, Figure 4 Intercity Rail
  Car (with accessible restroom); and as defined in 49CFR Part 38 Subpart F, Section
  38.123(a) shall be met or exceeded.
- A toilet stand with shroud assembly (see Chapter 15) shall be located in the toilet room.
- An automatic electronic flush mechanism shall be incorporated into the toilet. An
  electronic touch free back-up manual flush button shall be in an obvious and
  convenient location to the user. The toilet shroud shall be constructed of FRP with gel
  coat color to match the restroom shell or of stainless steel with brushed finish. The
  toilet seat and cover shall be constructed of Coralink or reinforced fiberglass.
- 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.
- Sink and countertop shall be constructed of a solid surface material or a brushed finish
  stainless steel.
- A 120VAC Ground Fault Circuit Interrupter (GFCI) duplex receptacle shall be located
  near the sink.
- An electronic touch free or Celeste foam soap dispenser base shall be mounted on the
  countertop in compliance with ADA regulations.
- A minimum of two heavy duty coat hooks, a toilet seat cover dispenser and a baby
  changing table (that can support 75 lbs) with child belt shall be provided.
- An Amtrak standard facial tissue dispenser shall be provided.
- The fittings in toilet rooms shall meet the attachment strength requirements defined in
  49CFR Section 238.233.

9.5.2 Optional Unisex Toilet Room (UTR)

If specified by the Customer, the Unisex Toilet Room (UTR) shall be located on the right side of
the A-end of each car type immediately adjacent to the Accessible Toilet Room (ATR). It shall
have the following features:

- The restroom shell shall be constructed primarily of FRP or thermoformed plastic with a
  high gloss gel coat finish on surfaces exposed to the public. All corners of the shell
  shall have a minimum 2 in. radius to eliminate the accumulation of debris and aid in
  cleaning.
- Trash bins shall be sized to use Amtrak standard 30 gal trash liners and have a large
  bin opening.
- 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
A tempered safety glass or polished stainless steel mirror with a minimum 20 in. by 30 in. 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.

A water-resistant, LED light fixture shall be mounted over the toilet vanity mirror.

A high velocity motion-activated hand dryer/blower.

A sliding pocket door with lock shall be provided. The lock shall be operable from the outside with a standard coach key. An LED TOILET ROOM OCCUPIED indicator light shall be provided on the outside of the toilet room, and 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 (see Chapter 11). A decal shall provide door lock operation instructions.

Stainless steel, anti-slip grab bars shall be provided.

A toilet stand with shroud assembly (see Chapter 15) shall be located in the toilet room.

An automatic electronic flush mechanism shall be incorporated into the toilet. An electronic touch free back-up manual flush button shall be in an obvious and convenient location to the user. The toilet shroud shall be constructed of FRP with gel coat color to match the restroom shell or of stainless steel, with brushed finish. The toilet seat and cover shall be constructed of Coralink or reinforced fiberglass.

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.

Sink and countertop shall be constructed of a solid surface material or a brushed finish stainless steel.

A 120VAC Ground Fault Circuit Interrupter (GFCI) duplex receptacle shall be located near the sink.

An electronic touch free or Celeste foam soap dispenser base shall be mounted on the countertop in compliance with ADA regulations.

A minimum of two heavy duty coat hooks, a toilet seat cover dispenser and a baby changing table (that can support 75 lbs) with child belt shall be provided.

An Amtrak standard facial tissue dispenser shall be provided.

The fittings in toilet rooms shall meet the attachment strength requirements defined in 49CFR Section 238.233.

9.5.3 Toilet Room Pan and Flooring

The floor pan of the toilet room modules shall be FRP with 2 in. 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. in height. The pan’s exposed edges shall be folded for safety and to provide stiffness. The floor

into contact with the floor heat. In addition, storage for additional toilet paper rolls shall be provided.
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. up the sidewalls to form the inside scuff/kick plate. The edges shall be sealed to form a watertight seal.

9.6 Interior Décor

The Contractor shall develop and provide to the Customer 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. The elements to be proposed on this palette shall include the colors, patterns, textures and gloss levels of the:

- Seat material (revenue seats)
- Seat material (lounge area booths)
- Carpet
- Curtain or shade material
- Wainscot fabric
- Melamine laminates for use on wall panels and table tops
- Fiberglass panels
- Acrylic countertops
- Thermoform plastic panels
- Skid resistance composite flooring for stairs, vestibules, toilet rooms, passageways and other non-carpeted areas
- Powder coated or anodized metal items

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 Customer, at the preliminary design review, the criteria that will be used to select the elements of the interior décor. The six storyboards shall be based on adequate differences so that the Customer has a wide variety of interior concepts from which to choose. Additional Customer considerations or requirements that will guide the development of the storyboard palettes are included in chapter 23. The Customer shall select the storyboard of its choice prior to the final design review.

Using the approved interior décor palette, the Contractor shall provide at the final design review a series of computer-generated conceptual images that represent the simulated appearance of the car interiors, including the fabrics, textures and patterns selected by the Customer.
These images shall include (but are not limited to) several views of each of the following areas of the cars:

- Passenger seating area
- Toilet rooms
- Vestibules
- Lounge area
- Galley area

These images shall be provided to the Customer in both electronic and large-format print. The Customer may use these images for purposes of public relations or other pre-production activities.

### 9.6.1 Floor Covering

#### 9.6.1.1 Carpeting

All carpet shall be designed per Customer specification and shall be designed to provide maximum passenger comfort and safety as dictated by ergonomic requirements. The carpet shall be compliant with all applicable APTA and ADA guidelines. See Chapter 23.

#### 9.6.1.2 Skid resistant flooring

Skid-resistant, waterproof composite floor covering, that has been tested and proven, shall be used in end passageways, operator’s cab compartment, restrooms, baggage room, galley areas and other utility areas where carpet is not installed. The floor design must be compatible with the requirements in Chapter 4 and comply with 36CFR Part 1192 Appendix (Advisory Guidance).

The floor covering shall have an integral cove, where specified, for easy cleaning, and shall extend from 2 in. to 6 in. up the wall, depending upon application.

Transition strips shall be provided between composite flooring and carpeted areas. Transitions between flooring types shall produce level changes in flooring surfaces less than 0.25 in.

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.

Floors in vestibules and end passageways shall have a 3 in. 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 Standard SS-PS-004-99 and shall be embedded in the floor system.

All flooring shall be installed using an adhesive system that is approved by the flooring manufacturer.
9.6.2 Seats and Tracks

9.6.2.1 Seats

All passenger revenue seating locations in the coach car, cab car and business class car shall use a fixed (non-rotating) 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 coach and cab cars. See Chapter 23 for Customer specifics regarding seats, seat pitch, seat fabrics and other details. Seats in the cab car shall all be facing the B-end of the cab car (rear-facing), except for the operator and crew seats, and seats at workstation tables.

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 facing pair of seats. The minimum distance between the two facing seats bottom cushion faces shall be 23 in.

APTA Standard SS-C&S-016-99, revision 2 or newer, *Standard for Passenger Seats in Passenger Rail Cars* shall be used as a design guideline.

Seats shall be designed to provide maximum passenger comfort and safety. The seat design shall maximize passenger legroom and have:

- Adjustable footrests
- Folding, adjustable tray tables
- Cup holders
- Magazine pouches

All colors, cushions, fabrics and appearance shall be as directed by the Customer. 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.

The seats shall be mounted in standard adjustable seat-mounting track allowing for pedestal or pedestal wall mounting. Mounting slots shall be included on the underside of the seat frame allowing for lateral adjustability.

9.6.2.2 Seat tracks

Revenue seats shall be mounted in seat tracks on the floor and wall of the upper and lower levels of all car types. Seat tracks shall be installed per Amtrak Drawing D 035-00244 (see Chapter 4). A rubber extrusion shall be inserted in all seat tracks (wall and floor) between seat pedestals. Seats shall be mounted to the seat track in accordance with the strength and crashworthiness requirements of APTA Standard SS-C&S-016-99.

9.6.2.3 Workstation tables

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 melamine laminate top surface and composite edge machined smooth and free of sharp edges and burrs. The top shall have a raised perimeter to retain spilled liquids.

Energy absorption features shall be built into the workstation table and/or its attachments such that human injury criteria for the 50th percentile HIII male ATDs are not exceeded during dynamic sled testing, per the requirements specified in APTA Standard SS-C&S-016-99, Section 5.2.1, modified for testing with a workstation table installed. The table must meet the performance requirements specified in Section 5.2.1.3 of APTA Standard SS-C&S 016-99. The table must not become detached from its mountings and the ATDs must remain compartmentalized between the table and the launch seat.

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 Amtrak Drawing D-035-00244. The table top of each workstation table shall measure 28 in. deep by 44 in. wide. The table leg shall be round, with a minimum 2.5 in. 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.

### 9.6.3 Curtains and Shades

A curtain track shall be provided at the top of the window area, along the length of the car for curtain installation. The curtains shall be free hanging at the bottom, but secured in the open position with a tie-back of the same fabric that is permanently attached to the curtain and secured with heavy duty Velcro-style hook and loop fastener.

Color and pattern of the curtains is specified in Chapter 23.

The fabric shall comply with the following test requirements:

<table>
<thead>
<tr>
<th>Test</th>
<th>Method</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>ASTM D3776/D3776M-09a</td>
<td>6.8 oz/square yard</td>
</tr>
<tr>
<td>Width</td>
<td>ASTM D3774-96</td>
<td>54.0 in.</td>
</tr>
<tr>
<td>Fabric Count</td>
<td>ASTM D3775-08</td>
<td>Warp: 88.8 ends per in.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fill: 46.0 picks per in.</td>
</tr>
</tbody>
</table>

The curtain shall be able to withstand normal cleaning without stretching, pilling, puckering, shrinking, rippling, zipper, fading or other adverse effect to its appearance or function. Curtains shall be machine cleanable using water and detergent followed by machine drying. The vendor shall provide recommended cleaning instruction in the service and inspection manual. The curtains shall not require dry cleaning.

As an alternative to curtains, adjustable height, roll-down, tinted, translucent or opaque, shades may be provided for any windows designated by the Customer. Shades shall prevent sunlight from coming through the windows. The shades shall be positional over the full height of the windows. Vibration and normal vehicle motions shall not cause the shades’ adjusted position to change.”
9.7 Signage and Labels

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:

- Location of safety equipment
- Hazards such as high voltage or heat sources
- Operation of emergency exit pathway equipment
- Operation of on-board equipment such as doors and door latches/locks
- Amenities such as trash and recycling containers, potable drinking water, 120VAC outlets, etc
- Toilet room amenities
- Seat numbers
- Capacities for storage locations such as luggage racks and overhead luggage bins
- Service-related signs for maintenance and inspection
- Exterior signage for service points

The interior and exterior signage shall conform to Amtrak Specification 697, National On-Board Signage Manual. The artwork, material, location and specifications for each sign shall be submitted to the Customer for approval at the design review.

Whenever possible, existing Amtrak signs shall be used. Where new sign designs are required the Contractor shall develop artwork per the Amtrak Onboard Signage Guidelines for approval by the Customer. The Contractor will provide a signage application drawing for Customer approval identifying all signs and labels used on each car type, including text, as well as the mounting location.

LLEPM shall be installed in accordance with APTA Standard SS-PS-004-99. 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.

9.8 Doors and Latches

All interior doors shall be constructed of melamine-faced plymetal to match interior walls, and shall be built of robust materials to withstand repeated use without deforming or losing adjustment. Doors shall have a minimum of three stainless steel heavy-duty 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, galley access, baggage room and utility locker doors shall have a grille located in the lower half of the door panel for air circulation.
Doors that shall use a standard coach key to open:

- Electrical locker
- Baggage room
- Cab compartment
- Utility locker
- Galley access

Doors that shall use a pencil lock to open (unless specified otherwise):

- Trash and recycling lockers
- Access panels
- Storage cabinets
- Emergency equipment locker

Electrical locker and utility locker doors shall have a release lever on the inside of the latch. Baggage room and galley access door latches shall be lockable with a standard coach key from the public side (the side facing the public seating area), and with a manual latch from the service side. Cab compartment doors are described in further detail in Chapter 16.

### 9.9 Noise and Vibration

#### 9.9.1 Interior Noise Levels (Passenger Areas)

When a single, completely assembled and operating car shall be moving at any speed up to 80 mph 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 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.

#### 9.9.2 Vibration

All vehicle equipment shall be designed to operate without damage or degradation of performance when subjected to vibration and shocks encountered during normal service.

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 0.10 in. 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. per second peak vibration velocity for the frequency range above 14 Hz.

Carbody-mounted components shall be designed to withstand vibrations of not less than 0.2 g at frequencies up to 100 Hz and randomly oriented shock loads of 2 g.
9.10 Mockup Requirements

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:

- Accessible toilet room, including wheelchair circulation in the adjacent vestibule;
- Cross-section of the upper level seating area, including side walls and windows, heater grilles and diffusers, overhead luggage bins and reading lights, facing seat pairs and workstation table, convenience outlets and curtains;
- Fully functional overhead luggage bin, including latch and hinge mechanism, mounted at the actual height above the floor;
- Wheelchair lift, including storage area and securement mechanism;
- Bike rack/luggage shelf area in the cab/baggage car; and
- Portions of the café/lounge and cab/baggage cars, per Chapters 14 and 16, respectively.
- Complete vestibule and side door area.

Details regarding the requirements for the construction and review of the mockups can be found in Chapter 3.

9.11 Optional Food Service Trolley Storage/Galley

If specified by the Customer, the end of the passenger interior adjacent to the restrooms of the coach car shall have an enclosed food service trolley storage/galley room to provide limited food service for passengers. It shall use a self-contained module design which is easy to use by crew, including loading and unloading provisions. The room must be arranged for ease of cleaning, sanitizing, maintenance, repair and security. The design of the room shall allow it to be readily installed in place of a row of seats, typically adjacent to a car bulkhead, so as to allow it to be installed into a coach car. The room shall have a door which opens to the aisle way which is lockable with a standard coach key. Alternatively, it could be located in place of the unisex restroom location. The room should be secured to the carbody via the seat tracks and rails and receive electric power from a dedicated 120VAC power feed. The design shall be such that only minimal car modification is required to install it. The final layout and components shall be developed during design review, with the aid of mockups, and shall be approved by the Customer.

The storage/galley room shall contain a countertop, on which is mounted a secure coffee pot. Two cart docking sites shall be located beneath the counter. One site for an insulated aircraft-style dry food storage cart, identical to those used in the food service car galley in Chapter 14, shall be used to service the storage/galley room. The second site shall be for a food service trolley used to sell food and beverages through the train. The carts shall not be refrigerated. A small self contained refrigerator shall be provided above the counter to chill the beverages. All commercially available appliances shall be approved by Underwriters Laboratories Inc. (UL) and the National Sanitation Foundation (NSF).

Stocking of provisions shall be handled through the use of the food carts. Pastries, juices, etc, as well as dry supplies will be loaded into the carts in a commissary and then transferred to
the train prior to a trip. Items to be chilled will then be transferred from the food cart to the refrigerator. The process is reversed at the conclusion of the trip.

9.11.1 Design Requirements

The storage/galley room module shall be composed of a self-contained unit that is bolted to the carbody via the seat rails and seat tracks. The components making up the module shall be of a size to allow them to fit through the body end door or side entrance door. The module shall be supplied complete with internal wiring and plumbing, ready for connecting to the corresponding car supply points, and installed so as to not block maintenance access. Water and drain lines shall be routed without high point traps so as to permit gravity drainage. The mounting space allowed for the coffee maker and refrigerator shall be oversized so as to easily permit a different model appliance of similar capacity to be installed in the future. Stainless steel fasteners shall be used for the carbody attachments.

The storage/galley room attachment to the carbody, appliance and cart securement schemes shall meet the crashworthiness standards of APTA Recommended Practice RP-C&S-006-98. This shall include the module structure when fully loaded with all supplies and loaded carts, securement of the filled coffee maker and refrigerator, and securement of the carts. All equipment and appliances, when fully loaded, shall be restrained against accelerations of up to 8g longitudinal, 4g lateral and 4g vertical with an approved restraint system.

The storage/galley room shall be of modular construction and designed to be easily removable as a unit. The installation of the coffee maker shall have special attention given for ease of future replacement by Amtrak with a different unit. The beverage station shall meet the requirements of this Specification, as well as the latest edition of the US Public Health Service FDA Food Code requirements. Ease of sanitation of all surfaces and components is required. To the extent possible, the station shall use components common to the food service car galley in Chapter 14. The design shall be suitable for service in the dynamic environment of a moving high-speed passenger train, including track geometry and superelevation, accelerating and braking. No component, such as drawers or covers, shall unintentionally open under such conditions. All approvals, including approvals from FDA, are the responsibility of the Contractor and the suppliers to the Contractor, and shall be submitted to the Customer.

The storage/galley room module shall be constructed of stainless steel and honeycomb panels faced with high pressure laminate. Panel thickness shall be selected on the basis of required strength determined by Finite Element Analysis (FEA), durability, impact resistance and minimum weight. The countertop shall be formed from stainless steel with a number 13 finish. Sealing and construction of the module shall not permit spilled liquids and moisture to harbor behind, over or under any of their surfaces. The countertop shall have a raised edge on all exposed faces and a cove on all edges at adjacent walls and bulkheads. The design shall make it easy to clean, and shall not have any pockets, cavities, square corners, etc. where residue can collect. The mounting scheme for the coffee maker and all accessories shall be designed to be easily cleaned and sanitized after each day of use. The entire storage/galley room shall have a floor pan to prevent any liquids from spills, failed plumbing or condensation from migrating into other parts of the car. Joint sealing and construction of the storage/galley room shall not permit liquids or moisture to harbor on or behind any surfaces. The design of the module shall incorporate adequate, easily cleaned storage for trash generated on a 12 hour trip.

Safety of crew and maintenance personnel shall be a prime consideration in design of the storage/galley room. All outside corners formed by two planes shall have a minimum radius of 0.25 in. Corners formed by three planes shall have a minimum spherical radius of 0.375 in.
Projections from the module face, including knobs and fittings, which could injure crew shall be recessed. Finger pinch points shall not be allowed. Metal surfaces of the module shall be suitably grounded, and any other means necessary taken to prevent electrical shock of personnel.

Fire safety shall be addressed by selecting materials meeting flammability, smoke generation and toxicity requirements. All food service system materials shall meet the Amtrak and FRA flammability and smoke emissions requirements. The Contractor shall provide a fire safety analysis laboratory test report (not just a letter of certification) for Customer review and approval, in accordance with APTA Recommended Practice RP-PS-005-00. The car interior sidewall heater elements in the storage/galley room shall either be disconnected or suitable vented as required to prevent overheating.

Food service components shall be designed to minimize noise. Anti-squeak tape shall be used between any joints subject to motion and also attachment to walls and structure. All food service equipment and all associated equipment (in any state to loading of stock) shall not rattle, vibrate, oil can, squeak or produce other objectionable noises under any car motion and at any operating speed.

Easy access shall be provided for all items that require periodic maintenance, defect repair or replacement. Panels and doors covering this equipment shall be hinged where possible and fastened with approved captive fasteners in a manner that permits these activities. Replacement for any major appliance shall not require any disassembly of the counter or enclosure.

Hinges for module doors shall be an edge-mounted, commercially available heavy duty design. Use of heavy duty piano hinges is acceptable. Metal hinged doors shall be double-wall constructed. All hinged doors, in their full open position, shall be capable of withstanding a 250 lb downward force applied to the top edge of the door 2 in. from the latch end without damage to door or attachment. All doors shall be capable of opening 180 degrees with sufficient clearance to prevent any tendency to bind. All module door latches shall be stainless steel. Strikers shall be used with all latches and shall be one piece formed or die-cast stainless steel, and shall be easily removable. Latches shall be easily operated, require no lubrication and maintain full door closure. Latches shall have no open areas for accumulation of dirt and moisture. All latches and strikers shall be readily commercially available and be designed for easy field replacement. Coach key latches shall be keyed to operate with the standard coach key defined in Chapter 1. Latches, strikers and hinges shall be mechanically attached with removable fasteners, and designed for ease of field replacement.

The storage/galley room shall contain the following components:

- One modular counter
- Two docking sites: one for dry storage cart, one for a food service trolley, each with quarter turn retaining tab
- One insulated food cart, complete with four 4 in. and two 6 in. drawers (two additional carts shall be provided for each coach car for "float", for a grand total of three food storage carts per coach car)
- One food service trolley cart (two additional carts shall be provided for each coach car for "float", for a grand total of three food service carts per coach car)
- One self-contained refrigerator with an approximate capacity of 4 ft³
• One coffee maker (Brewmatic, Amtrak AAMPS part number 36 580 03006) with water supply filter
• One coffee maker restraint
• Shutoff valve, drain valve and freeze protection for coffee maker water supply line
• Access panel for replacing water filter element
• One drip pad for coffee maker, to catch cup overfills and drips from faucet
• Coffee maker drain line
• Electrical receptacle for coffee maker
• Two duplex 120VAC, 20 amp, GFCI electrical receptacles for countertop
• One suitable electrical receptacle for refrigerator
• Overhead storage cabinets for dry goods (cups, trays, napkins, etc)

Cold water shall be supplied to the storage/galley room from the car water system, in accordance with Chapter 5 requirements. The storage/galley room shall incorporate suitable lighting and standard labeling.
Figure 9-1: Coach Car Conceptual Drawing
Figure 9-2: Business Class Car Conceptual Drawing
Figure 9-3: Café/Lounge Car Conceptual Drawing
Figure 9-4: Cab/Baggage Car Conceptual Drawing
* End of Chapter 9 *
Standardized Technical Specification

PRIIA 305 Next-Generation Equipment Committee
Single-Level Passenger Rail Cars

Chapter 10

HVAC System
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10.0 HVAC System

10.1 Overview

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 R400-series refrigerants for cooling. A non-chemical refrigerant system may be proposed for consideration by the Customer.

Temperature control shall be provided by a microprocessor based integrated HVAC control system that monitors outside and inside 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 Amtrak Specification 963.

Dampers on the fresh air intake vents shall control the amount of outside air taken in by the HVAC system.

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 at half the required capacity, in case of failure of the other system.

The vehicle shall have a main air distribution duct in the ceiling of the car, which shall supply the main ceiling air diffusers and supplementary side wall air diffusers located above the side windows.

Heating shall be provided by forced air overhead heat in the HVAC units and by convection floor heaters along the base of the side walls in the vehicle interiors.

Freeze protection shall be provided at the side door thresholds and all fresh water system components that may be exposed to freezing conditions.

10.2 General Requirements

The HVAC system shall provide a comfortable temperature controlled environment of the interior areas of all vehicles as follows:

- The vehicles shall be designed to operate in all environmental and climatic conditions identified in Amtrak Specification 963.
- The vehicle’s interior temperature, including the Engineer’s cab, shall be maintained to the specified value (68°F - 76°F) under all specified conditions.
- Passenger load shall be assumed to be AW3 for cooling load calculations.
- Heat and cooling requirements shall include the opening of both sets of side doors on alternating sides of the vehicle every 15 minutes and held open for 2 minutes, to simulate passenger loading and unloading in all outside ambient temperatures identified in Amtrak Specification 963.
- Ambient conditions as specified and heat losses due to train motion shall be included in HVAC system performance evaluation.
Air losses due to door and carbody leakage shall be included in the HVAC system performance evaluation.

A microprocessor based, integrated HVAC system 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 Customer’s approval during design review, a detailed heating and cooling load analysis along with recommended heating, cooling and ventilation capacities.

In no case shall the total heating capacity be less than 40 kilowatt (kW) not including the forced air control cab heater, nor shall the total refrigeration capacity be less than 192,000 BTU/Hr. The HVAC unit manufacturer shall conduct qualification testing to verify this design, heating and cooling capacity per ASHRAE Standard 37-05. This testing is further discussed in Chapter 19.

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 Amtrak Specification 963.

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 the refrigerant compressor motors. The startup timing shall be set to stagger the startup of the A/F-end unit at least 15 seconds before the B-end unit.

Freeze protection shall be provided and turned on when the ambient outside temperatures drop below 40°F, and shall shut off when the outside temperatures rise to 50°F.

The HVAC system shall be controlled by a microprocessor temperature control using a sufficient number of temperature sensors to properly regulate heating and cooling in response to temperature changes inside and outside the vehicle. Temperature sensors in the car body shall be located to accurately reflect temperature changes without being unduly influenced by external heat sources or solar radiation.

HVAC system circuit breakers and temperature control adjustment devices shall be located in the electrical locker and shall be accessible only to the operating and maintenance crews. Circuit breakers, controls and relays shall be inaccessible to the passengers.

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.

Pressure transducers shall be provided to allow the microprocessor to monitor both the discharge and suction line pressures. A technician using a laptop/PTU shall be able to monitor both pressures without the use of pressure gauges.

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.
10.3 Design Parameters

The following parameters are to be assumed in the design of the cooling system:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient Temperature</td>
<td>110°F Dry Bulb/76°F Wet Bulb, with 120°F air entering the condenser</td>
</tr>
<tr>
<td>Solar Load</td>
<td>Equivalent to 35° North Latitude, maximum solar heat rate, in accordance with ASHRAE calculation methods</td>
</tr>
<tr>
<td>Passenger Heat Load</td>
<td>440 BTU/hr/person at a heat ratio of 0.60</td>
</tr>
<tr>
<td>Number of Passengers</td>
<td>85 seated passengers (load level AW3)</td>
</tr>
<tr>
<td>Carbody Heat Transmission</td>
<td>In accordance with the Contractor's carbody insulation design to meet the requirements of this Specification but not greater than 800 BTU/hr-°F for Stainless Steel.</td>
</tr>
<tr>
<td>Minimum Fresh Air</td>
<td>15 Cubic Feet per Minute (cfm)/seated passenger, 9cfm/seated passenger permitted at outside temperatures above 100°F.</td>
</tr>
<tr>
<td>Other Heat Loads</td>
<td>Normal vehicle lighting, electrical equipment and appliance loads</td>
</tr>
</tbody>
</table>

The following parameters are to be assumed in design of the heating system:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient Temperature</td>
<td>-30°F Dry Bulb</td>
</tr>
<tr>
<td>Carbody Heat Transmission</td>
<td>In accordance with the Contractor's car body insulation design to meet the requirements of this Specification, and not greater than 800 BTU/hr-°F</td>
</tr>
<tr>
<td>Minimum Fresh Air</td>
<td>15 Cubic Feet per Minute (cfm)/seated passenger, 9cfm/seated passenger permitted at outside temperatures above 100°F.</td>
</tr>
<tr>
<td>Solar Load</td>
<td>None</td>
</tr>
<tr>
<td>Passenger Load</td>
<td>None</td>
</tr>
<tr>
<td>Other Heat Loads</td>
<td>“Quiet car” lighting only (see Chapter 11)</td>
</tr>
</tbody>
</table>

10.4 Comfort Requirements

10.4.1 Interior

The following temperatures shall be maintained within the vehicle, including toilet rooms and cab, when the associated ambient outside temperatures are present:

<table>
<thead>
<tr>
<th>Outside Ambient</th>
<th>Interior Vehicle Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below -30°F</td>
<td>As system will provide</td>
</tr>
<tr>
<td>-30°F to +60°F</td>
<td>70°F ± 2°F (±4°F for toilet room)</td>
</tr>
<tr>
<td>60°F to 110°F</td>
<td>74°F ± 2°F (±4°F for toilet room)</td>
</tr>
<tr>
<td>Above 110°F</td>
<td>As system will provide</td>
</tr>
<tr>
<td>Layover Cool Mode</td>
<td>85°F ± 2°F (±4°F for toilet room)</td>
</tr>
<tr>
<td>Layover Heat Mode</td>
<td>50°F ± 5°F (±4°F for toilet room)</td>
</tr>
</tbody>
</table>

During all modes of air conditioning, the interior relative humidity shall not exceed 50%.
Except within the area of the side doors and vestibules, the HVAC system shall maintain a temperature variation, within both the upper and lower levels, of the following:

- **Vertical variation:** On any vertical line, 4 in. above floor to 43 in. above floor, not closer than 12 in. from walls, and not closer than 20 in. from doors: 5°F maximum difference between end points of the vertical line.

- **Horizontal variation:** On horizontal planes measured 4 in., 43 in. and 67 in. from floor, not closer than 12 in. from walls and not closer than 20 in. from doors: The temperature at any point within each plane should not exceed ± 3°F from the average temperature in that plane.

- The average vehicle temperature shall recover within 2°F 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 15 minutes closed at the design conditions in both heating and cooling modes.

### 10.4.2 Noise

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, cab supply vents and galley ceiling air diffusers.

With the vehicle stationary and the HVAC unit in its noisiest cooling mode:

<table>
<thead>
<tr>
<th>Interior noise level: Coach seating areas, cab, toilet rooms and galley</th>
<th>As specified in Chapter 9.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exterior noise level</td>
<td>75 Decibels (Acoustic) (dBA) max (15 ft from centerline of vehicle)</td>
</tr>
</tbody>
</table>

### 10.5 Air Conditioning

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, and shall be located at the vehicle quarter-points. The same unit shall be used on all vehicle types. The units shall be designed for a 400-series refrigerant, conforming to 40CFR Part 82. All components within the unit, such as seals, shall be compatible with the refrigerant and its associated lubricants.

The roof mounted units shall be supplied with a stainless steel or aluminum housing and shall be mounted in water-tight recesses on the main carbody structural roof. There shall be a removable hatch over each unit that shall be of the same general appearance 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, without removing the equipment from the vehicle and without interference from other systems.

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/baggage car shall also have its own local thermostat.
HVAC System

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/76°F Wet Bulb, with air entering the condenser above 120°F, the air conditioning system shall be capable of maintaining cooling at a reduced capacity, but in no case shall the average interior temperature be more than 25°F 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.

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. The installation and removal process, including removing and installing all mounting hardware, and electrical connections, shall be demonstrated for Customer approval at the design review.

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.

The refrigeration system shall include, at a minimum, the following components and features:

- The units shall be designed for an R400-series refrigerant, conforming to 40CFR Part 82. All components within the unit, such as seals, shall be compatible with the refrigerant and its associated lubricants.
- A single scroll with modulation or two scroll-type refrigerant compressors working in tandem shall provide, at a minimum, 50% and 100% capacity control. If tandem scrolls are employed, means shall be provided to alternate use of compressors during single stage cooling so as to equally distribute use and wear.
- Refrigerant compressor shutdown control shall be by means of a pump down cycle that senses suction line pressure.
- Bump starting of the refrigerant compressors.
- A refrigerant control box, containing; pressure switches, transducers, service switches, etc.
- Direct drive condenser fan and motor assemblies.
- Condenser coil assemblies with 0.008 in. thick copper or coated aluminum fins on 0.38 in. diameter copper tubing at a spacing of 8 fins per in.
- One charging and one evacuation port equipped with high quality Schrader valves and sealing metal caps.
- A filter drier.
- Discharge line check valves.
- Sight glass/moisture indicators.
10.6 Heating

The cars shall be electrically heated using forced air overheads heaters in the roof-mounted HVAC unit and by convection heaters at the sidewalls. The heating system shall compensate for carbody losses and fresh air heating loads.

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 divided into stages, or shall be a single stage operating on a Pulse Width Modulation (PWM) switching device. If multi-staged, the size of each heating stage shall be chosen and controlled so that cycling of the heating contactors is minimized.

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 disable the overhead heat switching device and the refrigerant compressor switching device by disabling 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 total over temperature protection method shall be reviewed by the Customer at the design review.

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.

Antifreeze protection, activated at an outside temperature of 40°F, 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.

Layover heat shall be provided by the sidewall floor heat and shall maintain an interior temperature of 50°F ± 5°F, including the cab. During layover heating, the evaporator fans shall not operate and the fresh air damper shall be closed.
The heating system shall include, at a minimum, the following components and features:

- Staged or modulated forced air electrical overhead heat.
- Forced air heater over temperature protection devices.
- Staged or modulated electrical convection sidewall heaters.

For additional cab compartment heating requirements, refer to Chapter 16.

10.7 Ventilation

The ventilation system shall include, at a minimum, the following components and features:

- Exterior fresh air intakes with water eliminators and frame type disposable air filters
- Electrically motorized automatic fresh air dampers
- Frame type disposable return air filters
- Air distribution ducts
- Air diffusers and grilles
- Exhaust ducts
- Exhaust fans
- Emergency fan shutoff switches

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.

Re-circulated air shall pass through stainless steel grilles into a plenum chamber where it shall mix with the fresh air and passes 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. The duct shall be sized to minimize noise from air velocity.

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. Local diffusers shall also be provided for the Engineer cab and the galley in the café/lounge car.

The diffusers shall be designed to deliver equalized airflow throughout the car and meet the temperature variation requirements specified. The velocity of discharge air shall not exceed 100 feet per minute (fpm) measured 6 in. below the face of the diffusers. 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.

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. 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.
Intake of filtered fresh air shall be provided for each end of the vehicle at on-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.

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.

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.

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.

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.

The ventilation system shall provide a minimum positive carbody pressurization of 0.1 in. 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.

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 Amtrak Specification 685 and be commercially available.

In addition, the fresh air exterior intakes shall be fitted with louvers or grilles that prevent ingress of water.

10.8 Fresh Air Dampers

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 panel, 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.

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.

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
HVAC System

10.9 Controls

Heating and cooling control shall be controlled by a microprocessor using solid state sensors for temperature and pressure 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, shall preclude the simultaneous operation of heating and air conditioning. The microprocessor application software shall permit maintenance personnel using the PTU to modify temperature and pressure set-points as well as various other parameters, such as timers.

10.9.1 Sensors

At a minimum, the following temperature sensors shall be required:

- Three interior temperature sensors located throughout the passenger seating area.
- Return air sensor at each HVAC unit return air grille.
- Fresh air sensor at each HVAC unit fresh air inlet.
- Supply air sensor in each side of the split main duct.
- Freeze protection thermostat located in a position that accurately measures outside temperature.
- Evaporator coil sensors to detect ice build-up on the evaporator coils.
- Cab control compartment thermostat.

10.9.2 Use of Controls

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.

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.

Positions and functions are as follows:

<table>
<thead>
<tr>
<th>Name</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>NORMAL</td>
<td>Vehicle HVAC set up shall provide the normal occupied vehicle environment. All systems operate.</td>
</tr>
<tr>
<td>LAYOVER</td>
<td>Used for vehicle storage in summer to minimize energy consumption, yet still maintain interior temperature of 85°F. Used for vehicle storage in winter to minimize energy consumption, yet still maintain interior temperature of 50°F. Only floor heat shall be available.</td>
</tr>
<tr>
<td>OFF</td>
<td>Used to shut off all vehicle heating and cooling when vehicle is being serviced or in storage. Does not disable the freeze protection system.</td>
</tr>
</tbody>
</table>
10.9.3 Status Display

Each HVAC control panel 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, suction line pressure and discharge pressure shall be displayed for each HVAC unit. 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.

The control system shall include, at a minimum, the following components and features:

- Temperature control panel
- Temperature sensors
- Motor starters
- Motor protective devices
- Heater switching devices
- Pressure transducers
- Diagnostics and test capabilities

The Contractor shall submit a temperature control schedule and a detailed description of operation for approval by the Customer at the HVAC system design review.

10.9.4 Ventilation Cut-Out Switch

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 in accordance with Amtrak's interior signage manual. 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.

10.9.5 Freeze Protection

The freeze protection system shall allow unrestricted vehicle operation of water, waste and door systems down to -30°F ambient, under all weather and train operating conditions. See Chapter 15.

* End of Chapter 10 *
Chapter 11

Lighting System
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11.0 Lighting System

11.1 Overview

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.

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) or a combination of LEDs and fluorescent lights. LEDs are the preferred method of providing interior passenger seating area lighting. Lights in toilet rooms, stairways, vestibules, passageways, as well as reading lights and 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.

For lighting requirements in the lounge and galley areas of the café/lounge car, see Chapter 14. For lighting requirements in the cab control compartment and F-end of the cab/baggage car, see Chapter 16.

The Contractor shall prepare an interior and exterior lighting plan for Customer 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 Customer during the design review.

11.2 General Requirements

Fixtures installed on the vehicle exterior, and in the interior within 2 ft of a doorway, shall be watertight, except for interior ceiling lights.

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.

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 headlights and crossing lights on cab cars, and marker lights on all car types.

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.
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 the American Public Transportation Association (APTA) Recommended Practice RP-E-012-99 and APTA Standards SS-PS-002-98, SS-E-013-99 and SS-PS-004-99 Rev. 2.

All lighting components shall have prior experience in North American transit, commuter rail or intercity passenger rail application. The Customer 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 the Customer industrial design office and approved by the Customer during design review.

The lighting fixture housing or socket shall not be used as a ground return for any other electrical circuits.

11.3 Lighting Plan Design Review

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.

The Contractor shall provide drawings of the lighting arrangement of each car type for Customer 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.

Examples of each lighting fixture shall be provided for Customer approval at the final design review.

Lighting fixtures shall not be a source of Electromagnetic Interference (EMI) and shall be included in the Electromagnetic Compatibility (EMC) plan required by APTA Standard SS-E-010.98. See chapter 19.

11.4 Interior Lighting Levels

All light level measurements shall be made in accordance with the minimum standards defined by APTA Recommended Practice RP-E-012-99.

11.4.1 Lighting Color Temperatures

The lighting color for all interior lights and lamps in the passenger rail car shall be 3500° - 4100° Kelvin (K). The Contractor is to provide suggested light color plan for Customer’s review and approval during the preliminary design review.
11.4.2 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.

11.5 Interior Lighting Modes

11.5.1 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.

11.5.2 Quiet Car Mode

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. Car lighting during quiet car mode shall be adequate to charge the photoluminescent emergency signage and LLEPM system per the required standards. A dedicated, clearly labeled switch in the electric locker shall permit operating personnel to easily select either normal lighting or quiet car mode lighting. 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.

11.5.3 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 required standards. Minimum illumination levels for Standby mode are shown in Table 11-1.

11.5.4 Emergency Lighting Mode

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 Standard SS-E-013-99.

The Contractor shall provide for Customer 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 Standard SS-E-013-99. The Contractor shall demonstrate compliance with emergency lighting requirements and shall provide to the Customer written certification of compliance.

### 11.6 Interior Lighting Requirements

#### 11.6.1 Passenger Area

The following describes the individual lighting fixture applications and specifications for all areas of the car. Lights may be fluorescent or LED unless otherwise specified. Light fixtures in toilet room ceiling, vestibule ceiling and hallway ceiling shall be identical units if possible.

##### 11.6.1.1 Main ceiling

Two longitudinal rows of lights shall provide the primary lighting for the seating area in the revenue seating areas of coaches, cab and café/lounge cars, and shall be located adjacent to the center ceiling panels/air diffusers. Other arrangements can be proposed but are subject to Customer approval. These LED or fluorescent 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 terminal blocks or connectors, as approved by Customer, 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 be used in place of fluorescent tubes provided that they create an even light output and similar appearance to fluorescent lights.

##### 11.6.1.2 Passenger reading lights

Individual reading lights shall be white LEDs powered by 24VDC. They shall be mounted in an adjustable gimbal mount that allows for individual directional adjustment. Each reading light shall have an ON/OFF switch. A reading light shall be provided for each coach seat and the wheelchair parking location.

Passenger reading lighting shall be mounted in an adjustable track located on the underside of the luggage rack, so that the reading light fixtures can be relocated to match the seat pitch as specified by the Customer. See Chapters 9 and 23.
11.6.2 Vestibules and other Non-Seating Areas

11.6.2.1 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:

- Vestibule ceilings
- Toilet room ceilings
- Hallway ceilings
- Checked baggage room

11.6.2.2 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.

11.6.2.3 Vestibule ceiling at lower level 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 café/lounge and cab cars.

11.6.2.4 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:

- Hallway at accessible toilet
- Hallway past café galley
- Hallway adjacent to utility lockers, luggage racks and toilet rooms at end doors

11.6.2.5 Luggage rack/bike rack area

Recessed can-type LED fixtures shall be provided in the ceiling of the luggage rack/bike rack area in the cab cars.

11.6.2.6 Checked baggage room

The baggage room shall be equipped with no less than four flush-mounted ceiling fixtures over the luggage racks, similar to those in the luggage rack/bike rack area in the A-end vestibule of coach cars. Each fixture shall be equipped with a robust guard to protect the lens from damage. These fixtures are in addition to those in the vestibule above the side entrance doors.
11.6.3 Toilet Rooms

11.6.3.1 Toilet ceiling and mirror

Light fixtures shall be mounted on the ceiling of each toilet room to provide general lighting to the toilet room.

The lighting fixtures shall be wired in parallel and shall be provided as part of the toilet module.

11.6.3.2 Toilet room occupied/out of service sign

The toilet OCCUPIED/OUT OF SERVICE light fixture 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. These LEDs shall be yellow. Artwork for the labels shall be submitted to the Customer for approval during the design review.

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.

The LEDs used for these indicators shall be no less than 0.25 in. in diameter for clear visibility to passengers.

11.6.4 Service and Utility Rooms

11.6.4.1 Electrical locker

The electrical locker shall be illuminated by at least two overhead lights, controlled by a wall-mounted manual ON/OFF switch located adjacent to the door. 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.

11.6.4.2 Utility locker

At least one 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 ON/OFF switch. The lights shall be so located as to provide general illumination within the locker and be readily accessible for replacement.

11.6.4.3 Control cab

Lighting requirements for the control cab compartment in the cab/baggage cars are described in Chapter 16.
11.6.4.4 Café/lounge galley and lounge area

Lighting requirements for the food service galleys and the lounge seating area of the café/lounge car are described in Chapter 14, except as noted.

11.7 Exterior Lighting Requirements

11.7.1 Marker Lights

All cars shall be equipped with two red marker lights at each end of the car.

The marker lights shall be incandescent and shall meet FRA requirements in 49CFR Part 221.

The marker lights shall be operable during normal, quiet car and standby lighting modes.

The marker lights will be controlled by a 3-position switch in the electric locker, having A-END, OFF, and B-END positions (the A-END position marking will be replaced by F-END on cab cars).

The marker lights on the F-end of the cab cars shall illuminate when the selector switch in the electrical locker 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 marker light selector switch is in the F-END position.

11.7.2 Platform Lights

Each side door opening shall have a 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. 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.

At a minimum, the Contractor shall meet the requirements of 49CFR Section 38.101.

The platform lights shall also be a part of the emergency lighting system and shall conform to APTA Standard SS-E-013-99.

11.7.3 Exterior Indicator Lights

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 doors 2, 3, 6 and 7, so that their status is visible to the engineer 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.
Each car shall be equipped with two exterior brake indicator light units, one on each side of the car, adjacent to doors 2 and 6. Brake indicators shall be green and yellow LEDs, and shall display the following indications:

<table>
<thead>
<tr>
<th>Solid Yellow</th>
<th>Air brakes applied (handbrake released)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flashing Yellow</td>
<td>Handbrake applied (air brakes applied or released)</td>
</tr>
<tr>
<td>Solid Green</td>
<td>Air brakes and handbrake released</td>
</tr>
</tbody>
</table>

The brake indicator unit may be combined with the door open indicator light.

The three-light door/brake indicator unit shall be mounted with the indicator lights oriented top to bottom: green/yellow/red.

### 11.7.4 Exterior Door ADA Lights

A flashing blue 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.

### 11.7.5 Headlights and Crossing Lights

Requirements for cab car headlights and crossing lights are described in Chapter 16.

### 11.8 Systems Indicator Panel

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:

<table>
<thead>
<tr>
<th>System</th>
<th>Indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>HVAC (one indicator for each unit)</td>
<td>Blue (A/F-end and B-end)</td>
</tr>
<tr>
<td>Wheel slide control system</td>
<td>Green</td>
</tr>
<tr>
<td>Toilet system</td>
<td>Yellow</td>
</tr>
<tr>
<td>Battery charger</td>
<td>Red</td>
</tr>
<tr>
<td>Communication/public address system</td>
<td>White</td>
</tr>
<tr>
<td>Door system</td>
<td>Yellow</td>
</tr>
</tbody>
</table>

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.
11.9 Lighting Fixture Requirements

11.9.1 Fluorescent Lighting

LED lighting is preferred, but where fluorescent lighting exists it shall use rapid-start, T-8 lamps with a color temperature of 3500°-4100°K.

Where possible, the lighting fixtures shall be arranged with one-rapid start inverter ballast controlling two lamps in a master and slave arrangement. Stand-alone fixtures shall contain a ballast configured for efficient, single-lamp operation. The main interior light fixture shall be arranged for a F32T8 lamp or a F25T8 lamp.

Fixture design shall meet APTA Recommended Practice RP-E-012-99. Lampholder sockets shall be designed to support the ends of the lamp. Terminal pins shall not be the sole source of lamp support. Lampholders shall meet or exceed the requirements of UL542. Lamps shall be secured in the fixture and be able to withstand rough duty service as found in the railroad environment. Fixtures shall be dust and moisture resistant.

The main interior light fixture shall consist of a reflector and door joined by an integral, concealed hinge latched by captive quarter-turn Phillips head fasteners, minimum two per door. The fixture assemblies shall be positioned to maximize the light output projected towards the illuminated surface and center of the car.

The master fixture housing shall contain a ballast mounted on an integral hinged ballast plate retained by captive fasteners designed for repeated use (no self tapping screws allowed). All wiring shall be accessible by hinging the ballast plate down. The BALLAST ON LED shall be visible from the bottom of the ballast plate.

Fluorescent lamps shall be designed to use standard, commercially available length bulbs.

Each light fixture shall have a permanent label and/or stamping, visible when the light cover is removed or swung down, that contains the following information:

- Supplier part number
- Voltage and current or wattage ratings
- Lamp identification, wattage, including color
- Light Emitting Diode (LED) Lighting

LED fixtures shall conform to the requirements of the Energy Policy Act of 2005, and shall utilize white LEDs. The color temperature shall be 3500°-4100°K. Where practical, the LED lighting should be supplied from the 74VDC system and be available in both Normal Standby lighting modes.

An LED driver designed to ensure proper operation of the LEDs shall be mounted on the LED assembly. LED assemblies shall be removable without special hardware. Each LED assembly shall be removable after removing only the hinged lens. LED units shall be connected via interlocking, self-polarizing and modular connectors accessible when the light fixture is opened.
All fixtures shall be dust- and moisture-resistant, and shall be arranged to facilitate replacement of the LED assembly from the passenger compartment after opening the lens.

Fixtures equipped with lenses shall have a one-piece polycarbonate translucent white lens, 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.

LEDs used in passenger area overhead lighting (in lieu of fluorescent lights) 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 two LEDs on an individual board shall not create an appearance of a dark area on the fixture.

LED lighting shall be sized to provide the level of lighting as outlined in Table 11-1.

Changeable LED lamps are preferred and LED lighting may be dedicated to its fixture where the design is necessary.

11.9.2 DC/AC Ballasts

The fluorescent lighting fixtures shall contain DC inverter and/or AC electronic ballasts. Ballasts shall be high performance, rapid start and solid-state.

Ballasts shall incorporate reverse polarity, overload, open circuit, over-temperature, over-voltage, transient and internal short circuit protection. Inverter ballasts shall withstand transients of 10 Joules and have an electronic clamp to ground feature. The inverter ballasts shall be designed to operate normally from a 74VDC supply, with capability for continuous operation over 45-86VDC supply. Under-voltage protection shall be provided. The ballast shall automatically restart when voltage within the normal range is again applied, and require no reset, such as interrupting a circuit breaker under any conditions. Likewise, if a lamp is changed while the ballast is powered, no action shall be required to restart the ballast. Ballasts shall be equipped with an LED BALLAST ON indicator that illuminates when the ballast is functioning normally and power is on.

All ballasts shall have an over temperature protection feature that automatically resets when the temperature drops to an acceptable level.

The ballasts shall be integral parts of the fixtures, conveniently located and easily removed from the fixtures without disturbing other components and wiring. The ballast on ceiling lighting fixtures shall be replaceable with the fixture remaining in position. All ballasts shall meet the requirements of ANSI C82.

11.9.3 Capacitor-Based Lighting

The capacitors must be rated for a minimum of 500,000 charge cycles. 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:

- OEM name and manufacturer’s address
- OEM part number — revision/modification level and date
11.10 **Housings, Lenses and Diffusers**

The overhead light assembly shall be designed for lamp replacement from below. The hinged light lens shall swing down allowing easy lamp replacement.

No material shall suffer any loss of performance when exposed to temperatures ranging from -30°F to 150°F or exhibit degradation of properties (including color) under long-term exposure to ultraviolet light.

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. 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. 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.

11.11 **Controls**

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. 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. The passenger seating area cove lighting shall be separately controlled, as approved by the Customer. The switch locker shall also contain a master control for the passenger individual reading lights and the vestibule/restroom lights.

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:

- Each reading light shall have a separate ON/OFF switch located adjacent to the reading light.
- Each reading light at a wheelchair location shall have an ON/OFF switch located in accordance with the requirements of ADA.
- Electrical lockers shall have manual light switches located inside the equipment room adjacent to the entry door.
- Utility lockers shall have automatic light switches located inside the locker adjacent to the entry door.
Lighting System

- Selected lighting circuits in the food service area shall have ON/OFF switches. See Chapter 14 for details.
- 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 Standard SS-PS-004-99. The system shall operate in conjunction with the emergency lighting system. Details shall be submitted to the Customer for approval during design review.

11.13 Food Service Directional Sign

Each end of the passenger seating area shall have an approved food service directional sign, to inform passengers of the direction to the café/lounge car in the train consist. The design shall be performed by the Contractor’s Industrial Designer under the guidance of the Amtrak Industrial Design office, and shall be approved by the Customer. A concept similar to the Amtrak Amfleet cars shall be used to indicate on each end of the car if the café/lounge car is in This Direction or the Other Direction. The sign shall be controlled in each car by the train crew by an easily used switch in the car switch locker, adjacent to the car lighting controls, which includes a directional arrow for clarity.

11.14 Testing

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.

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.

The Contractor shall provide certification to the Customer that the car’s lighting system meets all standards and regulations. All required material certifications shall be provided to the Customer. See chapter 19 for more details.
### Table 11-1: Minimum Illumination Levels

<table>
<thead>
<tr>
<th>Area</th>
<th>Measured at:</th>
<th>Normal Lighting (foot-candles)</th>
<th>Quiet Car Lighting (foot-candles)</th>
<th>Standby Lighting (foot-candles)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Overhead</td>
<td>Table top</td>
<td>30</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Aisle way Lighting</td>
<td>Floor</td>
<td>20</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Indirect Lighting</td>
<td>Table top</td>
<td>5</td>
<td>5</td>
<td>N/A</td>
</tr>
<tr>
<td>Vestibules</td>
<td>Floor, threshold, side door panels</td>
<td>30</td>
<td>30</td>
<td>5</td>
</tr>
<tr>
<td>General Seating Areas</td>
<td>Table top</td>
<td>30</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Reading Lights</td>
<td>Table top</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>End Passageway/ Diaphragm Area</td>
<td>Grab handles Door panel at floor level.</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Bike/ Luggage Rack Area</td>
<td>Floor</td>
<td>10</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Luggage Rack Tower</td>
<td>Lowest shelf</td>
<td>10</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Toilet Room – ADA</td>
<td>Floor</td>
<td>30</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>Toilet Room – UNI</td>
<td>Sink</td>
<td>30</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Toilet</td>
<td>30</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Mirror</td>
<td>30</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Baby changing Door handles</td>
<td>30</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Door handles</td>
<td>30</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>Café Car-Lounge Area</td>
<td>Floor</td>
<td>30</td>
<td>30</td>
<td>5</td>
</tr>
<tr>
<td>Galley</td>
<td>Floor</td>
<td>30</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>Service Counter Area</td>
<td>Counter</td>
<td>30</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>Food Preparation Area</td>
<td>Counter</td>
<td>30</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>Electric Locker</td>
<td>Floor</td>
<td>30</td>
<td>30</td>
<td>5</td>
</tr>
<tr>
<td>Utility Closet</td>
<td>Floor</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Cab Overhead</td>
<td>Floor, cab console</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Cab Reading Lamp</td>
<td>Table height</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>

* End of Chapter 11 *
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Chapter 12

Communication System
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12.0 Communication System

12.1 Overview

This chapter describes the system requirements for the on-board communication system to be provided on each car. The communication system consists of four primary subsystems: the Public Address (PA) system, the Intercommunication (IC) system, the Onboard Train Information System/Passenger Information System (OTIS/PIS) and the Data Communication System (DCS). These four 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).

The PA and IC systems shall be fully compatible with existing cars operating in intercity service (TBD Cars), 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.

The Contractor may propose an alternative design for Customer approval. The alternative design shall be capable of utilizing up to date technologies, must include open architecture and still interface with systems that may already be installed in existing equipment operating in intercity service.

The car’s DCS shall be capable of multiple functions, including providing a data backbone for Ethernet-based communication within each car and car-to-car that can be used for 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, data transfer between the train and wayside communication systems.

Additional OTIS/PIS requirements that are exclusive to each customer are described in Chapter 23.

12.2 General Requirements

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.

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 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) and sequentially display and announce the upcoming stations at programmed locations. It shall allow for simultaneous voice and text messages sent directly from the client software through the Sign System Server (SSS) via cellular data communication.

These communication systems shall consist of the following equipment.
12.2.1 Public Address/Intercom (PA/IC) System Components

- PA control stations:
  - B-end vestibule of all cars
  - Crew workstation of café/lounge car
  - Serving counter area at galley in café/lounge car
  - Cab control compartment in cab/baggage car
- Intercom stations:
  - At all PA control stations
- Interior and exterior speakers
- Handset at each PA control station
- PA amplifier
- Interface to OTIS/PIS system
- Interface to trainlines

12.2.2 OTIS/PIS System Components

- Destination signs (interior and exterior signs); (all cars)
- Car Control Unit (CCU); (all cars)
- OTIS/Passenger Information System Control Unit (OTIS/PISCU); (master cars- café/lounge and cab/baggage cars)
- Data Communication System (DCS); (master cars-café/lounge and cab/baggage cars)
- GPS; (master cars-café/lounge and cab/baggage cars)
- OTIS/PIS communication trainline; (all cars)
- OTIS/PIS communication trainline IVDN and 802.11n access points; (all cars)

12.3 Public Address/Intercom (PA/IC) System

12.3.1 Public Address (PA) System

Cars shall be equipped with a PA system that provides a means for a train crewmember to communicate by voice to passengers 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 single-level equipment as specified in the compatibility provisions of this Specification.

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 a digital audio link, and drive the car speakers whenever the PA system or the OTIS/PIS generate audio messages. 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.

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.

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.
The PA system (from the input to the microphone to the output of the interior speakers) shall have a 90% intelligibility rating when tested according to ANSI Standard S3.2-1989 (R1999) 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

The PA amplifier shall incorporate a volume control adjustable only with the use of the Portable Test Unit (PTU).

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.

The PA amplifier shall be a programmable amplifier.

Power to the PA amplifier shall be supplied directly from the car low voltage battery circuit and shall be protected by a dedicated circuit breaker.

The unit shall incorporate at a minimum, the following indicators on the front panel:

- **PA amp output level** – displays audio level to speakers
- **Bar graph** – indicates audio output level
- **On-Off Light Emitting Diode (LED)** – indicates when switch is on and car battery is present

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.

### 12.3.1.1 Handset and holder

The handset shall use the standard Amtrak microphone handset and connector plugs (p/n 10623456).

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.

### 12.3.1.2 Interior and exterior speakers

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.

The PA system shall be designed to allow the crew to make announcements for distribution through the interior speakers. 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. PA announcements shall be simultaneously broadcast over the interior and exterior speakers when the door control station is energized and the doors are opened.
There shall be no feedback between car speakers and the control station handset when the public address system is in use.

12.3.1.3 Two-way crew intercommunications (intercom)

The IC system shall be designed to allow the crew to communicate with other personnel on the train including the Engineer in the control cab in the cab/baggage car.

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, 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.

12.3.1.4 Emergency two-way intercommunications (intercom)

Cars shall be equipped with an IC system that conforms to 49CFR Section 238.121 and provides a means for passengers and crewmembers to communicate by voice with each other in an emergency situation. At least one IC station that is accessible to passengers without using a tool.

The location of each IC 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 such intercom.

12.4 OTIS/PIS Capability

The OTIS/PIS shall be capable of full graphic and video display including advertising through the interior signs.

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 110°F (43.5°C) shall be incorporated into the design and shall be in accordance with Amtrak Specification 963.

It is the Contractor’s responsibility to supply equipment capable of operation in the rail environment consistent with Amtrak specification 963. 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 Customer at the Preliminary Design Review (PDR) to validate the conformance to these standards.

The equipment shall meet the requirements of IEEE Standard P1477 and all FRA, AAR and ADA applicable rules, regulations and guidelines.

The PA function of the carborne OTIS/PIS system shall utilize only digital communication signals between OTIS/PIS equipped cars, but be able to generate or use analog audio signals from other cars as specified.

All carborne OTIS/PIS equipment shall be powered from the 74VDC (nominal) low voltage car supply. All equipment shall function normally and provide the specified performance for all supply voltages between 58VDC and 86VDC. For voltages lower than 58VDC or higher than 86VDC, automatic shutdown of the equipment is acceptable, followed by automatic restarting as the voltage returns to the specified levels. No permanent damage shall be caused to the equipment following these conditions. See Chapter 13.
Communication System

All carborne OTIS/PIS equipment shall be protected from damage against a reversed voltage supply, and power supply shutdown and immediate reapplications.

All carborne OTIS/PIS equipment shall have integral power conversion and conditioning. External power supplies are not acceptable.

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 Customer.

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 Standard SS-E-005-98.

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 Customer for approval during design review.

Removal and installation of any component shall not require the removal of any other equipment.

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.

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.

12.4.1 Wireless/Satellite/Mobile/Ethernet Internet Connectivity

The OTIS/PIS system must accommodate wireless technology using satellite or mobile telecommunications ISP for internet connectivity, an Ethernet-type trainline network between cars and provision of 802.11n access point in each car to provide wireless internet services to passengers.

12.4.2 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.
12.5  OTIS/PIS Requirements

12.5.1  Display Signs

12.5.1.1  Interior signs

Interior signs shall be 17 in. diagonal display with a resolution of at least 1280 by 1024 pixels. They shall be capable of:

- Audiovisual automatic announcements that include information such as present station and next station and arrival times.
- Text displays that may include time and date, train number, destination, and on-time and delay information.
- Special audiovisual messages received from the SSS or initiated by the onboard personnel.
- Animated graphic displays, including entertainment and advertising.

The interior signs shall be Liquid Crystal Display (LCD). 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 60 ft (18.3 meters). The display shall have at least 50000:1 contrast ratio.

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.

All signs shall resume normal operation following supply power interruptions. No abnormal sign behavior shall follow any supply power interruption and reapplication.

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.

Interior displays shall be integrated 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.

12.5.1.2  Exterior signs

Exterior signs shall display train number and destination with fixed and scrolling text.

The exterior signs shall be alphanumeric, color LED matrix (single color or red/green/blue), high resolution and high brightness, with full text capability. All LEDs shall be used at 50% of the maximum nominal forward current to extend LED life.

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.

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, unless installed on the outside of the carshell. The exterior signs shall be designed to prevent fog and condensation.
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 m). 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.

Exterior signs shall be clearly readable in all ambient light conditions including total darkness and direct sunlight.

The signs shall be capable of displaying scrolling text. All signs shall resume normal operation following supply power interruptions. Self-testing or other functions shall only be activated by the CCU.

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.

### 12.5.2 Car Control Unit (CCU)

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 IVDN to verify their car systems status.

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, Close 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. It must also support 802.11n WiFi for passenger use. The CCU microprocessor usage shall not be greater than 60% of the available processor capacity.

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:

- Standard station stops
- Advertising messages
- Public service messages
- Unique messages, including trainset specific messaging
- Emergency messages

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.

Erasable Programmable Read-Only Memory (EPROM), Electrically Erasable Programmable Read-Only Memory (EEPROM) and flash Programmable Read-Only Memory (PROM) data storage systems shall be used for the operating software and for data storage. Back-up batteries shall not be used. Where removal of the chip is required for reprogramming, memory chips shall be socketed to make it easy to upgrade and replace. The CCU microprocessor control shall re-initialize automatically and safely at power up, and/or following loss of supply power.

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.
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.

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.

The CCU shall have a specific port for connection to a PTU for diagnostic investigations, fault log downloading, system testing, troubleshooting and software upgrading and modification. The connection between the CCU and the PTU shall be through a standard Universal Serial Bus (USB) 2.0 connection or Ethernet connection.

All CCUs shall be interchangeable and capable of performing the same functions.

All data communication between the train’s CCUs shall be through the IVDN.

The yellow indication shows that the system is working at a diminished performance, and that investigation, reset or repair is required.

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 255 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

<table>
<thead>
<tr>
<th>Description</th>
<th>COMM Wire Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>OTIS/PIS</td>
<td>3 &amp; 4</td>
</tr>
<tr>
<td>Train Intercom</td>
<td>5 &amp; 6</td>
</tr>
<tr>
<td>Train PA</td>
<td>7 &amp; 8</td>
</tr>
<tr>
<td>Tape Music</td>
<td>9 &amp; 10</td>
</tr>
<tr>
<td>Destination Sign Control</td>
<td>11 &amp; 12</td>
</tr>
<tr>
<td>OTIS/PIS</td>
<td>24 &amp; 25</td>
</tr>
</tbody>
</table>

### 12.5.3 OTIS/PISCU

Each Master 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 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 PTU, but it shall not allow any reprogramming of the CCU itself.

The OTIS/PISCU shall be of rugged heavy-duty construction with keypads and a visual display. The protected keypads and 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.

The keypads shall be located in proximity to the display screen aligned in a manner readily accessible. Each key shall be a long life, durable tactile feedback switch.
Communication System

The display shall be LCD with LED backlight and adjustable contrast and backlight intensity. The display shall be suitable for the function of the OTIS/PISCU.

The OTIS/PISCU shall be menu-driven for all the functions and the key legends shall correspond to the functions being performed.

Data storage, if included in the OTIS/PISCU, shall be via non-volatile solid-state memory.

Only master cars shall have OTIS/PISCU. When one unit is operated, it becomes the master and the other in the same train set is over-ridden and becomes the slave unit.

12.5.4 Data Communication System (DCS)

The Data Communication System (DCS) shall incorporate all of the data transmission radios. The DCS shall utilize both cellular and WiFi systems for data transmission between the master CCU and the Customer's system server. The DCS shall automatically utilize all available communication links so that the highest data transfer capability is available for any particular train location. Only the CCUs on the master cars shall be equipped with the DCS. Data transmitted to the master CCU shall be sent to all other CCUs of the train consist, through the IVDN as soon as it is received from the system server.

The antennas used for the DCS shall be designed and built for railway applications. The equipment shall be of robust construction and waterproof. Installation shall conform to all railroad equipment clearance restrictions and be contained in secure weatherproof enclosures.

12.5.5 Global Positioning System (GPS)

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.

The CCU shall use the GPS for all location events. It shall not use wayside transponders or wheel rotation to determine the traveled distance. 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. When the CCU loses GPS, all sign functions shall be displayed except those dependent on GPS information. All CCUs shall be equipped with GPS.

The antenna used for the GPS shall be designed and built for railway applications and shall conform to all operational and clearance requirements, including Amtrak's Bi-level Clearance Drawing B-066-0050. The equipment shall be of robust construction and weatherproof. The proposed antenna shall be evaluated during the design review process.

12.5.6 OTIS/PIS Communication Trainline

The OTIS/PIS system shall connect each car to the next one through an IVDN wireline to support Ethernet as required by the needs of the Customer.

The system shall support a consist of up to 10 cars.

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.
12.5.7 Provision for Wireless Internet

The Contractor shall install the hardware needed to establish bi-directional broadband connections to the trackside (i.e., 4.9 GHz and 5.x GHz) and cellular infrastructure.

12.6 Portable Test Unit (PTU) Software

The Portable Test Unit (PTU) software shall be designed to perform the following:

- Download software into the CCU
- Download sign information/updates to the CCU
- Retrieve the fault file from the CCU
- Perform system diagnostic and troubleshooting
- Perform equipment adjustment and calibration such as PA amplifier volume
- Perform system testing, message annunciations, graphic display, etc.

The PTU software shall be menu-driven, browser-based and user-friendly. The software and its functions shall be submitted to the Customer for approval at the design review. All PTU software is reproducible without additional cost as needed by the Customer to support the on-board sign system.

The contractor shall use a USB cable, or Ethernet cable to communicate with carborne equipment. The Contractor shall provide two communication test cables, 10 ft in length. The cable shall connect between the PTU and the CCU or the OTIS/PISCU.

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.

12.7 Software

12.7.1 Software/Programming Requirements

All software used shall be provided to the Customer with all pertinent documentation, including the source code except for the following: 1) commercial operating systems, 2) commercial applications and drivers, 3) proprietary firmware embedded in commercially available chips. This should apply to custom application software developed for this project or software that is not generally available on the open market. The information provided shall enable the Customer to maintain the software and modify it, if necessary, to make changes, improvements and additions.

For non-commercial software, it is permitted to place all the relevant information, including source code, in an escrow account, and made available to the Customer in case the original supplier no longer supports the software. The Contractor bears all costs to sustain any such escrow accounts.

12.7.2 Software License

In support of the program the Customer retains non-exclusive rights to Contractor-provided OTIS/PIS system software to copy, distribute and use as needed to support the sign system in the passenger rail application. The Customer may not sell or license Contractor supplied software. The Customer retains the right to use, modify and alter software via the Contractor or a third party to support the Customer’s rail operations without any additional cost or restrictions. The Customer shall agree to be bound by non-disclosure rules and retains the right to use the software freely.
12.8 **Electromagnetic Interference**

All carborne supplied equipment and its wiring shall be electromagnetically compatible and have no negative impact on:

- All other components on the cars;
- All components of the communication system;
- Operational electronics used by crewmembers, including radios, wireless ticketing devices and others;
- Consumer electronics used by passengers, including cell phones, computers, radios and others; and
- Wayside equipment including signaling systems.

The Contractor shall develop an Electromagnetic Compatibility (EMC) control plan, which shall describe the methodology used to measure control and mitigate all the Electromagnetic Interference (EMI) emissions by the supplied equipment. This plan shall be submitted to the Customer as part of the PDR for the communication system.

* End of Chapter 12 *
Chapter 13

Electrical System
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13.0 Electrical System

13.1 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), and electrical locker circuit breaker panels.

13.2 General Requirements

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.

All cars shall be equipped with 27-point locomotive control (MU) and communication (COMM) 27-wire trainlines. All trainline wires shall run the entire length of the car and be connected from end-to-end.

Receptacles for MU, COMM and HEP shall be located in accordance with APTA Recommended Practice RP-E-016-99.

All electrical systems and components utilized on all cars shall be electromagnetically compatible with other electrical systems and components, including the crew radio, the passenger information system, passenger cellular telephones and laptop computers.

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.

13.3 27-Pin Trainline Systems

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 trainline system shall be compatible with APTA Recommended Practice RP-E-017-99.

The 27-pin COMM, 27-pin MU and 480VAC HEP trainline control circuits shall be run in separate conduits between the ends of the car.

13.3.1 Communication Trainline

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. COMM jumper cable shall be connected between adjacent cars or a single 71 in. COMM jumper shall be connected between the locomotive and the car adjacent to the locomotive.

For COMM trainline pin assignments, see Table 13-1.

### 13.3.1.1 End of Train Functions

On the rear end of the last car of the train, a jumper is connected between the right side COMM receptacle and an adjacent white dummy COMM receptacle shall provide end-of-train detection for on-board systems including the door closed summary circuit. Looping relays shall be provided for each end of the car to establish “end of train” for the four communication trainline circuits (#19, #20, #23 and #26). The looping relay shall be energized when the 27-pin COMM jumper is connected between the COMM receptacle and the adjacent dummy receptacle at the end of the train.

### 13.3.2 Multiple Unit (MU) Trainline

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/baggage car to the locomotive by means of a standard multiple unit (MU) trainline.

A single 60 in. MU jumper cable is connected between adjacent cars, and a single 71 in. MU jumper is between the locomotive and adjacent car.

For MU trainline pin assignments, see Table 13-2.

### 13.3.3 Trainline System Application to Vehicles

The following receptacles and jumper cables shall be in accordance with APTA Recommended Practice RP-E-019-99 and be provided at each end of the car:

- 27-pin communication receptacle, painted blue, complete with contact insert and wiring: Amtrak Drawing D-63-7439.
- 27-pin communication dummy receptacle, painted white, complete with contact insert and wiring: Amtrak Drawing D-63-7440.
- 27-pin communication jumper cable, 60 in. car-to-car with blue heads: Amtrak Drawing C-01-1498.
- 27-pin MU receptacles, painted black, complete with contact insert and wiring: Amtrak Drawing C-63-7437.
- 27-pin MU jumper cable, 60 in. car-to-car with black heads: Amtrak Drawing C-63-7422.

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.

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 Recommended Practice RP-E-017-99. One MU and one COMM 27-point jumper cable shall be connected between adjacent
Electrical System 13-4

cars as well as to the locomotive. Jumpers and receptacles shall be color-coded as well as keyed to prevent cross-connection.

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.

There shall be no interference that restricts the receptacle cover from being fully opened to allow insertion or withdrawal of jumpers.

Under all operating conditions, a minimum of 2 in. 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.

Each car shall be delivered with one loose jumper cable of each type. CDRL

13.3.4 Trainline Junction Boxes

Separate stainless steel weatherproof junction boxes shall be provided at each end of the car for the communication and MU trainline systems. Trainline junction boxes at the F-end of cab/baggage cars shall be located behind the F-end truck or other Customer approved protected location.

The inside of the box shall be painted with an insulating paint or varnish. All wires shall be terminated using ring tongue 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.

13.4 480 VAC Head End Power (HEP) Trainline System

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 Recommended Practice RP-E-016-99.

In addition to the three main power conductors, the jumpers also include three control pins, which provide locomotive trainline complete signal (indicating all jumpers throughout the train are in place), and a car-to-car carbody ground bond. HEP circuit assignments shall be in accordance with Amtrak Specification 963.

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.

13.4.1 Receptacles and Jumpers

Each end of each car will be equipped with two fixed jumper cables and two receptacles with housings per APTA Recommended Practice RP-E-017-99 (Figure 4A) and APTA Recommended Practice RP-E-018-99. Components shall include:

- 480VAC fixed jumper (length to run from end sheet to transition bulkhead)
- 480VAC receptacle: Amtrak Drawing D-12-7191
Electrical System

- 480VAC receptacle housing: Amtrak Drawing D-12-7191

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. Receptacle mounting shall provide adequate clearance from all car apparatus 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. All HEP receptacles shall be labeled with appropriate DANGER 480V warnings, in accordance with Amtrak Specification 696. 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 lb force 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.

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.

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. of the top of rail (vertically) when connected to an adjacent car on straight, level track.

13.4.2 Wiring and Connections

13.4.2.1 Power Cable

The 3-phase HEP trainline power cables per APTA Recommended Practices RP-E-002-98 and RP-E-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.

The wire used in the trainline power cables shall be 4/0 as specified in APTA Recommended Practice RP-E-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.

The HEP cables shall run between junction boxes on the underside of the lower level of the car in a protected wire race. All cables and conduits shall be supported by suitable cleats at appropriate intervals not exceeding 24 in. Spare trainline wires shall be identified in the end-of-car junction boxes.

13.4.3 Power Junction Boxes

An 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 lower level of the car. The B-end junction box shall provide connection to the 480VAC power distribution circuit for the car.

13.5 480 VAC Power Distribution

The 480VAC power is distributed throughout the cars 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.

13.5.1 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.

13.5.2 Power Transformers

All transformers shall be of a dry type, and convection cooled, in accordance with Amtrak Drawing D-65-7449, rev. A. 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.

At a minimum, the following types of transformers shall be provided:

- All car types: Set of three single-phase 480/120VAC transformers connected delta-delta, ungrounded, to provide 120VAC service.
- All car types: Single-phase 480/120VAC single-phase Ground Fault Circuit Interrupter (GFCI), grounded to provide 120VAC.
- Café/lounge car: 3-phase 480/208-120VAC, delta-wye, to provide 120-208VAC, 3-phase service with grounded neutral.

All transformers shall be located inside the electrical lockers or under car equipment boxes. The Contractor shall demonstrate that there is sufficient ventilation to prevent component failure and/or damage resulting from excessive heat buildup, with Heating, Ventilation and Air Conditioning (HVAC) system off.

Transformers and inductors shall be derated at least 10% for current, or other appropriate approved factor, based upon duty cycle.

13.6 120 VAC Power Distribution

The 120VAC power is distributed throughout 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.

A master circuit breaker shall control power distribution to all 120VAC circuit breakers.
13.6.1 Passenger Convenience Outlets

A flush-style 120VAC duplex convenience outlet shall be installed in the wall panel at each seat pair location using the GFCI circuits. A single outlet may alternatively be located on each seat, depending upon seat design. The outlets are intended to provide power for passenger electronic equipment, such as laptop computers. Convenience outlets shall also be provided at each table in the lounge end of the café/lounge car.

Two duplex outlets 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 Customer. An Amtrak-standard 120V decal (Amtrak p/n 0065NS), per Amtrak Specification 697, shall be installed on the power strip conduit cover at each outlet location, 0.50 in. from outlet, between the outlet and the seat facing the outlet.

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.

13.6.2 Interior Service Outlets

Duplex service outlets shall be located in each toilet room, electrical locker and utility lockers in all car types, in locations and quantities suitable for their intended use in those areas.

The galley area of the café/lounge car and the cab area of the cab/baggage car shall also be equipped with service outlets as specified in Chapter 14 and Chapter 16, respectively.

Service outlets shall be protected locally by duplex service proven GFCI type circuit breaker rated for 120VAC, single phase, 60 Hz, 20 amps at each service outlet location. In addition, these circuits shall be protected by separate circuit breakers.

13.7 Battery Charger

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.

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.

The 74/64VDC 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.
The battery and charger system is comprised of:

- Battery charger with temperature sensor
- Battery (multiple cells)
- Load drop device

The same battery type and battery charger shall be used on all car types.

13.7.1.1 Operation

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. 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, with all normal car DC loads on. On the cab/baggage car, this includes headlights and crossing lights, and all cab loads from an active cab. 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.

13.7.1.2 Basic Charger Characteristics

Basic charger characteristics shall include the following:

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Voltage</td>
<td>480VAC nominal (tolerance range +10%/−15%), 3-phase, 3-wire</td>
</tr>
<tr>
<td>Input Frequency</td>
<td>60 Hz nominal (tolerance range 56-64 Hz)</td>
</tr>
<tr>
<td>Input Protection</td>
<td>3-pole circuit breaker (external reset)</td>
</tr>
<tr>
<td>Output Voltage, Temperature Compensated</td>
<td>73.6VDC at 20°C ambient; 80VDC maximum</td>
</tr>
<tr>
<td>Temperature Compensation</td>
<td>In accordance with the battery manufacturers recommendation.</td>
</tr>
<tr>
<td>Ripple</td>
<td>Maximum of 2 volts peak-to-peak any load within rating</td>
</tr>
<tr>
<td>Audible Noise</td>
<td>62 dBA maximum for components mounted inside the car</td>
</tr>
<tr>
<td>Ability to automatically recharge the battery from any state of discharge, including 0 volts on battery terminals.</td>
<td></td>
</tr>
<tr>
<td>Charging voltage ambient temperature compensated as sensed at the battery.</td>
<td></td>
</tr>
<tr>
<td>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.</td>
<td></td>
</tr>
<tr>
<td>Only a single circuit board, containing all charger control functions.</td>
<td></td>
</tr>
</tbody>
</table>

13.7.1.3 Circuit Breakers

The charger shall be equipped with two circuit breakers on the front face, one for the charger output and one for the battery disconnect.
13.7.1.4 Indicators

The charger shall include individual status indication LEDs that are displayed from the front face. These shall include:

<table>
<thead>
<tr>
<th>Condition</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply 480VAC On</td>
<td>Green</td>
</tr>
<tr>
<td>Current Limit (in current limit mode)</td>
<td>Amber</td>
</tr>
<tr>
<td>Load Dump Relayed Energized</td>
<td>Amber</td>
</tr>
<tr>
<td>Supply 480VAC off/out of tolerance</td>
<td>Red</td>
</tr>
<tr>
<td>Rectifier Failure</td>
<td>Red</td>
</tr>
<tr>
<td>Temperature Sensor Failure</td>
<td>Red</td>
</tr>
</tbody>
</table>

A lamp test pushbutton shall be provided, which when pressed will cause all lamps to light.

The charger shall include three meters on the front face:

<table>
<thead>
<tr>
<th>Meters</th>
<th>Ranges</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC Amps (total charger output)</td>
<td>0-100 amps</td>
</tr>
<tr>
<td>Battery Amps (current into/out of battery)</td>
<td>100-0-100 amps (zero center)</td>
</tr>
<tr>
<td>DC volts (charger output voltage)</td>
<td>0-100 volts</td>
</tr>
</tbody>
</table>

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.

13.7.1.5 Self-Protection

At a minimum, the charger shall be self-protected against the following fault conditions:

- Open circuited battery or wiring
- Short circuited battery or wiring
- Battery ground fault
- Temperature sensor fault
- Low input voltage
- Input phase loss
- Reversed phase rotation
- Reversed battery connections
- System overload
- Voltage or current over limit

13.7.1.6 Temperature Sensor

The temperature sensor shall be sealed and mounted onto one of the intercell plates of the battery.
13.7.1.7  Operation of Battery Charger

Operation of the battery charger is as follows:

**Normal:** 480VAC HEP “ON”; DC system “ON”
- All AC and DC loads available
- All DC loads fed by battery charger

**Standby:** 480VAC HEP “OFF”; DC system “ON”
- Battery voltage above 58 VDC
- All DC loads fed by battery

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.

**Emergency:** 480VAC HEP “OFF”; DC system “OFF”
- Battery voltage below 45VDC
- All DC loads are without power because the load drop device has disconnected the battery system or the battery system is disabled due to equipment failure.

In emergency mode only independently powered emergency lights remain on. See Chapter 11 for details.

Upon restoration of HEP, all DC loads shall be available immediately, including those that were disconnected as part of standby, emergency or load drop. DC load transfer by the battery charger shall be independent of the state of the battery when HEP is available.

13.7.1.8  Load Drop 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.) This device disconnects all DC loads so the battery is not damaged by running cell voltage to zero. Independently powered emergency light fixtures turn on automatically upon Load Drop. This condition is called Emergency.

13.8  Battery System

The battery shall provide power for necessary systems when the HEP system is not available. The battery system shall be compliant with APTA Recommended Practice RP-E-007-098R1.
13.8.1 Batteries

The Contractor shall submit a battery design that:

- Meets the load requirements found in Table 13-3 with at least 25% extra capacity;
- Provides the longest life-cycle cost effective system; and
- Provides the latest technology that is available in passenger rail battery design.

All car types shall utilize the same type of battery cell. The batteries shall be recharged by the battery charger as specified above.

Batteries shall be nickel-cadmium (Ni-CAD), lithium ion or nickel-metal hydride, whichever provides the most optimum performance as specified.

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.

The battery shall be designed to minimize hazards to operating personnel during service, operation, line maintenance and shop maintenance.

13.8.2 Battery Performance

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.

The batteries shall have a design service life of no less then 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 in no more than five hours.

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/baggage cars, the DC load shall include all cab loads plus headlights and auxiliary lights. Café/lounge cars shall include battery capacity to power the food service chillers for one hour through an inverter. This shall be accomplished through the use of a separate battery supply from that used to power the café/lounge car’s base DC loads.

A DC load budget shall be developed by the Contractor and submitted to the Customer 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.

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13.8.3 Battery Markings

Each battery cell or battery unit shall be permanently marked with the following information:

- Manufacturer’s name
- Battery type
- Catalog or part number
- Nominal rated capacity at five- and eight-hour discharge rates
- Serial number
- Date manufactured
- Customer name
- Customer part number
- Warning and safety precautions (i.e. USE NO ACID, etc.)
- Blank space where installation date can be written

Markings shall be resistant to the chemical and mechanical environment encountered in service for the design life of the cell.

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 of the negative post shall be identified with a black post insulator or bushing and/or a plainly marked N, NEG or - symbol.

13.8.4 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).
13.9  DC Power Distribution System

Power for all DC loads shall be distributed throughout the car through switch and circuit breaker panels located in the electrical equipment lockers.

13.9.1  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.

13.9.2  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.

13.10  Electrical Panels

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.

All circuit breaker and switch panels shall meet all recommendations of APTA Recommended Practice RP-E-002-98.

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.

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 Customer approval.

A wiring gutter shall be provided along the top, sides and bottom, for the routing of high-voltage leads to their designated circuit breakers.

The circuit breaker panel shall be configured for easy removal so that maintenance and repair action are not impeded.
13.10.1 Switch and Circuit Breaker Panel Arrangement

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.

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.

Circuit breakers for the 24VDC, 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.

13.11 Integrated Schematics

The Contractor shall prepare and submit, for acceptance by the Customer, an integrated schematic diagram package showing all electrical systems and including all components and wiring on the car. See Chapter 22.
## Table 13-1: Communication Trainline Pin Assignments

<table>
<thead>
<tr>
<th>Pin</th>
<th>Amtrak Standard (for information only)</th>
<th>APTA Standard (for information only)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Shield</td>
<td>Shield (Common)</td>
</tr>
<tr>
<td>2</td>
<td>Battery Negative</td>
<td>Battery Negative</td>
</tr>
<tr>
<td>3</td>
<td>PA/Tape Music #1 (black)</td>
<td>PA/Tape Music #1 (black)</td>
</tr>
<tr>
<td>4</td>
<td>PA/Tape Music #1 (white)</td>
<td>PA/Tape Music #1 (white)</td>
</tr>
<tr>
<td>5</td>
<td>Intercom (black)</td>
<td>Intercom (black)</td>
</tr>
<tr>
<td>6</td>
<td>Intercom (white)</td>
<td>Intercom (white)</td>
</tr>
<tr>
<td>7</td>
<td>PA Control (black)</td>
<td>PA Control (black)</td>
</tr>
<tr>
<td>8</td>
<td>PA Control (white)</td>
<td>PA Control (white)</td>
</tr>
<tr>
<td>9</td>
<td>Passenger Info (black)</td>
<td>Music-3 (radio)(black)</td>
</tr>
<tr>
<td>10</td>
<td>Passenger Info (white)</td>
<td>Music-3 (radio)(white)</td>
</tr>
<tr>
<td>11</td>
<td>Brake Application (spare-reserved for future use)</td>
<td>Brake Application</td>
</tr>
<tr>
<td>12</td>
<td>Brake Release (spare-reserved for future use)</td>
<td>Brake Release</td>
</tr>
<tr>
<td>13</td>
<td>Brake Negative (spare-reserved for future use)</td>
<td>Brake Negative</td>
</tr>
<tr>
<td>14</td>
<td>Open Doors R.H.</td>
<td>Open Doors R.H.</td>
</tr>
<tr>
<td>15</td>
<td>Open Doors L.H.</td>
<td>Open Doors L.H.</td>
</tr>
<tr>
<td>16</td>
<td>Close Doors R.H.</td>
<td>Close Doors R.H.</td>
</tr>
<tr>
<td>17</td>
<td>Close Doors L.H.</td>
<td>Close Doors L.H.</td>
</tr>
<tr>
<td>18</td>
<td>Door Closed Light</td>
<td>Door Closed Light</td>
</tr>
<tr>
<td>19</td>
<td>Brake Released Light</td>
<td>Brake Released Light</td>
</tr>
<tr>
<td>20</td>
<td>Brake Applied Light</td>
<td>Brake Applied Light</td>
</tr>
<tr>
<td>21</td>
<td>Hot Journal Light</td>
<td>Hot Journal Light</td>
</tr>
<tr>
<td>22</td>
<td>Conductor’s Signal</td>
<td>Conductor’s Signal</td>
</tr>
<tr>
<td>23</td>
<td>Conductor’s Door Closed Light</td>
<td>Door Close Lt</td>
</tr>
<tr>
<td>24</td>
<td>Tape Music #2 (black) (spare)</td>
<td>Tape Music #2 (black)</td>
</tr>
<tr>
<td>25</td>
<td>Tape Music #2 (white) (spare)</td>
<td>Tape Music #2 (white)</td>
</tr>
<tr>
<td>26</td>
<td>Conductor’s Door Light Feed</td>
<td>Conductor’s Door Light Feed</td>
</tr>
<tr>
<td>27</td>
<td>Attendant Call System (not active)</td>
<td>Attendant Call</td>
</tr>
</tbody>
</table>

| Shielded pairs | 3&4, 5&6, 7&8, 9&10, 24&25 |
| Source         | Amtrak dwg A-63-7676-1 (under revision) | APTA Std RP-E-017-99 |
## Table 13-2: Multiple Unit (MU) Trainline Pin Assignments

<table>
<thead>
<tr>
<th>Pin</th>
<th>Amtrak Standard (for information only)</th>
<th>APTA Standard (for information only)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Spare</td>
<td>Spare (reserved for cruise control)</td>
</tr>
<tr>
<td>2</td>
<td>Alarm Bell</td>
<td>Alarm Bell</td>
</tr>
<tr>
<td>3</td>
<td>D Throttle</td>
<td>D Throttle</td>
</tr>
<tr>
<td>4</td>
<td>Control Negative</td>
<td>Control Negative</td>
</tr>
<tr>
<td>5</td>
<td>Emergency Sand</td>
<td>Emergency Sand</td>
</tr>
<tr>
<td>6</td>
<td>Generator Field</td>
<td>Generator Field</td>
</tr>
<tr>
<td>7</td>
<td>C Throttle</td>
<td>C Throttle</td>
</tr>
<tr>
<td>8</td>
<td>Forward</td>
<td>Forward</td>
</tr>
<tr>
<td>9</td>
<td>Reverse</td>
<td>Reverse</td>
</tr>
<tr>
<td>10</td>
<td>Wheel Slip</td>
<td>Wheel Slip</td>
</tr>
<tr>
<td>11</td>
<td>Spare</td>
<td>Spare</td>
</tr>
<tr>
<td>12</td>
<td>B Throttle</td>
<td>B Throttle</td>
</tr>
<tr>
<td>13</td>
<td>Control Positive</td>
<td>Control Positive</td>
</tr>
<tr>
<td>14</td>
<td>Spare</td>
<td>Spare</td>
</tr>
<tr>
<td>15</td>
<td>A Throttle</td>
<td>A Throttle</td>
</tr>
<tr>
<td>16</td>
<td>Engine Run</td>
<td>Engine Run</td>
</tr>
<tr>
<td>17</td>
<td>Dynamic Brake Setup</td>
<td>Dynamic Brake Setup</td>
</tr>
<tr>
<td>18</td>
<td>Remote Loadmeter</td>
<td>Remote Loadmeter</td>
</tr>
<tr>
<td>19</td>
<td>Remote Loadmeter</td>
<td>Remote Loadmeter</td>
</tr>
<tr>
<td>20</td>
<td>Dynamic Brake Warning</td>
<td>Dynamic Brake Warning</td>
</tr>
<tr>
<td>21</td>
<td>Dynamic Brake Start</td>
<td>Dynamic Brake Start</td>
</tr>
<tr>
<td>22</td>
<td>Spare</td>
<td>Spare</td>
</tr>
<tr>
<td>23</td>
<td>Manual Sanding</td>
<td>Manual Sanding</td>
</tr>
<tr>
<td>24</td>
<td>Dynamic Brake Excitation</td>
<td>Dynamic Brake Excitation</td>
</tr>
<tr>
<td>25</td>
<td>Spare</td>
<td>MU Headlight</td>
</tr>
<tr>
<td>26</td>
<td>Remote Fault Reset</td>
<td>Remote Fault Reset</td>
</tr>
<tr>
<td>27</td>
<td>Brake Emergency</td>
<td>Brake Emergency</td>
</tr>
</tbody>
</table>
### Table 13-3: Power Phase Matrix

<table>
<thead>
<tr>
<th>Condition</th>
<th>Normal</th>
<th>Standby</th>
<th>Emergency</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description of Condition</strong></td>
<td><strong>HEP Power. Normal operation. All systems on and functioning.</strong></td>
<td><strong>After loss of HEP. Systems powered by main car batteries. ALL DC loads on.</strong></td>
<td><strong>No battery power. Lights are independently powered per FRA requirement.</strong></td>
</tr>
<tr>
<td>Timeline</td>
<td>normal</td>
<td>2 hours</td>
<td>90 minutes</td>
</tr>
<tr>
<td>Threshold</td>
<td>normal</td>
<td>after HEP loss</td>
<td>after load drop</td>
</tr>
<tr>
<td>Battery voltage</td>
<td>normal</td>
<td>64-58V DC</td>
<td>below 45V DC</td>
</tr>
<tr>
<td><strong>AC Lights:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seating Area</td>
<td>yes</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td><strong>DC Lights:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seating Area</td>
<td>yes</td>
<td>yes</td>
<td>no*</td>
</tr>
<tr>
<td>Vestibules</td>
<td>yes</td>
<td>yes</td>
<td>no*</td>
</tr>
<tr>
<td>Toilet Rooms</td>
<td>yes</td>
<td>yes</td>
<td>no*</td>
</tr>
<tr>
<td>Reading</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Electrical Locker</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Exterior Platform</td>
<td>yes</td>
<td>yes</td>
<td>no*</td>
</tr>
<tr>
<td>Passageway</td>
<td>yes</td>
<td>yes</td>
<td>no*</td>
</tr>
<tr>
<td>Marker</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Capacitor Lights (*)</td>
<td>no</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Café Sconce</td>
<td>yes</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td><strong>Doors:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Side Door control</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Side Door operators</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>End Door Controls and Operators</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Door Closed Summary Circuit</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>PA</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>HVAC</td>
<td>yes</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Toilet Systems</td>
<td>yes</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Toilet Room Exhaust Fans</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Destination Signs/PIS</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Wheelslide</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Convenience Outlets</td>
<td>yes</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td><strong>Cab:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Headlights and Crossing</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
</tbody>
</table>
### Electrical System

<table>
<thead>
<tr>
<th>Condition</th>
<th>Normal</th>
<th>Standby</th>
<th>Emergency</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description of Condition</strong></td>
<td>HEP Power. Normal operation. All systems on and functioning.</td>
<td>After loss of HEP. Systems powered by main car batteries. ALL DC loads on.</td>
<td>No battery power. Lights are independently powered per FRA requirement.</td>
</tr>
<tr>
<td>Lights (cab only)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cab Radio</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20 sec every 5 min</td>
<td></td>
</tr>
<tr>
<td>Locomotive Control</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Event Recorder</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Alerter</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>PTC</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Café/ Lounge:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chillers</td>
<td>yes</td>
<td>Yes*</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coffee Maker</td>
<td>yes</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Point of Sale</td>
<td>yes</td>
<td>Yes*</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elevator</td>
<td>yes</td>
<td>no</td>
<td>no</td>
</tr>
</tbody>
</table>

* End of Chapter 13 *
Chapter 14

Food Service
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14.0 Food Service

14.1 Overview

Providing food service is a highly variable part of the passenger rail service offering that is driven by the distance between terminal stations, the duration of journey for a majority of the passengers, and the revenue and train cost structure of the service. On a single train, there may be multiple levels of service offered defined by class of service or time of day. In establishing the requirements for food service, the operating entity purchasing railcars under this specification should use this Chapter to assemble the common elements described to assure maximum interoperability as required by PRIIA.

The common elements of this specification include:

- A galley area that includes a “point-of-sale” location with hot and cold food prep equipment, self-service refrigerated display cases, dry storage containers and refrigerated storage carts with modular chiller units. The galley will normally be installed in the “B” end of the car for commonality of undercar equipment.

- A lounge area, with stand-up counters and/or table/booth seating for parties of one, two or three people. The lounge is intended to be for non-revenue seating by passengers. One ADA seat location with wheelchair storage shall be provided. The design of the lounge, including lighting and amenities, shall provide a comfortable and distinctive area for passengers to eat, converse and relax. Convenience outlets, recycling and trash containers, a condiment station and accent lighting shall be provided. The installation of optional overhead racks for storage of small cases and coats may be installed above the booths and tables. This area shall normally occupy the center 60% of the car and have an accessible path over the length of the car.

- An ADA accessible restroom located above the truck of the A-end of the car opposite the electric locker and emergency equipment locker. The restroom shall be located on the vestibule side of the car bi-parting end doors.

- A conductor’s office with enclosed work area to isolate radio conversations and to allow the conductor to perform his accounting work in private at the A-end of the car adjacent to the restroom.

- A revenue Coach seating area with ADA wheelchair position in lieu of the lounge area with luggage tower, overhead luggage storage, reading lights, at-seat convenience outlets, and recycling trash containers. Refer to Chapter 9 for specifications.

- A revenue Business Class seating area with ADA wheelchair position in lieu of the lounge area with luggage tower, Business Class beverage station, overhead luggage storage, reading lights, at seat convenience outlets, and recycling trash containers. Refer to Chapter 9 for specifications.

This chapter specifies those systems, features and components found only on the café/lounge car. Areas of the café/lounge car that are not defined or specified in this chapter shall be governed by the applicable equivalent system requirements found elsewhere in this specification, unless specifically identified otherwise.

This specification does not provide a description of a café/lounge car offering sit-down meal service in a conventional “Dining Car” level of service. Amtrak has developed a separate
specification for full-service dining cars which should be consulted if that food option is desired.

14.2 General Requirements

The café/lounge car shall provide a positive atmosphere for a passenger to purchase food which may be consumed in this car or taken back to the seat. The galley shall provide a safe and efficient work space for the food service employees and train crew. The café/lounge car shall consist of a galley, lounge seating and/or a revenue seating area, a conductor’s workstation, one ADA accessible seat with wheelchair storage, and ADA compliant restroom.

Standard Seating and ADA Accessible Seating

The café/lounge car shall include an accessible seating area in the A-end of the car. The accessible seating area shall include a single seat, a small table and a wheelchair parking spot at the table, per 49CFR Parts 27, 37 and 38.

The components of the galley and food storage area shall be modular. The food service galley and lounge areas shall conform to all applicable regulations, including health and safety and food preparation requirements. Certification of compliance with FDA regulations shall be required.

A single level dining car need not have a restroom if no revenue seating is provided and an accessible path is available to an ADA compliant restroom in an adjacent car. The component arrangement and description of the food service will in part define the requirements for the restroom.

The café/lounge car interior configuration shall be in conformance with the conceptual drawing provided as Figure 14-1.

14.2.1 Galley Area

The galley shall be located at the B-end of the car, be modular in design and installation and shall contain the following features:

- Serving counter
- Self service lockable display cases with sliding clear polycarbonate resin thermoplastic or Lexan doors
- Countertops with adequate space for food preparation and storage
- Two chiller units, with each chiller cooling three carts
- Cart storage areas for six refrigerated carts
- Cart storage areas for three non-refrigerated carts or six dry storage carriers
- One hand washing sink and one utility sink, with hot water supply, paper towel and soap dispensers and an under counter storage area for cleaning supplies
- Mirror and accent light above hand washing sink
- Galley appliances:
  - Coffee makers (two)
  - Microwave ovens (two)
• Toaster
• Ice well
• Point-of-Sale (POS) unit
• Trash and recycling compartments – two of each
• Public address (PA) unit, with handset and function selector switch
• Storage location for a fire extinguisher and Customer-provided Automated External Defibrillator (AED)
• Jump seat
• Lockable under-counter storage area for crew use
• Security screen with storage locker
• Eight duplex service receptacles, four along each side wall of the galley, (exclusive of dedicated outlets)
• Heating, Ventilation and Air Conditioning (HVAC) diffusers, with an air adjustment feature, to provide air supply to galley
• Circuit breaker panel with door and paddle latch
• Dispensers:
  • Coffee cups
  • Coffee cup lids
  • Cold cups
  • Carryout boxes
• Overhead storage shelf with capacity for four trays

14.2.2 Lounge Area

Booths with seats and tables for one-, two- and three person seating shall be located on one side of the aisle way at the A-end of car, in conformance with the conceptual layout shown in Figure 14-1. The other side of the car shall have stand-up counters and railings or may replicate the booth configuration as specified by the customer. The aisle shall be wide enough to provide room for a line of passengers to form at the serving counter while permitting other passengers to pass through the lounge area unobstructed.

The booth seats shall be made of Fiberglass Reinforced Plastic (FRP) and shall be equipped with back and bottom cushions. The booth seats facing the side of the car shall have a handrail at the back, near the top of the seat back, for passengers passing through the aisle or standing in line to use as a handhold. Design of the booths and tables shall be in accordance with the ergonomic requirements for the range of passengers from the 5th percentile female to the 95th percentile male. Table edges shall be rounded and shall include a small lip around the perimeter of the table top to contain spilled liquids. Duplex convenience outlets shall be installed adjacent to each table.

The booths shall be easily cleaned and cushions shall be easily removed for cleaning and shall be attached to the booth in accordance with component attachment strength requirements. Food particles shall not be permitted to collect in any area of the lounge. Adequate clearance shall be provided under the booths and tables for cleaning of the floor, or the area under the booths shall be closed off.
**Food Service**

Upholstery and fabric selection for the booth seats shall be submitted to the Customer for approval as part of the interior décor palette. See Chapter 9.

### 14.2.3 Conductor’s Workstation (optional)

A seating area with a table for two persons enclosed with full height wall and glazed pocket door shall be located on the A-end for train crew to use as office space. An extra pair of duplex outlets shall be provided for the crew to use for charging of radios, cell phones and other equipment. A Public Address (PA) system control station, with handset and intercom, shall be provided at the conductor’s workstation.

The overhead luggage bin above the conductor’s workstation shall be fitted with a standard coach key lock.

### 14.3 Galley Design Requirements

The galley, serving counter and lounge areas shall be designed to provide an aesthetically pleasing and efficient area for passengers and crew. The Contractor shall be responsible for providing a comprehensive and unified appearance throughout all areas of the cafe/lounge car, as well as being complimentary and consistent with all other car types built to this specification. Choice of finish materials shall be submitted to the Customer for approval.

#### 14.3.1 Countertops and Serving Counter

Galley countertops shall be approximately 39 in. above the floor. The countertops and cart storage areas shall provide space for food storage and crew work area, including counter area for basic food preparation, hand washing and utility sinks, ice well, cutting board and basic appliances.

The serving counter shall be 48 in. above the floor and shall be no less than 14 in. deep (from passenger side to galley side). The top portion of the serving counter shall be made of Wilson Art Gibraltar Solid Surface 100% acrylic countertop material (or Customer approved equivalent), with raised exposed edge and cove molding where it abuts vertical surfaces. Color of the countertop shall be provided for to Customer approval at the design review.

#### 14.3.2 Design Requirements

The galley area shall be composed of several essentially self-contained modules that are attached to the carbody floor, wall and ceiling structure at several points.

The design and installation of countertops, wall panels, floor-to-wall joints, recycling and trash receptacles and lockers and component mounting shall not permit food particles, debris, liquids or moisture to harbor behind, over or under any of their surfaces. Countertops shall have a raised edge on all exposed faces and a cove on all edges adjacent walls and bulkheads and be properly sealed and caulked. All outside corners formed by two planes shall have a minimum radius of 0.25 in. Corners formed by three planes shall have a minimum spherical radius of 0.375 in.

The size and quantity of recycling and trash receptacles shall be adequate to accommodate the volume of recyclables and trash generated during revenue service. The size and configuration of trash receptacles shall be specified by the Customer. To the greatest extent possible, Amtrak standard receptacles should be specified to facilitate ease of maintenance.
14.3.3 Structural Requirements

All food service equipment shall meet the crashworthiness standards of 49CFR Section 238.233 and APTA Standard SS-C&S-006-98, including the complete galley, security screen, galley equipment, appliances and cart and chiller units. Compliance with 49CFR Section 238.233 shall consider the worst case scenario of the food service equipment.

This shall include the securement of:

- The galley structure when fully loaded with all supplies and an entire stock of fully loaded carts.
- Carts, chiller units and trays to galley structure, including the food service trays when held in the angled tray storage shelf.
- Galley appliances to the countertops.
- The security screen when stored.

The wall on which the jump seat is mounted shall provide structural strength to support a downward load of no less than 300 lbs. on the jump seat without deformation.

14.4 Galley Appliances

Countertop space provided for these appliances shall include adequate room to replace appliances with a different model or style with similar capacity.

Appliance change-out time (the time to remove a defective unit, install a replacement unit and verify function of the replacement unit) shall not exceed 30 min. for the galley appliances specified in this section.

All appliances shall be mounted within the galley in a manner that complies with regulations regarding attachment strength and resistance to acceleration forces. The retention mechanisms shall not interfere with appliance operation or routine cleaning or servicing and shall allow the removal and replacement of the appliances within the specified times.

All appliances shall be installed to provide adequate ventilation for cooling/heat dissipation and to prevent heat buildup on adjacent surfaces, per the appliance manufacturer’s recommendations.

Each appliance shall be powered through a separate dedicated, labeled circuit breaker with matching label at the protected simplex outlet. All appliances shall be properly grounded to the carbody.

All commercially available appliances shall be approved by Underwriters’ Laboratories (UL) and the National Sanitation Foundation (NSF).

14.4.1 Coffee Maker

Space to accommodate a Wilbur-Curtis Gemini G3 series coffee maker, model GEMTS16A1000 (or Customer approved equivalent) shall be provided, located on the working counter of the galley. The coffee maker shall include two coffee urns and an in-line water filter. The installation and securement design for the coffee maker shall be as configured for revenue service (coffee maker and both urns filled with water).
A drain pan shall be provided under the coffee maker urn spigots, with a 0.75 in. drain to ground, to catch spills and drips from the coffee spigots as well as to allow the unit to be drained for cleaning or servicing/replacement. The drain line shall be equipped with a check valve, which shall be located to facilitate replacement and maintenance.

The coffee maker shall be powered through a dedicated circuit breaker and the case shall be grounded to carbody.

Dispensers for coffee cups and coffee cup lids shall be located in the immediate vicinity of the coffee maker.

Basic characteristics:

- Coffee server capacity: 3 gal total (1.5 gal per urn)
- 208VAC, 3-phase, 7800W, 20-amp service
- Protection for heater element when no water is present
- Hot water faucet - adjustable, set to 180°F
- Manual drain to empty the brewer water tank
- Plug and receptacle type: NEMA 6-20R
- Quick disconnect fittings: Wilbur-Curtis JB-H20QC (female on coffee maker and male on galley side of water supply line) (or Customer approved equivalent)

### 14.4.2 Microwave Ovens

Space in the galley shall be designated to accommodate two commercial microwave ovens, such as the Panasonic NE-1257R, (or Customer approved equivalent), elevated above the work counter. These microwaves shall be mounted one above the other, in a frame that permits removal of one microwave without requiring the disturbance of the other.

The microwave ovens shall meet all current radiation and labeling requirements of the Federal Communications Commission (FCC).

Basic characteristics:

- Capacity: 0.62 ft³
- 1200 W cooking power
- 120VAC, 18 amp service
- Plug and receptacle type: NEMA
- Labels at oven: MICROWAVE OVEN 1 (upper), MICROWAVE OVEN 2 (lower)

### 14.4.3 Freezer

If shown on plans, an industrial/transportation grade, self-contained under counter freezer shall be provided in the galley below the working counter, to be used for storing bagged ice cubes, ice cream and other frozen food. Freezers shall meet all FDA and NSF requirements. The freezers shall be SubZero model 249FF or Customer approved equivalent. Freezer condensate shall drain into a drain pan integrated into the unit. No external drain shall be required.
Basic characteristics:

- Operating temperature: 0°F or colder (thermostat setting locked)
- Capacity: 4.6 ft³
- Rating: capable of consistently maintaining food at the FDA required 0°F or colder under all combinations of the following:
  - Continuous operation with the galley at an ambient temperature of up to 90°F
  - Under all state-of-load situations: empty, partial load, fully loaded
  - Attain a pull-down to 0°F or below within 45 min of startup from an overnight soak of the refrigerated space at 90°F
- Door hinged on left side on upper level freezer, hinged on right side on lower level freezer
- Door shall have a positive self-latching handle
- Door shall have a padlock hasp to permit the freezer to be locked with a crew-issued padlock (0.25 in. inside diameter hole in hasp)
- A digital thermometer, reading internal box temperature, shall be installed on the upper section of the front face of the door
- 120VAC, 15 amp service, with NEMA type plug and receptacle

14.4.4 Toaster

A commercial-grade, four-slice toaster, Waring Commercial model WCT 708 or Customer approved equivalent, shall be provided in the galley area. The toaster shall operate on 120VAC with a rating of 1800 W and shall have a plated steel case with a brushed chrome finish. The toaster shall be installed on the countertop using a securing mechanism that prevents unauthorized removal but permits maintenance – Bell Plastics Toaster Holder, Black - p/n TH 127, or Customer approved equivalent.

14.4.5 Point-of-Sale (POS)

A standard Point-of-sale (POS) unit will be provided in the galley. The POS unit shall be manufactured and installed in accordance with Amtrak POS standards in effect at the time of design and manufacture of the café/lounge cars. The POS operation shall be supported during Head End Power (HEP) outages by an inverter that supplies 120VAC from the chiller backup battery source.

Provision shall be made for the POS to communicate with the car-based communication system for real-time inventory reporting, credit card transactions, etc. This will be defined by the Customer during design review.

14.5 Cart System Operation Overview

Food and supplies for the galley and on-board food sales will be delivered to the train via free-rolling, airline-style insulated food storage carts. Carts containing perishable items shall be docked at locations with access to chilled air ducts to provide cooling for the perishable items. Self-contained chiller units will circulate refrigerated air through the carts, with the chilled air returning to the chiller for re-refrigeration. Chilled and return air will be transferred to and from the carts through magnetic rubber seals on the ducts that make contact with steel plates.
on the rear of the cart. The duct openings shall be equipped with a spring-loaded, hinged flapper that closes and seals the duct opening when no cart is docked and automatically opens when a cart is docked at that location to allow chilled air to circulate into the cart. The chilled carts shall be docked under the countertop.

Carts containing "dry" items (non-perishable food and other supplies) shall be docked at non-chilled locations under the counter on the left side of the galley.

Carts will be loaded onto the car through the B-end vestibule door. Carts will be docked under the working counters and will be retained in position using quarter-turn latches.

14.5.1 Cart Docking

Café/lounge carts and chiller units will be docked in assigned locations in the galley. The design of these docking sites shall include the necessary guides to ensure the carts are held securely in position on an individual basis and shall not rely in any way on an adjacent cart to be held into the proper position. Docking sites for dry goods carts shall be wide enough to allow the cart to be parked in position with the door opened flush along the right side of the cart.

Docking sites for food service carts shall include the following features:

- Flat floor to allow the carts to be moved in and out easily;
- Lower guide along the side of the cart cavity walls;
- Top “T” guide to locate the top of the cart and separate adjacent carts;
- Condensate pan and drain on floor (chillers and chilled carts only);
- Magnetic rubber seal and hinged flapper on chilled air duct (chilled cart docking locations only);
- Rear stop to prevent the cart from moving too far into the cavity but will allow adequate contact with the magnetic rubber seal on the chilled air ducts;
- Quarter-turn retaining latch to secure the cart in place;
- Each cart position numbered using label kit; and
- Sufficient clearance in the guides and aisle so that any cart can be removed and replaced without the need to disturb any other cart.

14.5.2 Cart Securement

Carts shall be retained in place using aircraft-style quarter-turn retention latches. The quarter-turn retaining latches shall be spring loaded with a detent at the 3 and 6 o’clock position and shall be indexed so that they cannot be rotated out of position. Latches shall be red anodized aluminum. The latches shall be installed underneath the edge of the countertop so that the edge of the counter is free of latches or other protrusions that may pose a safety risk to the attendant. The latches shall not interfere with the normal operation of the cart doors.

The retaining latch and rear stop shall be designed so that, when secured with the latch, the cart is held in place against the rear stop and has adequate contact with the magnetic rubber seal on the chilled air ducts to ensure a tight duct seal but is not crushing the magnetic seal.
The cart securing mechanism, including latch, countertop structure and fasteners shall be designed to provide adequate cart retention under regulated acceleration forces for fully loaded carts.

### 14.5.3 Food Service Carts

Each cafe/lounge car shall be delivered with three sets of food service carts, manufactured in accordance with current Amtrak requirements.

### 14.6 Chiller-Based Cart Refrigeration System

The perishable food refrigeration system is composed of: a self-contained chiller unit that cools air to prescribed temperature and distributes the chilled air to the food service carts through a series of enclosed ducts. Spring-loaded, hinged flappers on the ducts open automatically when a cart is docked and permit chilled air to enter the cart and return air to be vented from the carts and returned to the chiller unit for re-cooling. Magnetic rubber seals shall provide a low-leakage connection between the carts and the ducts. The spring holds the flapper door tightly closed when no cart is docked.

Hot exhaust air from the chiller shall be vented to the outside of the carbody through a dedicated duct and vent.

### 14.6.1 System Performance

The performance of the food refrigeration system (including chillers, carts and ducts) shall meet all applicable FDA and Amtrak requirements regarding the maintenance of perishable food temperatures between 33° and 40°F consistently under all combinations of the following conditions:

- The café/lounge car is operating in revenue service, with the café open and serving (frequent cart door openings to access contents);
- The café/lounge car is in layover between trips, but still stocked (such as overnight layover);
- The café/lounge car interior temperature is maintained within the range of 65°F to 90°F under normal HVAC operation;
- Chilled carts may be empty, partially loaded or fully loaded; and
- Chillers may be operating with as few as two carts in position on that chiller’s duct circuit.

Qualification testing of all refrigeration systems shall be included in car qualification tests, as described in Chapter 19.

### 14.6.2 Chiller Units

Conditioned air to chill the food service carts within the required temperature range shall be provided through the use of self-contained, roll-in chiller units. Two identical chiller units shall be provided and installed beneath the countertop in the galley adjacent to the food service carts they chill.
Each chiller shall provide chilled air for up to four food service carts. To balance the air flow and temperature distribution, the carts to be chilled shall be docked on both sides of the chiller. (If the chiller provides chilled air to three carts, two carts shall be docked on one side of the chiller.) The chiller compartment shall be separated from the adjacent cart docks by an insulated wall, made of heat-reflecting aluminum foam-core material no less than 0.5 in. thick, to minimize heat transfer from the chiller to the carts.

14.6.2.1 Electrical requirements

Each chiller unit shall be powered from its own circuit breaker, and the chiller unit case shall be grounded to the carbody through the wiring harness. In addition, a toggle switch shall be provided for each chiller unit to allow the unit to be switched off manually. A green Light Emitting Diode (LED) pilot shall be provided for each switch, wired so that it will illuminate when power is on at the load side of the respective closed chiller unit switch.

Power for the chiller shall be provided by a quick disconnect seven-pin connector, Amphenol MS3102A16S-1PF, or Customer approved equivalent, mounted at the front of the top of the chiller unit. The male half of the connector is mounted on the chiller case and the female half is on the carbody wiring harness. Wiring for the electrical connector shall conform to Amtrak Specifications. The wiring harness shall be long enough for easy attachment and disconnection of the plug without having to remove the chiller from the compartment.

14.6.2.2 Chiller securement

The chiller units shall be wheeled into position and secured with a quarter-turn latch and compartment door.

The compartment in which each chiller is mounted shall have a hinged door that closes off the chiller compartment, to reduce the noise and heat of the chiller from entering the galley work space. This door shall have a small round window so that the temperature gauge on the chiller is visible through the door. The door shall also have a perforated stainless steel grille to allow intake air to pass through the door and enter the chiller. The door shall be secured with a paddle latch and shall provide as much noise and heat reduction as possible.

Each chiller shall be positively secured in place using a heavy-duty aircraft-style quarter-turn latch. The latch and its attachment to the galley structure shall be able to restrain the chiller against regulated accelerations per 49CFR Section 238.233 and APTA Standard SS-C&S-006-98. The latch shall not interfere with the normal operation of the chiller, or with the view of the temperature gauge.

14.6.3 Chiller Air Duct System

There shall be three distinct ducts for each of the groups of chillers and refrigerated carts:
- Chilled supply air
- Return air
- Chiller unit condenser exhaust air

The supply and return air ducts connect the chiller with three adjacent refrigerated carts. The ducts shall be mounted on the wall of the galley and shall be well insulated on all sides, including the side adjacent to the carbody side frame. Each chiller’s duct circuit shall be separated from the other duct circuits.
All ducts shall be insulated to prevent heat transfer from any adjacent heat source, including
the chiller, the exterior of the car, the cavity between the back wall of the galley and the inside
of the carshell, or any other galley component.

The supply, return and exhaust ducts shall be designed and installed to properly interface with
the carts and chillers as specified. The interface between the duct and the carts and chiller
unit shall be with a magnetic rubber seal (similar to commercial refrigerators). When the
refrigerated cart or chiller is in its operating position, it presses against the seal, allowing the
magnetic seal to contact a steel plate on the rear of the cart or chiller and providing a low-
leakage seal.

14.6.3.1 Supply and return ducts

Both the supply and return air ports at each of the cart docking positions shall be equipped
with a magnetic rubber seal that mate with the rear of the cart and a spring loaded flapper
door, which will seal the port when a cart is not docked at that position. The seals shall be
easily replaceable. The magnetic rubber seals shall be sufficiently robust to withstand routine
duty cycles of removal and installation of carts.

A non-adjustable boss on each flapper will push the flapper open when a cart is positioned and
locked in place with the quarter-turn latch. The ducts shall be deep enough to allow the
flapper to open sufficiently to allow adequate air flow into and out of the carts. Flappers shall
be hinged on the top edge and will have a return spring to close the flapper and seal the air
port when no cart is present.

A rear stop shall be mounted on the back wall of the cart docking spot to ensure that the cart
is not inserted too far into the slot and flatten the magnetic seal.

The ducts shall be designed to provide an even, stable, non-turbulent air flow to and from each
of the carts and will be designed so that each cart receives equal percentages (± 5%) of the total
chiller supply air flow. Airflow volume into and out of each cart will be verified for each food
service cart position as part of the chiller system acceptance test on each car. The air flow and
chiller system functional test shall be conducted with a full complement of carts in place and
properly loaded with perishable food items.

14.6.3.2 Chiller exhaust duct

The chiller exhaust duct will convey the hot air emitted by the operating chiller unit to the
exterior of the car, through an insulated duct made of stainless steel. The exhaust vent shall
have a screen to prevent entry of vermin into the car interior and shall be oriented downward
to prevent collection of rainwater. Each chiller shall have its own exhaust duct; two or more
ducts may share a common vent to the outside provided that the vent does not restrict the flow
of the exhaust air.

14.6.4 Drain Pan

Each chiller and chilled cart docking site shall be equipped with a drain pan with removable
screen to catch chiller unit condensate or defrost water and drain it outside the car. The
design of the drain pan shall be adequate to capture and drain all condensate and defrost
water produced by the chilled carts and chiller units so that no water drips onto the galley
floor. The drain shall be equipped with a removable screen and backflow preventer and shall
drain to ground under the car.
14.7 Ancillary Food Service/Lounge Appurtenances

The following ancillary galley appurtenances shall be provided if shown on plans.

14.7.1 Display Case

A display case of at least 36 in. wide by 30 in. tall by 12 in. deep shall be provided adjacent to the serving counter to display various items for sale. Access to the inside of the display case shall be provided through opaque sliding panels on the back of the case. The case shall be lockable with a commercially available ratcheting showcase lock (to be provided by the Customer) that secures the two panels against each other. The sliding doors shall have a small handle to facilitate opening and closing. The glazing on the front of the case shall be of Lexan or equivalent material and shall not be removable from the front side of the case.

The case shall be equipped with two adjustable-height transparent shelves, each equipped with an anti-slip surface or material so that the contents of the display case do not move due to train motion. The shelf adjustment mechanism shall be built into the display case and shall not have any clips, pins, or other small components that must be moved to change shelf height. The range of shelf adjustment shall be in 0.5 in increments from 5 in. from the top of the case to 5 in. from the bottom of the case. The shelves shall be strong enough to support a full complement of beverage cans and bottles without flexing. An intermediate support may be used to hold up the shelf.

The display case shall include a dedicated LED light source to illuminate the contents of the case.

14.7.2 Cart Tray Shelf

An angled shelf for storing four standard food service cart drawers shall be mounted on the right side wall of the galley approximately 24 in. above the countertop. The shelf shall be able to securely accommodate standard drawers that are either 4 in. or 6 in. tall. These food cart trays shall be used for storing and dispensing non-perishable goods. Trays shall be stored with their long dimension perpendicular to the centerline of the car. The trays shall be appropriately secured when stored on this shelf. The shelf shall be designed to adequately support a total combined tray weight of 130 lbs.

14.7.3 Ice Well

A stainless steel ice well shall be mounted in the countertop at the serving counter, approximately 9.5 in. deep, 12 in. wide and 11.5 in. tall, with a folding hinged cover. The design of the ice well shall facilitate easy cleaning, with no sharp edges or tight radius corners. The bottom of the ice well shall slope to the center, where the drain is located. The well shall be integral with the countertop and have a raised edge so fluids spilled onto the countertop do not drain into the ice well. The underside of the ice well shall be sufficiently insulated with a suitable material to prevent heat gain, surface condensation and rapid ice melt. Melt water from the ice well shall drain to ground on the underside of the vehicle via a dedicated drain line. The ice well drain shall be segregated from the other galley drains and shall have a backflow preventer to ensure there is no contamination of the ice well contents through the drain system.
14.7.4 Dispensers

The galley countertops and adjacent areas shall be equipped with the following dispensers. All dispensers shall be kitchen-grade stainless steel unless otherwise specified.

- Carryout box dispenser:
  - For fold-up boxes sized 9.25 in. wide by 6.875 in. deep
  - Capacity 100 boxes

- Cold beverage cup dispenser:
  - For cups sized 3.375 in. diameter by 3.5 in. tall
  - Capacity 100 cups

- Coffee cup dispenser:
  - For cups sized 3.375 in. diameter by 4.25 in. tall
  - Capacity 50 cups

- Holder for coffee cup lids:
  - For lids 3.375 in. diameter
  - Capacity 50 lids

- Paper towel dispenser with push button latch:
  - For tri-fold towels sized 9.25 in. by 3.125 in. (when folded)
  - Capacity 200 towels

- Soap dispenser:
  - Celeste Industries, TR-BR10W/F (foam pump)

14.7.5 Recycling and Trash Receptacles

Recycling and trash receptacles shall be provided in the passenger seating area. A minimum of two of each type shall be provided. All recycling and trash receptacles shall meet all applicable FDA and NSF requirements for recycling and trash containers and their materials. To the degree possible, the receptacles shall utilize Amtrak standard trash bins:

- Small bins use Amtrak 30 gal liner (16 in. by 14 in. by 36 in.)
- Large bins use Amtrak 55 gal liner (22 in. by 14 in. by 58 in.)

The receptacles shall be stored in lockers, with openings in the locker doors for depositing trash and recyclables. Flaps shall cover the openings, shall close by gravity and shall not open and close from car motion. The locker doors shall be secured closed with a paddle latch consistent with the rest of the galley. The locker shall use as few joints as possible in fabrication and shall be permanently sealed against moisture and vermin. All corners shall be of large radius to make the enclosure easy to clean. The opening for inserting recyclables and trash shall be as wide as possible and shall direct the contents into the bin to keep spillage to a minimum.

Recycling receptacles (including locker doors and flaps) shall be colored green and shall have a different size and style opening that will permit the depositing of the recyclable material but
discourage placement of trash in the receptacle. Signage shall clearly label each type of receptacle.

### 14.7.6 Jump Seat

A folding jump seat shall be provided for the service attendant. The seat shall be secured to suitable structural members of the galley and be designed to support a load of no less than 300 lbs. The jump seat shall be located such that the attendant may see passengers approaching the service counter.

### 14.7.7 Condiment Station

A condiment station shall be provided near the galley service counter, located on top of the service island. See Figure 14-1. The design shall be easy to clean without requiring removal of any components and shall have no pockets, cavities, square corners or other locations where residue can collect.

The condiment station shall include the following:

- Countertop
- Condiment holder:
  - 14 separate condiment containers
  - Stainless steel, seamless construction
  - Containers shall be 4 in. diameter by 4.5 in. deep
- Napkin dispenser - stand-type with capacity for 500 napkins
- Recycling and trash containers

The countertop shall be made of solid surface 100% acrylic countertop material, or approved equivalent, with raised exposed edge and cove molding where it abuts vertical surfaces. Color of the countertop shall be subject to Customer approval.

The recycling and trash receptacles shall have vertically mounted doors that are integrated into the design of the condiment station and shall not be able to slam closed. Recycling and trash bins shall have appropriate labels and signage.

### 14.7.8 Menu and Photograph Holders

A minimum of five metal-framed menu holders shall be provided to accommodate 24 in. by 24 in. menus. The menu shall be inserted by sliding the menu sideways into the frame. They shall be installed:

- In a location visible to passengers waiting in line to place an order;
- On the upper level A-end bulkhead near the end door;
- On the passageway wall above the condiment station.
- At the B-end of the galley, facing the revenue seating area; and
- On the wall visible to passengers seated at the wheelchair parking location.
Four metal-framed food photograph holders shall be provided. Each holder shall measure 11 in. wide by 17 in. tall, for insertion of a tabloid-format photograph by sliding it into the frame from the top. The frames shall be mounted along the wall opposite the POS location.

14.8 Galley Electrical System

The café/lounge car electrical distribution system will provide 208VAC, 3-phase, 60 Hz 4-wire (grounded neutral) and 120VAC single-phase 60 Hz neutral-grounded power to the galley (see Chapter 13). Locate panel boards in the electric locker area to contain all terminal boards, circuit breakers and other items required for distribution of electrical power. Each circuit breaker shall interrupt all lines of the circuit. Circuit breakers and electrical outlets intended to provide a dedicated power circuit to a specific galley appliance shall be permanently and clearly labeled for that appliance.

The Contractor shall provide both a complete electrical schematic and a wiring diagram for all galley equipment. This shall show power distribution circuitry from the 480VAC HEP to the 208VAC and 120VAC transformers, through the circuit breaker panels and to the loads. Switch and receptacle terminal identification shall be provided for each receptacle and device.

14.8.1 Circuit Breaker Panel - Galley

The galley panel shall include circuit breakers for the galley equipment as well as control switches for each chiller unit and galley lighting. It shall be covered with a clear polycarbonate resin thermoplastic or Lexan door (to allow the positions of the switches and circuit breaker to be seen) with a paddle latch to keep the door closed.

Power switches for the chillers shall include a green LED indicator that is illuminated when the chiller is powered on.

Circuit breakers shall include, at a minimum:

- Chiller unit # 1
- Chiller unit # 2
- Freezer if provided
- Microwave oven #1
- Microwave oven #2
- Combination oven
- Coffee makers
- Water heater
- Toaster
- POS
- Display cases
- Service receptacles - chilled side (GFCI)
- Service receptacles - dry side (GFCI)
- Lights (AC)
- Lights (DC)
• Two spare circuit breaker locations that will accommodate either 120VAC or 208VAC outlets

Switches shall include, at a minimum:

• Chiller unit # 1
• Chiller unit # 2
• Counter lights
• Ceiling lights
• Display case light
• Service counter lights

14.8.2 Service Receptacles

The walls of the galley shall be equipped with 120VAC 20A duplex GFCI-type service receptacles as follows (excluding dedicated appliance outlets):

• Above chilled carts: two duplex outlets adjacent to the POS unit; two additional duplex outlets evenly spaced between the POS and hand washing sink.
• Above dry carts: four duplex outlets evenly spaced.

14.8.3 Convenience Receptacles

All public seating areas of the café/lounge car, including revenue and non-revenue seats shall be equipped with duplex convenience outlets for passenger use. See Chapter 13 for details regarding the installation of convenience outlets.

14.8.4 Dedicated Outlets

Dedicated simplex outlets shall be provided for the galley appliances. The outlets shall be labeled for the appliance and each outlet shall be protected by a dedicated circuit breaker labeled for the appliance it protects.

Galley:

• Coffee makers
• Microwave #1
• Microwave #2
• Combination oven (if provided)
• Freezer (if provided)
• Toaster
• POS
14.9 Water System and Drains

Potable water shall be provided to the galley for the hand washing and utility sinks and the coffee maker. Drains shall be provided for each sink, the ice well, the coffee maker pan and the condensate drain on each chiller. All fresh water lines and drains shall conform to applicable health and safety codes.

All drains shall have backflow preventers. All check valves and backflow preventers shall be located to facilitate access and replacement.

The grey water from the sinks shall be captured and sent to the waste tank, either through gravity flow or a sink tank. The ice well, condensate drains and coffee drain shall flow to ground under the car.

The Contractor shall submit a water distribution and plumbing system drawing for the galley, identifying water and drain line sizes, materials and sink fittings.

14.9.1 Water Distribution

Pressurized potable water from the rail car supply tank shall be provided to the galley for distribution to the utility and hand wash sinks and the coffee maker.

The potable water supply to the galley shall have a particulate filter and an antibacterial filter to purify the water to Public Health Service (PHS) standards. These filters shall be located between the fresh water tanks and the galley equipment and shall be located for easy cleaning and replacement. These filters shall be identical to those specified for the potable water system on the coach cars, to the extent possible. See Chapter 15.

At a minimum, separate ball type shut off valves shall be provided for the following:

- Hand wash and utility sinks (single valve that feeds water to water heater as well as cold faucet valves)
- Coffee maker

Manual ball type drain valves shall be provided to allow draining all of the galley piping, either for water system servicing or manual draining of the car in advance of storage, or in anticipation of freezing conditions. These valves shall drain the water system to the ground under the car.

14.9.2 Water Heater

A one-gallon, 120VAC hot water tank shall be provided beneath the hand wash sink area to provide hot water to the utility and hand washing sinks. The water heater element shall be protected from damage when no water is in the tank. The water heater installation shall facilitate easy replacement of the element as well as replacement of the tank. Access shall be provided to facilitate adjustment to the tank thermostat.
### 14.9.3 Sinks

Separate utility and hand wash sinks shall be provided as an integral part of the countertop as shown on drawings. Each sink shall measure 12 in. wide by 14 in. deep by 10 in. tall. The sinks shall be formed of 300-series stainless steel, with rounded corners and edges, a raised edge around the perimeter of the top of the sink and the bottom of the sink sloping to the drain. A permanent drain screen shall be provided for each, with a maximum hole or mesh size of 0.125 in. The underside of the sinks shall be insulated to prevent condensation. An FDA-compliant splash guard shall be provided between the two sinks.

Each sink shall have its own single-handle faucet. Each faucet shall be capable of swiveling the width of the sink, but shall not swivel to the other sink. Faucets and controls shall represent best commercial design and be commercially available standard plumbing fixtures. Faucets shall be tall U-shaped swivel design.

All drain lines, screens and fittings shall be easily cleanable and corrosion-resistant.

All water supply lines shall include FDA-approved backflow prevention devices.

#### 14.9.3.1 Utility sink

A utility sink shall be mounted in the countertop and shall be equipped with an industrial grade single-handle faucet and a flexible hose with spray nozzle. The design and location of the utility sink shall be adequate to easily clean the coffee urns.

The faucet shall be self-venting and drip-free, with the swivel outlet approximately 8 in. above the sink-top level.

The flexible spray nozzle and hose shall be kitchen grade and shall recess into a holder on the countertop. The hose, when retracted under the sink, shall not contact or interfere with any under-counter appliances or equipment.

#### 14.9.3.2 Hand wash sink

A hand wash sink shall be mounted in the countertop and be equipped with an industrial grade single-handled faucet.

The faucet shall be self-venting and drip-free, with the swivel outlet approximately 8 in. above the sink-top level. The faucet shall have a pre-set mixing valve to deliver hand washing water at a temperature consistent with FDA and Amtrak health code requirements, but not less than 100°F.

The hand wash sink shall be labeled HAND WASHING ONLY.

### 14.9.4 Drains

The drains and piping in the galley shall be designed for reliable operation, ease of cleaning and free of sharp bends and fittings that may contribute to clogging.
The galley shall be equipped with the following drains:

- **Hand wash and utility sinks**

  Minimum drain line inside diameter shall be 2 in.; minimum bend radius of the drain line shall be 5 in. The drain line shall have a minimum downward slope angle of at least 3 degrees to avoid water traps. The drain shall be covered with a permanent strainer to prevent food particles from entering drain. The sinks shall drain to the waste tank, either through gravity or by use of a sink tank and pump. The drain for the sinks shall include an overflow system that will allow the grey water to drain to ground in the event of a sink tank or waste system failure.

- **Coffee maker drain pan**

  A drain pan shall be provided under the coffee maker urn spigots to catch spills and drips from the coffee spigots as well as to allow the unit to be drained for cleaning or servicing/replacement. The coffee maker drain shall be a minimum of 0.75 in. inside diameter and shall flow to ground under the car.

- **Ice well**

  The ice well shall include a drain for melt water. The ice well drain shall have a minimum inside diameter of 0.75 in and shall flow to ground. It shall be fully segregated from other drains and shall include a backflow preventer, per FDA requirements.

- **Chiller**

  Each chiller unit shall be equipped with a drain pan to catch chiller condensate or defrost water. Chiller condensate shall drain to ground. The chiller drain shall be designed to capture all chiller condensate, to ensure that no condensate flows onto the galley floor. The chiller drain shall have a minimum inside diameter of 0.75 in and shall include a screen to keep the drain from clogging from debris.

### 14.9.5 Freeze Protection

An air-temperature-sensing automatic drain valve shall be provided to cause automatic draining of the galley water piping to avoid freeze damage, should the galley approach freezing temperatures. See Chapter 15.

### 14.10 Doors and Latches

All hinged doors shall be double-wall constructed, except as noted. All hinges shall be made of stainless steel. Hinges for the serving counter swing door shall be of a heavy duty design capable of withstanding a 250-pound downward force (applied to the top edge of the door) without deformation or loss of alignment. All doors shall be capable of opening 180 degrees (if possible) with sufficient clearance to prevent any tendency to bind. Paddle latches shall be used on all doors unless otherwise specified.

All latches shall be stainless steel. Strikers shall be used with all latches and shall be one-piece formed or die-cast stainless steel and shall be easily replaceable. Latches shall be easily operated, require no lubrication and maintain full door closure. A hasp for use with a padlock, with an inside diameter of 0.25 in. to 0.375 in., shall be installed on doors as identified below.
14.10.1 Galley

- Circuit breaker panel door – Clear polycarbonate resin thermoplastic or Lexan with paddle latch
- Under-sink storage cabinet for cleaning products – paddle latch
- Under-counter storage cabinet for crew use – paddle latch with lock hasp
- Recycling and trash receptacles – paddle latch
- Chiller compartment - paddle latch
- Under-counter cabinet below ice well – paddle latch
- Security screen storage compartment – paddle latch
- Galley access door – standard self-latching lock, opened with a handle on galley side and standard Amtrak coach key on passenger side; equipped with a small safety window; swing open into galley area; hinged on dry cart side
- Serving counter swing door – sliding deadbolt latch on galley side of door – no key required, no lock hasp; swing open into elevator lobby; hinged on edge away from elevator
- Display case doors – Two-piece opaque sliding panels to be secured with a ratcheting showcase lock (provided by Customer)

14.11 Galley Security

The galley must be secured when the car is unoccupied to prevent unauthorized access and potential pilferage of food, supplies or equipment. When secured properly, access to the galley and display cases will be restricted to authorized crew with an Amtrak coach key. All food items shall be secured with padlocks issued to the service attendant. A galley security assessment, demonstrating that the galley can be secured by crew members in accordance with this specification, shall be provided by the Contractor for Customer approval.

14.11.1 Galley Security Screen

A sliding security screen shall prohibit access to the galley at the serving counter when the attendant is not present. The screen shall compress for storage in a locker adjacent to the electric locker and shall slide smoothly when being deployed or stored. The screen shall provide security for the entire width of the serving counter, and shall secure the counter area and the display case. When deployed, the screen shall be locked in place from the galley side using a standard crew-issue padlock in a hasp with a 0.25 in. opening. The screen shall be secured at the top and bottom and shall not require a visible lower track on the counter, potentially being secured on the underside of the countertop. The security screen shall be aluminum or stainless steel and designed to be tamper-resistant and sized to keep passengers from reaching through the screen mesh to the countertop. The screen shall be functional as well as visually attractive. The storage locker for the screen shall have a door, equipped with a paddle latch that will adequately secure the screen in place while the car is in motion and meet the required deceleration resistance. The screen mechanism shall be free of pinch points or other safety hazards.
14.11.1.1 Serving counter swing door

The serving counter door shall be constructed of durable materials and be equipped with a sliding deadbolt-type latch on the galley side. No means of unlatching the door from the passenger side shall be provided.

14.11.1.2 Cart security

Each cart shall have a padlock hasp for securing by a padlock issued to each attendant.

14.11.1.3 Freezer security

Each freezer and refrigerator shall have a padlock hasp for securing by a padlock issued to each attendant.

14.11.1.4 Display case security

The display case shall be secured by a ratcheting showcase lock that will be provided by the Customer.

14.12 Lighting

Food service area lighting shall be in accordance with APTA Recommended Practice RP-E-012-99 and U.S. Public Health Service Food Code of 2005. All normal light levels in the food service and galley areas shall be a minimum of 30 foot-candles, except for the food preparation area which will be a minimum of 50 foot-candles. Standby lighting will provide a minimum of 10 foot-candles in all areas of the galley.

Lighting in the galley shall be along the entire length of the countertops, including track lighting over the service counter and storage shelves. Accent lights shall be installed above the service counter, in the display case and above the sink area.

Decorative sconces shall be installed in the lounge area and along the hallway next to the exterior wall of the galley.

Types and styles of lighting fixtures shall be presented by the Contractor for approval by the Customer during the design review.

14.12.1 Galley Lighting

Light locations shall be located so they will not produce glare, nor shine into the face either of passengers or food service attendant. The fixtures selected shall be suitable for the railroad environment: robust, easy to clean, maintainable for the life of the galley.

Functioning galley lighting shall be subject to specific design approval by Customer.
Lighting shall be provided in the following locations:

- Recessed mounted LED fluorescent ceiling lighting along the length of the galley
- Surface mounted LED/fluorescent counter lighting shall be mounted on the underside of the overhead shelves
- LED or fluorescent lighting over the serving counter
- LED or fluorescent lighting over the dry goods on display
- LED or fluorescent lighting in the display case
- LED or fluorescent lighting in the elevator car

Switches controlling this lighting are described in the circuit breaker panel section of this chapter.

14.12.2 Lounge Area Lighting

Lighting in the lounge area shall provide overhead and accent lighting for illumination of the aisle and table tops. Lighting levels for the lounge area shall be equal to those specified for the revenue seating areas of the coach cars. See Chapter 11. If conventional coach seating or business class seating is installed, refer to Chapter 9.

14.13 Materials and Workmanship

All materials and appliances for the café/lounge car shall meet all applicable UL, NSF FRA and FDA requirements.

All components and materials used shall be durable, easy to clean and easy to replace if damaged or worn.

The installation of walls, ceilings, counter tops, sinks, etc. shall be in accordance with manufacturer’s recommendations. Countertops and working surfaces shall be free of fasteners, holes, joints or cracks. Fasteners shall not interfere with the operation or appearance of any surface, component or appliance.

14.13.1 Materials

The primary structural material for the galleys shall be honeycomb composite sandwich panels, or approved equivalent, with a minimum core density of 4 lbs./cu. ft. and face sheets of FRP with a thickness of at least 0.020 in. Panel thickness shall be selected on the basis of required strength determined by finite element analysis, durability, impact resistance and minimum weight.

Countertops shall be formed from stainless steel finish #13, except for the serving counter and condiment station, which shall be 100% acrylic, 13mm solid surfacing. Color of serving counter material shall be submitted to the Customer for approval as part of the interior décor palette. See Chapter 9.

Flooring in the galleys, serving counter area, hallway and area adjacent to the condiment station shall be seamless rubber flooring that conforms to the flooring material requirements in Chapter 9. Color and texture of the flooring material shall be submitted to the Customer for approval as part of the interior décor palette.
Food Service 14-25

Carpets shall be installed in the revenue seating and lounge areas, in conformance with the carpeting requirements in Chapter 9. Carpet in the revenue seating area shall match the carpet in the seating areas on coach cars. A sample of the carpet in the lounge area shall be submitted to the Customer for approval as part of the interior décor palette.

Unless otherwise specified, the wall and ceiling panels shall be made of the same material as the wall and ceiling panels in the coach cars. The wall panels in the hallway shall have a decorative laminate that compliments the décor of the lounge area. See Chapter 9.

14.13.2 Mechanical Design

Food service components shall be designed to minimize noise. Anti-squeak tape shall be used at all locations where walls and bulkheads are attached, or where they come into contact with structure or other interior components.

Easy access shall be provided for all items that require periodic maintenance, defect repair or replacement. Panels and doors providing access to this equipment shall be hinged where possible and fastened with approved captive fasteners in a manner that facilitates maintenance. Replacement of any major appliance shall not require any disassembly of the galley structure.

All wiring and piping shall be installed in a manner that provides future access as may be needed for repairs. Stainless steel fasteners shall be used to attach the galley structure to the carbody. Use of vibration-damping inserts shall be required for all galley-to-car structure attachments. Metal surfaces of the galley shall be suitably grounded to the carbody to prevent electrical shock.

14.14 Safety, Health and Environmental Requirements

The galley and all ancillary food service equipment shall be designed to accommodate passengers and crews from the 5th percentile female to the 95th percentile male ranges. Safety of passenger, crew and maintenance personnel shall be a prime consideration in design of all food service equipment.

Projections from the galley face or edge of countertop which could injure crew members, including knobs, switches, outlets and latches, shall be recessed. There shall be no finger pinch points anywhere in the galley area, elevator or elsewhere in the cafe/lounge car.

14.14.1 Sanitation

The food service equipment shall meet all applicable requirements of the U.S. Public Health Service Food Code of 2005.

Sealing and construction of the modules shall not permit liquids/moisture to harbor behind/over/under any of their surfaces. Countertops shall have a raised edge on all exposed faces and a cove on all edges adjacent walls/bulkheads.

All approvals, including approvals from FDA, are the responsibility of the Contractor. All cars shall be certified for conformance with FDA regulations. All approvals shall be supplied with each vehicle history book.
14.14.2 Fire Safety

All food service system materials shall meet the flammability and smoke emissions requirements of 49CFR Section 238.103.

The Contractor shall provide a Fire Safety Analysis for Customer review and approval in accordance with APTA Recommended Practice RP-PS-005-00 (see Chapter 22).

14.14.3 Emergency Equipment

In addition to the basic emergency equipment to be provided on all car types, as identified in Chapter 17, the café/lounge car shall also have the following emergency equipment:

- The galley area shall be equipped with a dry-chemical 2.5 pound 1-A:10 type B/C fire extinguisher;
- The galley shall be equipped with a standard first aid kit and a set of snap lights, identical to that specified in chapter 17; and
- The galley shall be equipped with a storage location for an Automatic Electronic Defibrillator (AED), to be provided by the Customer, in accordance with Amtrak’s AED installation specification.

The emergency equipment storage locations shall be labeled in accordance with all applicable signage requirements.

14.14.4 Noise

Noise levels in the car’s interior shall be kept to a minimum. Continuous noise level in the galley shall not exceed 73 dBA, with chiller units running and car HVAC system in operation and shall not exceed 68 dBA in the adjacent passenger revenue seating and lounge areas.

14.14.5 HVAC System

The car HVAC system will provide ventilation, heating and cooling to the galley as part of the overall car HVAC system.

The car’s basic HVAC system, as described in Chapter 10, shall maintain the environment throughout the range of operating conditions to which the food service system is exposed. The Contractor shall ensure that the HVAC system in the café/lounge car is designed to remove the heat produced by the chiller units, freezers, coffee makers, ovens and any other heat sources. The Contractor will supply a heat load analysis to the Customer for review. See Chapter 10.

All galley food service equipment shall be installed in the galley with sufficient free space between the unit and the galley walls to permit circulation of cooling/ventilation air, as needed for cooling in accordance with the manufacturer’s recommendations.
14.15 Mockup Requirements

The Contractor shall create a series of soft and hard mockups of the galleys, lounge and associated areas of the café/lounge car, to assist the Customer in evaluating the design, layout and detail of assembly for efficiency, compliance, ergonomics and aesthetics. See Chapter 3 for details.
Figure 14-1: Café/Lounge Car Conceptual Drawing

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Chapter 15

Water and Waste System
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15.0 Water and Waste System

15.1 Overview

Each car shall be equipped with a pressurized water supply system, along with toilets and a constant vacuum type waste retention system. An alternative toilet type may be proposed for review and approval by the Customer.

The café/lounge car shall have systems of larger capacity for food preparation needs, as detailed in Chapter 14. 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 Customer for approval.

All water, waste and sanitation systems on the car shall comply with all Federal regulations, such as the most recent edition of the US Food and Drug Administration (FDA) Food Code, the requirements of the US Public Health Service (USPHS), and the applicable Code of Federal Regulations for the FDA and Environmental Protection Administration (EPA) concerning general sanitation, water, toilets and interstate conveyance sanitation, including 21CFR Part 1250. In addition, the systems shall comply with the latest edition of the Amtrak Food Service Sanitation regulations and the Amtrak Public Health Standards. The Contractor shall arrange for a 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 21CFR Section 1250.41. Documentation of compliance is required to be submitted to the Customer. 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 Amtrak-approved liquid sanitation compounds to sanitize and flush the entire water system, as periodically required by the FDA.

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 restrooms and drinking water system must be routed through the base of the sidewall in the car interior, from the vestibule restrooms 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, similar to the concept used on the Amtrak Acela trainsets.

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 Customer, shall be stainless steel including connections. Servicing and shutoff valves shall be stainless steel quarter-turn ball valves unless otherwise specified. The sidewalk piping shall be one piece without joints between the two restrooms, and between the restroom to the point of exit from the car interior. All piping shall have complete gravity drainage slope from the restroom to the undercar tanks, and be securely mounted to sidewalk using vibration resistant mountings. All parts of the restrooms and their 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 toilets, sinks, drains, all piping and all fittings, shall be designed and installed to be replaceable in an Amtrak terminal yard within 30 minutes. All piping and tanks shall be installed with attachments which prevent vibration while in service, and also take into account thermal expansion and contraction.

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 discontinued 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, and especially all café/lounge water system appliances such as coffee makers. 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. All such designs must comply with all FDA sanitation requirements and be approved by the Customer, and be verified in the climate room tests.

Each water consuming device inside the car, such as each sink, drinking water dispenser, toilet, coffee maker, etc., 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.

Complete details of the water and waste systems on all car types, including café/lounge appliances and restrooms, shall be presented to the Customer 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 so as to permit the car to safely be exposed to subfreezing shipping and storage conditions without damage.

### 15.2 Water System

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 drinking, hand washing, café/lounge car galley requirements and waste disposal. The design and materials shall be approved by the Customer. Particular emphasis shall be placed on meeting the winterization and maintainability requirements of Chapter 15. Refer to Chapter 14 for additional café/lounge car galley requirements.
The water system shall be pressurized using filtered air derived from the air brake main reservoir system. Water system pressures shall be 20 pounds per square inch (gauge) (psig) (nominal) for potable water and 30 psig (nominal) for toilet flushing, or other levels as approved by the Customer. 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.

15.2.1 Capacity

The water storage capacity shall be a minimum of 112 gal, except on café/lounge cars which shall have a minimum water storage capacity of 224 gal. The required storage capacity may be provided in one or more tanks.

15.2.2 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 psig. 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.

15.2.3 Freeze Protection

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 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.

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. 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.

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.

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 (temperature falling) and close at 40°F (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 comply with the requirements of Amtrak AAMPS catalog number 24 770 11000, and shall use a valve assembly which complies with the requirements of Amtrak AAMPS catalog number 24 770 10000, and a replaceable heater with pilot light which complies with the requirements of Amtrak AAMPS catalog number 24 770 11100.

All electrical heat tape shall be of an automatic self-limiting 120VAC 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. Amtrak desires that such heat tape be of a design that can withstand the application of live steam at 212°F without damage, as this is often the only method available in the Amtrak maintenance facility for thawing a frozen car.

All details of the freeze protection system shall be submitted to the Customer for approval during design review. Maintainability aspects of the system shall be demonstrated on the interior mockups.

15.2.4 Water System Fill Locations

Maintaining high-levels of sanitation of the water system fill points is of great concern to the Customer. 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 Amtrak rolling stock.

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 overcenter 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, in order 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.

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.

The water fill point shall be compatible with existing Amtrak filling equipment and shall be designed for a maximum fill time of 10 minutes. The system shall permit existing Amtrak 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.

### 15.2.5 Hot Water

The hot water system shall provide hot water for restrooms and galley service. The water heating system shall be capable of providing one gal of water heated to 110°F 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 psig. 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.

### 15.2.6 Drinking Water Cooler

A Customer approved self-contained modular drinking water cooler shall be provided in each car in the A-end vestibule area, to supply the drinking water station described in Chapter 9. The water cooler shall be capable of producing at least 5 gal of 50°F chilled drinking water per hour, and be capable of chilling water from 80°F to 50°F within ten minutes. The cooler shall use an environmentally acceptable refrigerant and meet US Federal regulations. R12 and similar CFC refrigerants shall not be utilized. It shall use a water cooler currently in use on Amtrak, operate from 120VAC power supply and be unitized for quick removal and replacement. The water cooling system shall allow for easy access for cleaning, sanitization and servicing.

### 15.2.7 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, similar to the design concept used on the Amtrak Acela trainsets. 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 Customer.
15.2.8 Piping

All water system piping and fittings, unless otherwise approved by the Customer, 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.

15.2.9 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. Customer 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.

15.2.10 Water Raising

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 7. A desiccant type air filter with automatic drain and oil removal filter shall be provided to remove all contaminants 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 psig (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.

The potable water supply to the sinks and drinking water dispenser shall be provided through a check valve and pressure reduction valve set at 20 psig (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 psig (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.

15.2.11 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 Customer. See Chapter 9 for additional details.

15.2.12 Galley Supply

The galley in the café/lounge car shall draw filtered, potable water from the car supply, and distribute it to hand and utility sinks and coffee brewers, and other water consuming appliances in accordance with the requirements of Chapter 14. All water system exposed parts shall be stainless steel. All fixtures, dispensers and appliances shall be constructed in accordance with the requirements of USPHS.

15.3 Waste Retention System

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 all restrooms. See Chapter 14 for details of galley drain
water collection on the café/lounge car. All waste collection fixtures and components shall be constructed in accordance with the requirements of 21CFR Part 1250 and USPHS.

The drain water from all restroom sink drains, drinking water dispenser drains, café/lounge car galley sink drains, coffee brewer and server drains, chiller unit drains, and all other drains not handling human wastes shall be piped using a drain trap or check through the car floor to discharge under the car, well clear of the track rails and adjacent undercar apparatus. Freeze protection heat tape similar to Chapter 15 shall be applied. Ice shall not be allowed to build up at the drain point.

Waste incineration is not permitted. The system configuration, except as otherwise specified, shall be generally similar to that used on the Amtrak Acela trainset. 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.

The WCRS shall be a vacuum system with sufficient useable 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 225 gal, 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 is frequent foreign object blockages of the toilet system encountered in the nature of Amtrak 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.

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 Amtrak Specification 963. 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 Customer for approval during design review.

### 15.3.1 System Requirements

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 10,000 ft elevation.

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.

Fresh water shall be provided for toilet flushing in the amount of 8 oz per flush at 30 psig (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.
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 contaminants 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 psig (nominal). The toilet system shall be operable over the pressure range of 60-100 psig. 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. The air line shall be designed and configured to allow future conversion to a vacuum line, for use with vacuum controlled toilets, for vacuum operation up to 12 in. Hg. Toilet flushing shall be inhibited due to lack of either air pressure, vacuum or electric power.

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 enroute 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.

Vacuum loss for the entire system at 10 in. Hg shall not exceed 1 in. Hg per hour with new equipment. There shall be no loss in excess of 2 in. Hg 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 shall not exceed 0.5 in. Hg per hour with new equipment. This shall be verified on each car during production testing.

**15.3.2 Toilet Operation**

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. If required, the system controller shall only permit one toilet on the car at a time to operate a toilet flush cycle, delaying the second toilet cycle until the first is completed. The toilet waste shall be drawn by vacuum from each toilet and transported through a minimum 2 in. 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.

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 Customer:

- **AIR EJECTOR ON** signal from flush initiation, not to exceed 5 seconds;
- **1.0 to 1.5 second RINSE**, activated 0.5 to 0.7 second from flush initiation; and
- **3.0 to 3.5 second DRAIN**, activated 1.0 to 1.5 second from flush initiation.

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.
15.3.3 Toilet

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 Customer. 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.

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.

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. 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. 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.

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.

The stainless steel flush-drain valve shall be a pneumatically operated, self contained unit which provides a zero leakage 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 zero leakage seal shall be maintained under 15 in. Hg of vacuum and a 3 ft head of water. At 6 to 10 in. Hg there shall be no more than 0.01 oz of water leakage across the flush valve in a 24 hour period with toilet bowl full of water. At 6 to 10 in. Hg there shall be no more than 0.02 in.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.

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 enroute from inside the car. A stainless steel vacuum isolation valve shall be provided on the toilet assembly with locking actuator handle accessible enroute from the right front of the toilet at floor level.

The toilet assembly and its components shall be mounted so as 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 Customer 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.

15.3.4 Waste Tank Assembly

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.

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. The tank design shall allow all internal portions of the tank to be cleaned by maintenance personnel.

Self cleaning sight glasses or LED displays at the FULL, 2/3 and EMPTY levels shall 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. 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 to 40 psig (maximum allowable of 75 psig) and shall apply a minimum of 5 gallons per minute (gpm) 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. 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. 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. 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 toilets. 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.

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 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. 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.

Waste tank drainage shall be readily possible from either side of the car, through a 4 in. 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, and the valve station shall withstand a 3,500 in.-lb 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 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 Amtrak 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.

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. full port stainless steel. The installed waste tank assembly, including all pipes, valve stations and fittings, shall not have a loss of vacuum in excess of 0.5 in. Hg per hour.

### 15.3.5 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 in compliance 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.
15.3.6 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 vent system shall be improved from that used on the present Amtrak Acela trainset toilet venting system, which produces objectionable odors in station areas. The Contractor shall investigate use of easily replaceable filters or other such methods. 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 Customer.

15.3.7 Piping

All waste system 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 Amtrak 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 each toilet outlet to the waste shall be a minimum 2 in. diameter, installed in the sidewall of the car interior per Chapter 9. The sideline piping shall be one piece without joints between the two restrooms, and between the restroom to the point of exit from the car interior. 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 so as to avoid collapse under a continuous 29 in. Hg vacuum and it shall be easily removable for cleaning. All piping and tubing shall have a smooth interior finish. Vacuum and pressure test ports shall be provided for system troubleshooting. Pneumatic system piping shall comply with Chapter 18.

All drain piping for drains not connected to the WCRS shall be seamless stainless steel tubing. This shall include the drain water from all restroom sink drains, drinking water dispenser drains, café/lounge car galley sink drains, coffee brewer and server drains, chiller unit drains and all other drains not handling human wastes. They shall be piped using a drain trap or check through the car floor to discharge under the car, well clear of the track rails and adjacent undercar apparatus. The drain piping shall not transmit underfloor noise into the car interior. All drain piping shall be installed with positive gravity drainage slope, and have generous radius sweep bends and elbows to avoid blockages. Piping shall be designed to minimize the chance of blockage, with all fittings chosen with this goal in mind. The piping shall be designed to facilitate the clearing of any line blockage. Freeze protection heat tape shall be applied. Ice shall not be allowed to build up at the drain point.

15.4 Status Indicators

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 Customer.

A water and waste system status indicator panel shall be installed in the car electrical locker and also 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:

- **Power Off (red):** Electrical power off
- **Low Air (red):** Less than 60 psig of air pressure at toilets
- **Low Water (amber):** Car water tanks less than 1/3 full
- **No Vacuum (red):** Less than 3 in. of Hg available (vacuum leak)
- **Tank Valve Open (red):** Tank drain valve or manual vent valve open
- **Tank Full (red):** Waste tank full
- **Tank 2/3 Full (amber):** Waste tank 2/3 full
- **Tank Empty (green):** Waste tank empty

The low vacuum indicator shall be disabled for the normal flush cycle, and shall only display actual fault conditions.

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.

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.

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 Customer.

### 15.5 Waste System Controls

A Customer 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.

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 to capacity 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 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) in the waste line when a toilet flush is actuated. Tank vacuum shall be maintained at 6 to 10 in. Hg through
flush operation. The vacuum pump blower shall cycle on when the system differential pressure falls below 6 in. Hg and cycle off when the differential pressure rises above 10 in. Hg. 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 is filled, or during tank drain servicing.

The Contractor during design review shall present for Customer 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 Customer, with complete software provided to the Customer to make such adjustments.

### 15.5.1 Control Panel

An electronic central control panel shall be an interface between all toilets 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 toilets by disconnecting both legs of the 120VAC input power. It shall prevent flushing whenever 3 in. Hg of vacuum cannot be achieved at the toilets or when air pressure falls below 60 psig. 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.

### 15.5.2 Water Sensor

A nonadjustable 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 water sensor shall be unaffected by water deposits.

### 15.5.3 Air Pressure Switch

A nonadjustable air pressure switch shall be provided to prevent flushing of toilets when the supplied air pressure drops below 60 psig, and to provide a low air pressure signal to the control system. The switch shall open when pressure rises above 60 psig.

### 15.5.4 Vacuum Switches

Three nonadjustable vacuum switches, color coded and labeled with their vacuum setting, shall be provided to provide 3 in. Hg (coded red), 6 in. Hg (coded amber), and 10 in. Hg (coded green) control and status panel signals. The switches shall close above the vacuum specified and be accurate within 5% of their nominal setting.

### 15.5.5 Limit Switches

Three valve handle position detector switches shall be supplied to provide control signals for the two waste tank drain valves 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.

* End of Chapter 15 *
Chapter 16

Cab and Train Controls
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16.0 Cab and Train Controls

16.1 Overview

This chapter describes the design and functionality of the cab area of the cab/baggage car, including locomotive control equipment, instruments and gauges for systems necessary for the safe and efficient operation of the train from the Engineer’s cab and ancillary equipment for crew comfort and safety.

16.2 Cab Car Arrangement

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 Engineer, Assistant and an optional third crew member in a jump 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. The passenger seating area shall generally be configured similar to the coach type of car, as interior space permits.

An Engineer’s cab compartment for use by the Engineer, conforming to FRA requirements and sized for three crew members, including a jump seat location, shall be provided at the F-end of the cab car. This cab compartment will extend the full carbody width. It is of great importance that the cab compartment be designed to provide maximum comfort and alertness for the Engineer and Assistant 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 Engineer. The layout shall maximize the use of available space and shall employ sound ergonomic and industrial design principles in its development, yet designed to be rugged and easily maintained. The more critical displays as identified herein shall be located adjacent to the windshield, in the Engineer'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 Engineer shall be a design objective. Controls shall be arranged so that those which are most often used, or are of critical importance, are the most convenient to the Engineer, 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 49CFR Section 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 Customer for approval during the design review process. A cab mockup shall be constructed as detailed in Chapter 3.

Adequate space shall be provided on the cab console for maintenance personnel to place a standard laptop computer for operation during vehicle tests. The Engineer’s cab shall be isolated from passenger access, 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.

The cab compartment 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. 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 Engineer 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 Engineer and Assistant 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. 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.

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.

The Engineer's minimum clear viewing distance from the seated position shall be no more than 20 ft to the top of rail. The cab layout shall also be arranged so as to provide the Engineer 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. The Engineer's field of view, especially to the left, shall be equal to or better than the current Amtrak 9600 series cab cars in this regard.

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 Customer approval a series of general arrangement diagrams of the interior of the Engineer's cab compartment. They shall include the location of all features and appointments, as well as general arrangement diagrams of the Engineer's control consoles, Assistant's work station, and jump 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 Engineer and Assistant of the specified percentile range shall be included. The review period for these initial cab and controls arrangement drawings shall permit internal review by Customer 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 Customer during design review.

### 16.2.1 Cab Enclosure

The cab shall be completely enclosed, and shall contain an Engineer’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 Engineer’s and Assistant’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. The cab will be arranged to allow the Engineer visibility to observe the far left side of the track such as at grade crossings.

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. 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 0.5 in. 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 Engineer compartment styling.

An operable window shall be provided on the Engineer’s right and Assistant’s left side, and shall incorporate an exterior rain deflection gutter. 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 lbs applied at any location without permanent deformation.

Incorporated into the rear wall of the cab in an approved, easily accessed location shall be lockers for the Engineer’s and Assistant’s personal effects. These lockers 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, and in addition shall have a hasp for locking with a padlock supplied by the train crew, with a stainless steel scuff plate used to protect the interior finish from the padlock. The doors shall be mounted with a stainless steel piano hinge, and have an external face treatment matching the cab decorative effect. The minimum inside dimensions shall be 2 ft wide, 1 ft 4 in. high and 10 in. deep. An open door stop shall be provided. A second, smaller storage locker shall also be located on the rear wall, without a hasp. It shall contain an intermediate shelf, and be used for storage of crew individual portion water bottles, crew kit, paper towels, etc.

A jump seat for a third crew member shall be installed at an appropriate location in the cab.

### 16.2.2 Cab Door

The center-rear of the Engineer’s cab shall have a fully hinged door which shall swing outward, toward the passenger area. The door design, hardware and location shall facilitate rapid Engineer evacuation in the event of an emergency. The cab door shall contain a fixed window and a fixed louvered grille. 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. 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 lbs 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.

The cab door shall have a window in its upper portion. The clear viewing area shall be approximately 6 in. vertically by 8 in. horizontally and located on the centerline of the door, approximately 3 ft 6 in. above the bottom edge of the door. The window material shall be 0.25 in. 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. An opaque roller curtain or similar approved arrangement shall be provided on the inner face to permit an Engineer to block any light transmission through the door window into the cab.

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. thick, and shall be reinforced with two 0.125 in. thick vertical stiffeners. The size of the grille shall be approximately 7 in. vertically by 9 in. horizontally and located on the centerline of the door, at least 12 in. above the floor.

The cab door shall have an approved snap-type lock, which shall hold the door closed and can only be opened from the passenger area side by the standard coach key. 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. A large horizontal bar push-type panic bar handle shall be provided on the cab side of the door to facilitate rapid unlatching and exit without the use of the key. The door lock mechanism shall be easy to access for repair or replacement. 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.

### 16.2.3 Windshield Wiper

A Customer approved, heavy-duty, automatic electric windshield wiper powered by the low voltage power system shall be installed at the top of the Engineer's and Assistant'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 Engineer/Assistant 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.

A Customer 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 capacity, shall be mounted under the car. It shall be easily accessible and refillable from track level from the side of the car, incorporate a drain valve and require no special hardware for filling.

16.2.4 Sun Visor

A Customer approved, adjustable sun visor shall be installed in each cab which meets the flammability and smoke emission requirements. The visor shall be mounted on the left side of the Engineer's windshield as the Engineer 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 Engineer 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. Vibration and normal vehicle motions shall not cause the sun visor to change position. A similar visor will be provided for the Assistant. The design and placement shall be approved by the Customer.

16.2.5 Mirror

On both sides of the cab at the forward edge of the side window, shall be an exterior locomotive style combination adjustable windshield wing and mirror. It shall contain an integral vertical tilt mirror, and be arranged to swing flat against the carbody. The mirror mounting and support shall be designed so that when overloaded the mirror will break away without damage, scuffing or deformation of the carbody. Final location and arrangement of all mirrors shall be approved by the Customer and determined at the front end mockup detailed in Chapter 3.

16.2.6 Engineer's Seat

Each cab shall be equipped with a heavy-duty, cloth upholstered Engineer's and Assistant'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 provide a minimum of 0.5 in. 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 Engineer/Assistant 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 Engineer/Assistant 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.

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 49CFR Section 238.233. In addition, the seat shall comply with the requirements of APTA Standard
SS-C&S-011-98, but may be supplied without a rotation feature. Where conflicts exist, the most restrictive shall apply. The seat assembly shall meet the smoke and flammability requirements of Chapters 2 and 18.

Heavy-duty transportation grade cloth upholstery having an approved color and weave pattern meeting the requirements of Chapter 18 shall be used. 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 Customer. 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. One sample seat shall be submitted by the Contractor for approval by the Customer following completion of testing.

The seat 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.

The seats shall contain mechanical components only and shall provide simple, smooth adjustments while an Engineer is seated. The seats shall have a minimum of 6 in. fore/aft adjustment (9 in. 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.

### 16.2.7 Horn

A roof mounted horn shall be supplied which shall comply with the requirements for Amtrak AAMPS catalog number 23 523 83075. A Nathan/Airchime model K-5LA, type WH-301703, or approved equivalent, pneumatic horn with bell frequencies of 311, 370, 415, 494 and 622 Hz, with all bells facing outward 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 Customer. To reduce vibrations transmitted into the carbody, the horn shall be mounted on a 0.5 in. 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.

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 Customer-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.
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 49CFR Section 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 Customer. All valves, switches and controls shall be completely accessible for maintenance. Details of the horn installation shall be approved by the Customer.

16.2.8 Bell

A 12 in. 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. 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 shall be located on the left side of the center cab console. 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 shall cause the auxiliary light control in Chapter 11 to operate as approved by the Customer. All valves, switches and controls shall be completely accessible for maintenance. An electronic bell will be considered as an alternative. Details of the bell installation shall be approved by the Customer.

16.2.9 Miscellaneous Cab Items

The following shall be provided in each cab and each item will be approved by the Customer:

- A cab signal/Automatic Train Control system
- White reading lights and red night time illumination
- Alerter system
- A ceiling air diffuser, a floor heater element and a forced air heater
- A Conductor communications signal system pushbutton and alarm shall be located in the cab, along with a crew intercom speaker with integral volume control which cannot be muted
- The cab windshield shall be heated
- A permanent car number identification plate shall be applied to the console in a prominent location near the speedometer
- Four flush, heavy-duty, spring loaded coat hooks with integral rubber bumper shall be located on the rear partition
- One 8.5 in. by 11 in. "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 Customer and in accordance with 49CFR Section 229.23(d)
- An "air slip" inspection form clip holder for a 3 in. by 5 in. daily inspection form shall be located on the rear partition wall near the cab door
- Stainless steel tubular footrests for both the Engineer and Assistant, no less than 9 in. long, shall be provided as directed by the Customer
- Clipboard-type spring loaded holders shall be installed with clear areas sufficient to hold 8.5 in. by 11 in. bulletin orders shall be located within easy reach of the Engineer and Assistant.

- A cup holder to retain a large coffee cup or soft drink container shall be mounted on the side wall below the side window sliding sash and forward of the Engineer’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 Assistant.

- One 120VAC grounded duplex GFI-protected receptacle, protected for 15 amps service, and a 74VDC receptacle, shall be located in the lower cab wall.

- Side window arm rest and Blue Flag bracket.

- Flat writing surfaces sufficiently large to hold 8.5 in. by 11 in. paper shall be located directly in front of the Engineer and Assistant, at the base of the windshield, in order to permit the Engineer or Assistant to write train orders. These surfaces shall also be sufficiently large to allow a laptop computer to be used by maintenance personnel.

- 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.

- 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.

- A flag holder and a fireproof closed metal container for fusees shall be provided in accordance with 49CFR Section 229.119(f), and as directed by the Customer.

- A shallow luggage shelf shall be provided above the side window for crew use.

- A small trash container shall be provided that uses an available Amtrak trash liner.

- 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.

### 16.2.10 Security and Authorization System

To prevent unauthorized activation of the cab controls or train movement, the Contractor shall submit during design review for Customer approval an electronic keycard control system to secure the cab controls. The system shall comply with U.S. Transportation Security Administration (TSA) guidelines. Unless otherwise approved, the system shall utilize the electronic data contained on the Amtrak employee photo identification card, or Amtrak-issued authorized contractor identification card, to identify the individual, and shall meet the security requirements of the Amtrak Police department. A contactless-type ID card reader system is desired. No additional electronic card shall be required for identification purposes. The system shall retain in a downloadable memory system data which provides a time-stamped identity of the individual activating the cab controls, and shall prevent unauthorized access to cab controls. The system software shall be protected against modification by unauthorized personnel, and revisions shall require reprogramming memory circuit packages. The system shall comply with the materials and workmanship requirements of Chapter 18.
16.3  Cab Controls

16.3.1  Arrangement of Controls

The Engineer's cab shall feature a desk-type, primary control console centered below the Engineer's windshield, with an additional vertical instrument and control panel located to the Engineer'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 Customer. The console cabinet color and design shall match the adjacent cab lining scheme. Indicator and annunciator lights shall be positioned centrally to the Engineer's forward line of sight, arranged so they do not cause reflections in the Engineer'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 Engineer or Assistant 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).

The arrangement of controls to satisfy the ergonomics of a wide range of Engineer physical sizes shall be given particular attention by the Contractor. All controls shall be positioned for ease of access for Engineers 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 Engineer's eye position. The layout of the cab shall be coordinated with the Customer, shall be incorporated into the car mockup per Chapter 3 and shall be subject to review and final approval by the Customer. All aspects of the cab design shall be approved by the Customer.

Locomotive traction power shall be controlled by the Engineer 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 patterned after the AEM-7 locomotive units now in use on Amtrak. 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 Engineer 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 Engineer.

The vertical instrument and control panels flanking the windshield shall be arranged to be angled toward the Engineer, so that critical displays are located at a 90° angle to the Engineer's field of view. All indicators and annunciator lights shall be LEDs, which shall have a lamp test feature. A rotary dimmer switch shall be incorporated in the cab to control the intensity of all indicators and annunciator lights from bright to dim, and shall not have an OFF position.

All operating controls, displays and all indicators shall be positioned within the Engineer'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.
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 minimum 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 Customer.

16.3.2 Center Console

The center console located in front of the Engineer and Assistant at the bottom of the windshield shall be generally arranged as a flat desk sloped downward toward the Engineer. 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 Engineer’s and Assistant’s side cabs shall be identical components.

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 and its deadman function. The Engineer’s side center desktop console shall contain the following, generally from left to right:

- Bell ringer valve
- Master controller
- Sanding switch
- Writing space for train orders
- Horn sequence pushbutton
- Headlight control switch
- Cab signal acknowledge pushbutton
- Horn control valve lever
- Reading light/cab lighting rocker switches and dimmers
- Brake controller with integral display screen
- Auxiliary light control switch
- Windshield wiper control

16.3.3 Other Controls, Switches and Gages

The following controls, switches and gages shall be positioned at appropriate locations in proximity to the Engineer to provide optimum access to the Engineer, with minimal hindrance to visibility. Potential areas include the vertical control panel on the right and the upper panel.

- Provisions for future 10 in. video monitor
- Fault display panel
- Conductor communicating signal pushbutton switch
• Fault reset switch
• Gauge light dimmer
• Heated windshield switch
• Cab heater rotary switch
• Car number plate (at optimum viewing location)
• Two duplex air gauges (at optimum viewing location)
  • (main reservoir/equalizing reservoir)
  • (brake pipe/brake cylinder)
• Radio and communications control
• Emergency locomotive shutdown pushbutton
• Locomotive type (electric/diesel) toggle switch
• Locomotive alarm bell silence pushbutton switch (bell inside panel)
• Main circuit breaker (electric) toggle switch
• Bulletin order clipboard
• Cab signal departure test panel
• Cab signal cutout and bypass switches
• Cab signal train type selector switch
• Indicator LED and annunciator panel
• Aspect display unit with 150mph speedometer (at optimum viewing location, with 4 in. additional space below ADU for future expansion of display)
• Non cab signal territory mode switch
• Pantograph raise/lower control switches
• Alerter panel
• Marker light switch
• Headlight/auxiliary light status indicators (centered)
• Locomotive dynamic brake/wheel slide warning buzzer
• Conductor’s emergency brake valve
• Locomotive alarm bell pushbutton switch (bell inside panel)

The following switches are to be sealed in the normal (down) position using a secure plastic tie seal method. A 0.1015 in. (No. 38 drill) diameter hole shall be provided in each switch toggle and in an adjacent sealing wire standoff for each switch:

• Propulsion/doors interlock bypass switch
• Speed interlock bypass switch
• Friction brake interlock bypass switch
• Traction master bypass switch
• Spare switch location
The area above the windshield shall be used for infrequently used devices.

**16.3.4 Desktop Console – Assistant’s Side**

The Assistant’s desktop console will contain the following equipment and controls:

- Bell pushbutton (on/off)
- Horn pushbutton (3 position)
- B-3-B emergency brake valve
- Track warrant holder with spring clip

**16.3.5 Other Controls, Switches and Gages - Assistant’s Side**

The Assistant’s side will contain the following equipment and controls:

- Radio handset, control panel and handset storage cradle
- Radio keypad
- Car number plate
- Reading light switch
- Ceiling light switch
- Windshield wiper control
- Speedometer
- Cab reading light dimmer

**16.3.6 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. 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 Engineer. A heavy-duty moisture-sealed cab signal 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.

**16.3.7 Master Controller**

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 by the Amtrak Industrial Design office and approved by the Customer, taking into account the human factor guidelines referenced in Chapter 2.
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 lbs. 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.

The master controller shall have a COAST position, which shall be closest to the Engineer, and eight power positions (POWER LEVEL 1-8). Each position shall have a medium detent tactile indicator sufficient for the Engineer 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 forward away from the Engineer. No master controller handle deadman feature shall be used.

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 Customer.

16.3.8 Control Functions

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.

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 Customer’s approval:

1. An analysis of potential failures, their operational importance and how they will be annunciated to the Customer.
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.

16.3.9 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 Engineer 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:

- Audible alarm panel
  - ATS alert (Sonalert) 4.5 KHz continuous tone
  - Loco alarm (Sonalert) 2.9 KHz intermittent fast pulse tone
  - Conductor communicating signal (Buzzer) 4.5 KHz continuous tone
  - Wheel slip/brake warning (Sonalert) 1.9 KHz continuous tone
- Alerter panel
  - Alerter audible alarm (yelp)
  - Overspeed (whistle under center console)

16.3.10 Pantograph Control

Trainlined controls for raising and lowering the pantographs of electric locomotives shall be provided in the cab. These controls shall be active only when the cab car is in control of the 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.
### 16.3.11 Indicator Lights

The following indicator lights shall be provided in the left and right side panels in Customer 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 Engineer 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 some cab signal system indicators will be contained in the aspect display unit.

<table>
<thead>
<tr>
<th>Light Group</th>
<th>Condition</th>
<th>Indicator Light Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating status</td>
<td>MU control power on</td>
<td>Green</td>
</tr>
<tr>
<td></td>
<td>PCS open</td>
<td>Red</td>
</tr>
<tr>
<td></td>
<td>Sanding (loco or Cab car)</td>
<td>White</td>
</tr>
<tr>
<td></td>
<td>Wheel slip (loco)</td>
<td>White</td>
</tr>
<tr>
<td></td>
<td>Dynamic brake warning</td>
<td>Red</td>
</tr>
<tr>
<td></td>
<td>Loco alarm: failure</td>
<td>Red</td>
</tr>
<tr>
<td></td>
<td>No power brake</td>
<td>Red</td>
</tr>
<tr>
<td></td>
<td>Excess T/M current</td>
<td>Red</td>
</tr>
<tr>
<td></td>
<td>Auto power limit</td>
<td>White</td>
</tr>
<tr>
<td></td>
<td>High beam</td>
<td>Yellow</td>
</tr>
<tr>
<td></td>
<td>Spare</td>
<td>Red</td>
</tr>
<tr>
<td>Safety equipment status</td>
<td>ATS overspeed/penalty</td>
<td>Red</td>
</tr>
<tr>
<td></td>
<td>ATS cutout</td>
<td>Amber</td>
</tr>
<tr>
<td></td>
<td>Alerter cutout</td>
<td>Red</td>
</tr>
<tr>
<td></td>
<td>Suppression</td>
<td>Amber</td>
</tr>
<tr>
<td></td>
<td>Overspeed cutout</td>
<td>Red</td>
</tr>
<tr>
<td></td>
<td>No motion</td>
<td>Blue</td>
</tr>
<tr>
<td></td>
<td>Spare</td>
<td>Red</td>
</tr>
<tr>
<td>Cab Car status</td>
<td>Heated windshield on</td>
<td>Amber</td>
</tr>
<tr>
<td></td>
<td>HEP on</td>
<td>Blue</td>
</tr>
<tr>
<td></td>
<td>HEP off</td>
<td>Red</td>
</tr>
<tr>
<td></td>
<td>No battery charge</td>
<td>Red</td>
</tr>
<tr>
<td></td>
<td>Spare</td>
<td>Red</td>
</tr>
<tr>
<td></td>
<td>Spare</td>
<td>Amber</td>
</tr>
<tr>
<td>Train status</td>
<td>Brakes applied</td>
<td>Amber</td>
</tr>
<tr>
<td></td>
<td>Brakes released</td>
<td>Green</td>
</tr>
<tr>
<td></td>
<td>Car doors closed</td>
<td>Green</td>
</tr>
<tr>
<td></td>
<td>Car hot journal</td>
<td>Red</td>
</tr>
<tr>
<td></td>
<td>Spare</td>
<td>Red</td>
</tr>
</tbody>
</table>
16.4 Electrical Circuits

16.4.1 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 Engineer, in a location approved by the Customer. 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:

- Locomotive control
- Dynamic brake cutout
- Engine run switch
- Generator field switch
- Door interlock bypass switch (sealed)
- Heated windshield
- Windshield defogger
- Cab heat
- Auxiliary lights
- Number signs
- Radio
- Indicator and gauge lights
- ATS
- Event recorder/alarter/speedometer (sealed)
- 72VDC receptacle
- Spare
- Headlights

16.4.2 Propulsion (MU) Control Circuits

16.4.2.1 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 any Amtrak electric locomotive (AEM-7 DC, AEM-7 AC, or HHP-8 locomotives) equipped with a standard 27-point diesel AAR propulsion MU control trainline. The cab locomotive controls and communications shall be interfaced using the existing propulsion trainline protocol in Amtrak Drawing A-63-7675-3. 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.
16.4.2.2 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 Engineer an indication that MU trainline power is available from the locomotive.

16.4.2.3 Trainline functions

The MU control trainline functions shall conform to the control pin assignments of APTA and Amtrak Drawing A-63-7675-3. The following special trainline features shall also be provided:

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 Engineer 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.

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.

Trainline Circuit 26 (Ground Relay Reset): A pushbutton shall be provided to apply 74V to this trainline to reset the locomotive.

16.4.2.4 Power knockout functions

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 deenergizing 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.

To restore locomotive traction from an emergency brake application, the Engineer must be required to perform the following actions:

- Place brake handle in emergency brake position;
- Wait for brake system timeout from the application of emergency brakes;
- Place throttle handle in coast;
- Move brake handle to release position; and
- Move throttle handle to a power position.

To restore locomotive traction from a penalty brake application, the Engineer must be required to perform the following actions:

- Place brake handle in suppression position;
• Place throttle handle in coast;
• Perform actions that satisfy the system that initiated penalty (i.e., acknowledge alerter);
• Move brake handle to release position; and
• Move throttle handle to a power position.

16.5 Heating, Ventilation and Air Conditioning

16.5.1 Climate Control

The cab shall be provided with a quiet, forced air supply of conditioned air from the car's main HVAC system, along with a separate cab heater system. See Chapter 10 for additional details. Full climate control with air supply through an individual fully adjustable ceiling diffuser shall be provided. The local cab heater shall be controlled independently of the HVAC unit with Engineer adjusted thermostat control. Care shall be taken to avoid all drafts.

16.5.2 Air Distribution

The cab shall have durable individually adjustable diffusers for the Engineer and Assistant with manual direction and volume, infinite adjustment between maximum and minimum air volume and direction. The diffusers shall not create drafts on the Engineer's or Assistant's back or neck. The diffusers shall not allow complete blockage of the cab air. The volume of conditioned air delivered to the cab through each diffuser shall not exceed 30 cubic feet per minute (cfm) when the diffuser is in a minimum position, and shall be a minimum of 175 cfm when the diffuser is fully opened.

16.6 Cab Lighting

16.6.1 Headlights and Auxiliary Lights

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 suitable 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 Amtrak Specification 962. The fixtures shall comply with the requirements of 49CFR Sections 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 Customer. 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 49CFR Part 221.

The headlight shall use a Customer approved PAR 56, 30VDC, 200W sealed beam lamp, type 200PAR, in compliance with the requirements of Amtrak AAMPS catalog number 25 180 08209. The auxiliary light shall use a Customer approved PAR 56, 30VDC, 350W sealed beam
lamp, type 300PAR, in compliance with the requirements of Amtrak AAMPS catalog number 26 555 00014. 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 Customer. 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 Customer.

The headlights shall be under the control of an easily-reached Engineer’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.

The auxiliary lights shall be under the control of a second easily-reached Engineer’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 49CFR Section 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 Engineer to dim the auxiliary lights for an adjustable time period, initially set for 20 seconds, to avoid blinding an oncoming train Engineer. 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.

### 16.6.2 Interior Cab Lighting

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 Engineer’s console, Assistant’s console and the general cab area and avoid glare on the windshield. LED light fixtures shall be used if possible. These lights shall be controlled by a three position (RED-OFF-WHITE) rocker switch with an adjacent rotary dimmer control. The minimum lighting intensity provided by the white ceiling lights shall be 15 foot-candles on both the floor and the console.

For reading purposes, additional recessed, focused, gimbal-type ceiling Engineer and Assistant’s reading lights shall be provided. It shall comply with the requirements of 49CFR Section 229.127, and shall produce at full intensity a minimum of 25 foot candles at an elevation of 2 ft 9 in. above the floor in the Engineer’s and Assistant’s work area. The reading lights shall be controlled by two position (ON-OFF) rocker switches with an adjacent rotary dimmer control.

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 Engineer/Assistant. All
lights shall be powered by the battery circuit. All light fixtures shall be dust tight, designed for ease of relamping and if incandescent shall use lamps supplied by a domestic U.S. manufacturer. The type and location of the lights shall be approved by the Customer.

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.

16.6.3 Car Number Signs

Three illuminated car number signs shall be provided on each cab car, arranged to be easily visible from the wayside. One shall be located on each side as near to the cab end as possible and at an approved location, and one shall be located on the front cab end at an approved location. The number signs shall have a four digit number, 8 in. high. Each sign shall use a 40W, "U" tube fluorescent lamp for uniform illumination, be powered from the car battery with an electronic DC ballast, and be easily relampable from inside the car. The design and location shall be approved by the Customer. They shall be illuminated whenever the cab has been activated and is in control of the train.

16.7 Alerter and Event Recorder System

The cab shall be equipped with a combination alerter and event recorder system which shall comply with the requirements of Amtrak AAMPS catalog number 2603005759 (Wabtec model 17792). Its functions shall configured by the Contractor to operate similar to that on the existing Amtrak AEM-7 AC electric locomotives. All aspects of the design and installation shall be approved by the Customer during design review.

16.7.1 Alerter System

The Engineer’s activities shall be monitored over a specified time period. If the Engineer 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 Engineer 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 Engineer shall wait for the PCS light to extinguish, and the Engineer shall then release the brakes. It shall not be necessary to stop the train.

An alerter system shall be reset each time the Engineer performs one of the following:

- Throttle change
- Change of direction
- Automatic brake adjustment of more than 5 psi
- Cab signal/ATS acknowledgement
- Activate the horn
- Activate or deactivate the bell
- Presses the alerter reset pushbutton
The alerter reset interval shall decrease with train speed, in conformance with the interval/speed function exhibited on the existing Amtrak AEM-7 AC electric locomotives. The alerter shall become dormant if it meets the same criteria for dormancy as employed on the AEM-7 AC 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.

If the alerter system fails, the Engineer 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.

### 16.7.2 Event Recorder

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.

The following items as specified in 49CFR Section 229.135 are required minimum parameters to be recorded:

- Train speed
- Direction of travel
- Time and date
- Distance
- Throttle position
- Train brake application and operation: analogue
- Parking brake application and operation: analog BCP and on/off
- Dynamic brake request
- Cab signal aspect
The parameters to be recorded shall be as follows, subject to revision during design review:

<table>
<thead>
<tr>
<th>No.</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Digital</td>
<td>Brake cylinder pressure 15 psig (bench mark)</td>
</tr>
<tr>
<td>2</td>
<td>Digital</td>
<td>Alerter reset</td>
</tr>
<tr>
<td>3</td>
<td>Digital</td>
<td>Brake pipe charging cut-off (port 53)(lead/trail)</td>
</tr>
<tr>
<td>4</td>
<td>Digital</td>
<td>Engineer initiated emergency brake</td>
</tr>
<tr>
<td>5</td>
<td>Digital</td>
<td>Bell use (air signal)</td>
</tr>
<tr>
<td>6</td>
<td>Digital</td>
<td>Horn use (full volume horn blast, air signal)</td>
</tr>
<tr>
<td>7</td>
<td>Digital</td>
<td>Self test of alerter</td>
</tr>
<tr>
<td>8</td>
<td>Digital</td>
<td>Alerter control override (electric cutout)</td>
</tr>
<tr>
<td>9</td>
<td>Digital</td>
<td>ATS enabled (combination electronic &amp; pneumatic)</td>
</tr>
<tr>
<td>10</td>
<td>Digital</td>
<td>Generator field excitation</td>
</tr>
<tr>
<td>11</td>
<td>Digital</td>
<td>Throttle valve A</td>
</tr>
<tr>
<td>12</td>
<td>Digital</td>
<td>Throttle valve B</td>
</tr>
<tr>
<td>13</td>
<td>Digital</td>
<td>Throttle valve C</td>
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<tr>
<td>14</td>
<td>Digital</td>
<td>Throttle valve D</td>
</tr>
<tr>
<td>15</td>
<td>Digital</td>
<td>Direction of travel forward</td>
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<tr>
<td>16</td>
<td>Digital</td>
<td>Direction of travel reverse</td>
</tr>
<tr>
<td>17</td>
<td>Digital</td>
<td>Dynamic brake setup</td>
</tr>
<tr>
<td>18</td>
<td>Digital</td>
<td>Sand magnet valve</td>
</tr>
<tr>
<td>19</td>
<td>Digital</td>
<td>Penalty brake (output to alerter magnet valve)</td>
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<tr>
<td>20</td>
<td>Digital</td>
<td>Headlight switch – headlights dim</td>
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<tr>
<td>21</td>
<td>Digital</td>
<td>Headlight switch – auxiliary lights on</td>
</tr>
<tr>
<td>22</td>
<td>Digital</td>
<td>Horn sequencer switch</td>
</tr>
<tr>
<td>23</td>
<td>Digital</td>
<td>HEP on/off</td>
</tr>
<tr>
<td>24</td>
<td>Digital</td>
<td>Door closed light</td>
</tr>
<tr>
<td>25</td>
<td>Digital</td>
<td>Parking brake applied</td>
</tr>
<tr>
<td>26</td>
<td>Digital</td>
<td>PCS open</td>
</tr>
<tr>
<td>27</td>
<td>Digital</td>
<td>ATS acknowledge</td>
</tr>
<tr>
<td>28</td>
<td>Digital</td>
<td>ATS request for acknowledgement</td>
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<td>29</td>
<td>Digital</td>
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</tr>
<tr>
<td>30</td>
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</tr>
<tr>
<td>31</td>
<td>Digital</td>
<td>Cab signal high overspeed select (ATS is cut in)</td>
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<tr>
<td>32</td>
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</tr>
<tr>
<td>33</td>
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<tr>
<td>A1</td>
<td>Analog</td>
<td>Brake pipe pressure</td>
</tr>
<tr>
<td>A2</td>
<td>Analog</td>
<td>Brake cylinder pressure</td>
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<td>Analog</td>
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<td>A4</td>
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</tr>
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<td>A7</td>
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<tr>
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<td>Speed</td>
</tr>
<tr>
<td>F2</td>
<td>Freq.</td>
<td>Not used</td>
</tr>
<tr>
<td>F3</td>
<td>Freq.</td>
<td>Not used</td>
</tr>
<tr>
<td>F4</td>
<td>Freq.</td>
<td>Not used</td>
</tr>
</tbody>
</table>
The memory module shall be designed and demonstrated to be reasonably secure, tamper resistant and waterproof. Reasonably secure and tamper resistant means that the system shall have data retention during extended loss of power to the system, provide physical protection during vehicle catastrophic occurrences, flame resistant and contain constraints against accidental or deliberate data erasure or overwriting.

16.7.3 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 60 hours in normal railroad operation. Recorded data will be capable of convenient download on demand to a compatible computer and a credit card (SRAM or flash) memory board. The credit card memory device will be the primary means of download.

16.7.4 Data Retrieving

Event recorder download capability shall be available at any time, including during train operation. The download shall include the car number. Data shall be recovered by the following methods:

- Credit card memory module (PCMCIA’s - SRAM or FLASH) of either Type II or Type III configuration shall be located in the cab area. The memory card shall be capable of storing multiple loadings, either from the same vehicle or more than one vehicle.
- Direct downloading to an IBM or compatible laptop PC, using an adapter cable (Amtrak Drawing C-69-7570) and the access port on the memory module.
- Use of a USB style portable Memory Stick.

16.7.5 Deliverables

Prior to the delivery of the first cab car, the Contractor shall deliver to the Customer 25 complete sets of the event recorder diagnostic software required for retrieving and manipulating 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 Customer.

16.7.6 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.
16.8 Sanding

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.

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 ft³, 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 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 Customer for approval during design review.

16.9 Radio System

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 Engineer/Assistant 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 Engineer/Assistant, and orientated for proper microphone voice recognition. This shall be verified during design review and in the cab mockup.

The radio system shall be similar to the standard Motorola clean-cab Astro Spectra locomotive radio but must support both narrowband and NXDN technologies, or as otherwise specified by the Customer. All wiring, connector plugs and mounting systems shall be fully compatible with the Motorola Astro 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.
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 Engineer 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.

The radio equipment in each cab shall be operable when the cab has been activated by the Engineer. 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 Customer.

16.9.1 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.

16.9.2 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.

16.10 Locomotive Digital Video Recorder

The operating cab of the cab car shall be equipped with the Amtrak standard solid state Locomotive Digital Video Recording (LDVR) system to record the Engineer’s forward view through the cab windshield. The LVDR shall be a Wabtec model 25484 system or approved equivalent, including a model 25630 camera, model 25213 microphone, video system and wireless download system. The Contractor shall design and supply all interface devices, mounting brackets and cables required for installation. The equipment shall be mounted in a locker at the F-end interior of the car.

The video camera shall be mounted within the cab at the top of the cab windshield, in the area served by the windshield wiper, such that it records the same view seen by the Engineer. Its mounting shall not interfere with normal operation within the cab environment. The camera
shall be capable of recording a color image by day and a black and white image by night. All exposed cab equipment shall have smoothly rounded exposed corners, be as small as possible and have a black or unobtrusive exterior case finish. Wire connectors and mounting hardware exposed in the cab shall be resistant to tampering. The microphone shall be of a weatherproof design, and mounted on the exterior of the cab to clearly receive the sound of the horn and bell.

The video storage must be lockable from tampering. The recorder must support JPEG export of data. Data storage shall be by use of a shock-mounted 80 GB capacity hard drive, along with a non-volatile front end flash memory of a minimum 1 GB capacity. The system shall have a minimum of 72 hours of media storage capacity. The maximum recording rate shall be 30 fps. The system shall date/time stamp or equivalent each frame of image. Video compression shall be per H.263 or equivalent. There shall be a system clock with back up battery, and a minimum of 4 isolated inputs (74VDC nominal). The digital recording device shall be painted orange.

The system shall operate on 55-100VDC with circuits isolated from case ground. The recording unit shall have download capability by both a wired connection to a Microsoft Windows-based laptop computer, and a wireless system using IEEE 802.11b or g protocol and proper data encryption software with a low-profile antenna, with a minimum transmission distance of 1500 ft. All download methods shall use Customer approved data encryption and secure password systems. The system shall not interfere with other cab car systems.

It is mandatory that the video system recorder unit must obtain all speed and time data from the event recorder system, so that both systems have identical time-based data. It is the responsibility of the Contractor to perform all data commutations and data transfer for speed and time. Methods used to accomplish this shall be approved by the Customer.

The video system, unless otherwise approved by the Customer, shall commence recording data when the cab car commences movement, and continue recording for a software-adjustable time, such as 15 minutes, after movement has ceased. Data collection shall utilize the entire capacity of the memory system, upon which the oldest data will start to be overwritten.

The video system shall contain a health monitor indicator light, to easily permit a maintainer or Engineer to determine that the system is operating correctly and is not in a fault condition. Unless otherwise approved by the Customer, there shall not be a power switch to the system so as to prevent the Engineer from disabling the system while in service. The system shall monitor its health status, including data logging of evidence of tampering, and shall restart if an error is detected. Details of the design and installation shall be approved by the Customer.

16.10.1 Event Recorder

An event recorder/aleter system shall be provided. It shall be Wabtec Train Trax model TTX-REC-M5, or approved equivalent.

The event recorder, including memory and download modules, shall be designed and installed in accordance with 49CFR Section 229.135. Memory modules shall be painted orange for easy identification following an accident. These components shall be located in the secure top portion of the cabinet behind the Engineer’s cab.

The parameters to be recorded, and the rate of scan for those parameters, shall be provided to the Customer for review. Time, date, car number and distance traveled shall also be recorded.
At a minimum, the system shall record the following parameters:

<table>
<thead>
<tr>
<th>No.</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Digital</td>
<td>Brake cylinder pressure 15 psig (bench mark)</td>
</tr>
<tr>
<td>2</td>
<td>Digital</td>
<td>Alerter reset (use of alerter reset button)</td>
</tr>
<tr>
<td>3</td>
<td>Digital</td>
<td>Brake pipe charging cut-off <a href="lead/trail">port 53</a></td>
</tr>
<tr>
<td>4</td>
<td>Digital</td>
<td>Engineer initiated emergency</td>
</tr>
<tr>
<td>5</td>
<td>Digital</td>
<td>Bell use (air signal)</td>
</tr>
<tr>
<td>6</td>
<td>Digital</td>
<td>Horn use (full volume horn blast, air signal)</td>
</tr>
<tr>
<td>7</td>
<td>Digital</td>
<td>Self test of alerter</td>
</tr>
<tr>
<td>8</td>
<td>Digital</td>
<td>Alerter control override (electric cutout)</td>
</tr>
<tr>
<td>9</td>
<td>Digital</td>
<td>ATS enabled (combination electronic &amp; pneumatic)</td>
</tr>
<tr>
<td>10</td>
<td>Digital</td>
<td>Generator field excitation</td>
</tr>
<tr>
<td>11</td>
<td>Digital</td>
<td>Throttle valve A</td>
</tr>
<tr>
<td>12</td>
<td>Digital</td>
<td>Throttle valve B</td>
</tr>
<tr>
<td>13</td>
<td>Digital</td>
<td>Throttle valve C</td>
</tr>
<tr>
<td>14</td>
<td>Digital</td>
<td>Throttle valve D</td>
</tr>
<tr>
<td>15</td>
<td>Digital</td>
<td>Direction of travel forward</td>
</tr>
<tr>
<td>16</td>
<td>Digital</td>
<td>Direction of travel reverse</td>
</tr>
<tr>
<td>17</td>
<td>Digital</td>
<td>Dynamic brake setup</td>
</tr>
<tr>
<td>18</td>
<td>Digital</td>
<td>Sand magnet valve (locomotive sander only)</td>
</tr>
<tr>
<td>19</td>
<td>Digital</td>
<td>Penalty brake (output to alerter magnet valve)</td>
</tr>
<tr>
<td>20</td>
<td>Digital</td>
<td>Headlight switch – headlights on (high or dim)/off</td>
</tr>
<tr>
<td>21</td>
<td>Digital</td>
<td>Crossing lights on/off</td>
</tr>
<tr>
<td>22</td>
<td>Digital</td>
<td>Horn sequencer foot switch use</td>
</tr>
<tr>
<td>23</td>
<td>Digital</td>
<td>HEP on/off</td>
</tr>
<tr>
<td>24</td>
<td>Digital</td>
<td>Door closed summary circuit (doors closed/not closed)</td>
</tr>
<tr>
<td>25</td>
<td>Digital</td>
<td>Holding brake pressure (HBPS) (parking brake applied)</td>
</tr>
<tr>
<td>26</td>
<td>Digital</td>
<td>PCS open</td>
</tr>
<tr>
<td>27</td>
<td>Digital</td>
<td>ATS acknowledge</td>
</tr>
<tr>
<td>28</td>
<td>Digital</td>
<td>ATS request for acknowledgement</td>
</tr>
<tr>
<td>29</td>
<td>Digital</td>
<td>High horn</td>
</tr>
<tr>
<td>30</td>
<td>Digital</td>
<td>Low horn</td>
</tr>
<tr>
<td>31</td>
<td>Digital</td>
<td>Cab signal high overspeed select (ATS is cut in)</td>
</tr>
<tr>
<td>32</td>
<td>Digital</td>
<td>Door closed summary circuit status (normal/bypass)</td>
</tr>
<tr>
<td>33</td>
<td>Digital</td>
<td>Not used</td>
</tr>
<tr>
<td>A1</td>
<td>Analog</td>
<td>Brake pipe pressure</td>
</tr>
<tr>
<td>A2</td>
<td>Analog</td>
<td>Brake cylinder pressure</td>
</tr>
<tr>
<td>A3</td>
<td>Analog</td>
<td>Headlights high/dim/off</td>
</tr>
<tr>
<td>A4</td>
<td>Analog</td>
<td>Crossing lights on/flashing/off</td>
</tr>
<tr>
<td>A4</td>
<td>Analog</td>
<td>Not used</td>
</tr>
<tr>
<td>A5</td>
<td>Analog</td>
<td>Cab signal</td>
</tr>
<tr>
<td>A6</td>
<td>Analog</td>
<td>Not used</td>
</tr>
<tr>
<td>A7</td>
<td>Analog</td>
<td>Not used</td>
</tr>
<tr>
<td>F1</td>
<td>Freq.</td>
<td>Speed (1 mph increments)</td>
</tr>
<tr>
<td>F2</td>
<td>Freq.</td>
<td>Not used</td>
</tr>
<tr>
<td>F3</td>
<td>Freq.</td>
<td>Not used</td>
</tr>
<tr>
<td>F4</td>
<td>Freq.</td>
<td>Not used</td>
</tr>
</tbody>
</table>
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 60 hours of data collected in normal railroad operation.

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 60 hours in normal railroad operation. Recorded data will be capable of convenient down-load on demand to a compatible Windows-based computer and a removable memory storage device. The credit card memory device will be the primary means of download. The list of recorded inputs is to be submitted for Customer approval.
Figure 16-1: Possible Cab Arrangement (1/2)
Figure 16-2: Possible Cab Arrangement (2/2)
Table 16-1: Controls and Switches (other than throttle, reverser and brake)

<table>
<thead>
<tr>
<th>Location</th>
<th>Switch Function</th>
<th>Switch Type/Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desktop</td>
<td>Alerter reset</td>
<td>Yellow, mushroom-style push button (Cutler-Hammer 10250ED1309-4)</td>
</tr>
<tr>
<td>Horn</td>
<td>Blue, mushroom-style push button, 3 position (Off, Low, High) (Cutler-Hammer 10250ED1309-5)</td>
<td></td>
</tr>
<tr>
<td>Bell control</td>
<td>Yellow, square, two button, push button (On, Off buttons) (Cutler-Hammer E30CED6)</td>
<td></td>
</tr>
<tr>
<td>Sand</td>
<td>Blue collar type push button (Cutler-Hammer 10250ED1309-2)</td>
<td></td>
</tr>
<tr>
<td>Floor (foot space)</td>
<td>Horn automatic sequence</td>
<td>Pedal (yellow) (Square-D AW-13)</td>
</tr>
<tr>
<td>Left auxiliary console</td>
<td>Headlight selector</td>
<td>4-position rotary (Electro Switch Corp 101405A-S)</td>
</tr>
<tr>
<td></td>
<td>Cab reading light dimmer</td>
<td>Rotary dimmer switch with off detent</td>
</tr>
<tr>
<td></td>
<td>Windshield wiper</td>
<td>Rotary switch with variable speed</td>
</tr>
<tr>
<td>Right side overhead console</td>
<td>Defogger</td>
<td>Rotary (On/Off) (Cutler-Hammer 10250ED1309-6)</td>
</tr>
<tr>
<td></td>
<td>Defroster</td>
<td>Rotary (On/Off) (Cutler-Hammer 10250ED1309-9)</td>
</tr>
<tr>
<td></td>
<td>Console light dimmer</td>
<td>Rotary switch (Angstrohm Precision 5ES443.1)</td>
</tr>
<tr>
<td></td>
<td>Cab ceiling light</td>
<td>Rocker switch (NKK SW3821D/328)</td>
</tr>
<tr>
<td></td>
<td>White reading light</td>
<td>Rocker (NKK SW3821D/328)</td>
</tr>
<tr>
<td></td>
<td>Red reading light</td>
<td>Rocker (NKK SW3821D/328)</td>
</tr>
<tr>
<td></td>
<td>Inter car end door light</td>
<td>Rocker (NKK SW3821D/328)</td>
</tr>
<tr>
<td></td>
<td>Locomotive alarm silence</td>
<td>Red collar type push button (Cutler-Hammer 10250ED1309-8)</td>
</tr>
<tr>
<td></td>
<td>TL GRD/EAB loco fault reset</td>
<td>Black collar type push button (Cutler-Hammer 10250T23B)</td>
</tr>
<tr>
<td></td>
<td>Emergency locomotive shutdown</td>
<td>Push button, red jumbo mushroom type. Two position – push to activate, pull to reset (Cutler-Hammer 10250ED1309-7)</td>
</tr>
</tbody>
</table>

* End of Chapter 16 *
Standardized Technical Specification

PRIIA 305 Next-Generation Equipment Committee
Single-Level Passenger Rail Cars

Chapter 17

Emergency Equipment
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17.0 Emergency Equipment

17.1 Overview

Each rail car shall be equipped with emergency equipment per the requirements of 49CFR Section 239.101. Emergency equipment provided shall include fire extinguishers, pry bars, sledge hammers, first aid kits, chemiluminescent snap lights and seat-back passenger safety information cards. Additionally, a storage container for an Automatic External Defibrillator (AED) shall be provided in the café/lounge car, per Amtrak AED standards.

17.2 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 Customer.

17.3 Emergency Equipment Lockers

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 in accordance with Amtrak Drawing E-140-2959. 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.

The locker shall be marked with emergency equipment signage that is compliant with federal emergency signage standards and compatible with Amtrak standard signage per Amtrak Specification 697 for the safety equipment contained therein.

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.

17.3.1 Emergency Tools

Each emergency equipment locker shall include the following emergency tools:

- A 6 lb sledge hammer with an 18 in. ash handle
- An 18 in. pry bar

The tools shall be installed in a manner that will prevent vibration and rattling and be readily available for emergency use.
17.3.2 Fire Extinguisher
The extinguisher shall be securely mounted in a manner that will prevent vibration and rattling and allow their 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.

A dry-chemical, 10-pound fire extinguisher, UL rated 2A-40 type B/C shall be included in the emergency equipment locker of each car.

A fire extinguisher, identical to that specified above, shall also be mounted in the emergency equipment locker behind the cab area of the cab/baggage car. See Chapter 16.

A dry-chemical, 2.5 lb fire extinguisher, UL rated 1A-10 type B/C shall be included in the café/lounge car. See Chapter 14.

Fire extinguishers shall have all required certifications prior to shipment of the car.

17.3.3 First Aid Kit
A first aid kit, compliant with the requirements of 49CFR Section 239.101, Pac-Kit p/n 6311AMT, shall be included in the emergency equipment locker.

First aid kits, identical to those specified above, shall be located in the emergency equipment locker behind the cab area of the cab/baggage car (see Chapter 16), and in the galley area of the café/lounge car (see Chapter 14).

17.3.4 Snap Lights
Each emergency equipment locker shall include one package (quantity 10) of 6 in. yellow 12-hour chemiluminescent snap-lights, Cyalume p/n 9-01360. Snap lights shall also be provided in the café/lounge car.

17.4 Automatic Electronic Defibrillator (AED)
A storage container for a Customer-provided Automatic Electronic Defibrillator (AED) shall be provided in a location accessible to crewmembers in the galley of the café/lounge car, in accordance with Amtrak AED installation specification. The container shall be a minimum of 9 in. wide by 20.5 in. deep, and shall provide no less than 19 in. of vertical storage clearance. If the AED is to be lifted vertically out of the holder, a minimum clearance of 24 in. 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 Customer review and approval (see Chapter 14).

17.5 Seat-Back Safety Information Card
The Contractor shall develop the artwork for a seat-back safety information card illustrating the type, location and use of all safety features, emergency equipment, emergency signage and emergency exit pathways for each car type. This safety card shall be designed in the format of Amtrak’s “Passenger Safety Instructions” and shall include a clear Braille overlay. Artwork is to be provided for Customer review and approval.

Electronic artwork, suitable for printing, shall be provided to the Customer prior to the delivery of the first vehicle.
The Contractor shall be responsible for the printing and delivery of the first 5000 copies of the seat-back safety card prior to the delivery of the first vehicle. Seat-back safety cards shall be shipped to a location to be determined by Customer.

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Chapter 18

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18.0 Materials and Workmanship

18.1 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 the Customer'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.

18.2 General Requirements

18.2.1 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.

18.2.2 Marking and Storage

All materials intended for use on these vehicles shall be marked or stored so as to be readily identifiable, and shall be adequately protected during handling and storage.

All stored material subject to corrosion shall be protected by waterproof covers, coatings or packaging.

Equipment covers, cable entrances and openings shall be closed to prevent ingress of water or dirt.

All dated material shall have the expiration date clearly marked. Expired material or material expiring within one year of car acceptance shall not be used.

Material or components, which require maintenance during storage, shall be properly maintained per the component(s) manufacturer's instructions. The Contractor shall document such maintenance, and provide these records as requested by Customer.

Rejected material shall be clearly marked and stored in an area specifically designated for that purpose.
18.2.3 **Prohibited Materials**

The following materials shall not be used in the construction of the vehicle:

- Polyvinyl Chloride (PVC)
- Asbestos
- Lead in brake shoes
- Un-encapsulated urethane foam
- Chlorinated Fluorocarbons (CFCs) that may cause environmental degradation or handling hazards
- Materials that, in their normal installed state, emit products that are known to be toxic or irritants

18.2.4 **Material Reporting Requirements**

Whenever a commercial material is not covered by a specification or standard, the Contractor shall identify the material by the commercial trademark, name and address of the Supplier. The Contractor shall submit a description and the technical data specifications of the material composition for approval at the design review.

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.

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 Customer as part of the material certification test requirements. See Chapter 19.

The Contractor shall maintain records that trace all materials to their manufacturers and production specifications and methodologies.

18.3 **Joining and Fastening**

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.

The Contractor shall submit joining and fastening data, specifications and standards for all types and methods of fastening and joining used to the Customer for review and approval at the design review.

The Contractor shall submit to the Customer 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 Customer.
18.3.1 Joint Fitting

Joints shall be properly fitted, whether exposed or concealed. When not otherwise specified in drawings or specifications, gaps between joints shall be held to a dimension not greater than 10% of the thinner material being joined, or 0.002 in., whichever is greater. Gaps shall be uniform in width. The edges of panels shall have a smooth, finished appearance.

Where excessive gaps (greater than those permitted by approved drawings or standards) are found to exist at the 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 Customer. 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.

18.3.2 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.

18.3.3 Wood-to-Metal Connections

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.

All bolts or rods passing through wood shall be coated with aluminum paint conforming to GSA Federal Standard TT-P-38E.

18.3.4 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.

18.4 Fasteners

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.

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.

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 Customer. A fastener is safety related if a single fastener failure will create an unsafe condition.
Self-tapping screws and structural Velcro shall not be used without written Customer approval.

18.4.1 Threaded Fasteners

All inch-standard threaded fasteners shall conform to ANSI Standard B1.1 or Industrial Fasteners Institute 1970 Fastener Standards.

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.

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.

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.

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 Customer approval.

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. for bolts 0.25 in. 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., regardless of bolt size.

18.4.2 Metric Fasteners

Subject to the Customer 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 Customer, 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.

Metric fasteners shall be marked as required in Metric Fastener Standards, Industrial Fasteners Institute, latest edition.
18.4.3 Structural Fasteners

All structural fasteners shall have documentation identifying manufacturer and purchase specifications available for examination by the Customer 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.

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 Customer. 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.

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.

All structural bolts for undercar equipment shall be a minimum Grade 8 and the bolt diameter shall be no less than 0.375 in., regardless of design load. 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.

18.4.4 Decorative and Appearance Fasteners

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.

All exterior fasteners visible to passengers shall be austenitic stainless steel for steel, Low Alloy High Tensile (LAHT) steel and stainless steel car bodies. Exterior aluminum shall be joined by austenitic stainless steel or aluminum alloy fasteners, as appropriate to the design and appearance requirements. Fasteners used on the side sill to attach heavy equipment brackets shall be considered structural fasteners.
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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. and be of adequate strength.

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 Customer to review for a period of not less than the expiration of the warranty period of the last vehicle accepted.

18.4.5 Torquing

All safety-related fasteners, including truck and brake equipment bolts and all fasteners exposed to fatigue loads, shall be torqued to a minimum preload equal to 75% of their proof load and “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.

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 Customer may require bolt torque-tension tests to verify that installed preload is equivalent to 75% of proof loads.

18.4.6 Washers and Lock Washers

Washers shall be used under the heads of all bolts and under all nuts. Where high strength fasteners are applied, washers shall be hardened and comply with IFI Fastener Standards, latest issue.

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.

Other types of washers, including Belleville washers, may only be used for special applications with the Customer’s approval.

18.4.7 Rivets and Lock Pins

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. Exposed heads shall be concentric with the shank and free from rings, fins, pits and burrs.

Swage-locking (Huckbolt type) fasteners shall conform to Military Specification MIL-P-23469/1B. 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.
18.4.8  Plating of Fasteners

All carbon, alloy and martensitic steel fasteners shall be plated with cadmium or zinc, unless specifically waived by the Customer.

Cadmium plating shall conform to GSA Federal Standard QQ-P-416F, Class 2 or 3, Type II.

Zinc plating shall conform to ASTM Standard B633-07, Type II SC2, SC3 or SC4.

18.4.9  Rivet and Bolt Holes

Rivet and bolt holes shall be accurately located and aligned, and, when necessary during assembly, holes shall be reamed round to specified size in position. Bolt hole clearances shall not exceed the 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.

18.5  Stainless Steel

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.

All stainless steel surfaces subject to paint application shall be cleaned and painted in accordance with a Customer approved general paints and corrosion protection process.

Finishing methods: surface finishes shall be uniform and of such texture that the original finish will be maintained through repeated brush washings.

Buffing and polishing of stainless steel, where required, shall be done without the use of any composition-containing iron or iron oxide.

18.5.1  Chemical Composition

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.

Chemical composition of stainless steel alloys used for non-structural purposes shall conform to ASTM Standard A666.

The material shall be free from precipitated carbides and from surface imperfections of a magnitude which would prevent its meeting bend requirements.

18.5.2  Mill Reports

It shall be the responsibility of the Contractor to insure 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 Customer
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for approval if they differ from ASTM Standard A666 requirements and submitted with the car history book.

18.5.3 Design Stresses

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 Customer.

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 Customer.

18.5.4 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.

18.5.5 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. in 8 ft.

18.5.6 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.

- 80 grit on exterior surfaces
- 180 grit on interior surfaces

18.6 Low-Alloy High-Tensile Steel

LAHT steels shall be more than twice as corrosion resistant to atmospheric exposure as plain carbon steels. 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 ASTM Standard A572, ASTM Standard A588, ASTM Standard A606 - Type 4, ASTM Standard A715 - Grade A or 70 and ASTM Standard A710, Grade A, Class III.

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 Customer upon request and submitted with the vehicle history book as requested.
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 Customer upon request.

18.6.1 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 Customer. 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 Customer of the selected values.

18.7 Steel Castings

Steel castings shall comply, shall be tested, inspected and accepted in accordance with procedures of the applicable AAR standards.

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 E94-04, E446-98(2004)e1 or E186-06, as may be applicable. The radiographic sensitivity shall be at least 2% (2-2T) for sections >3/4 in. thick and (2-4T) for sections ≤3/4". Acceptance levels for the radiographic testing shall be submitted to the Customer for review and approval. The surface quality of the steel castings shall be evaluated in accordance with ASTM Standard A 802/802M-95 (re-approved 2006). 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 Customer.

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 Customer, the Contractor and the subcontractor. This frequency shall be influenced by the critical requirements of the part.

18.7.1 Heat Treating

All steel castings used in the truck structure shall be made of electric furnace or controlled open hearth steel and shall be heat treated.

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.

18.7.2 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 Customer.
18.7.3 **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.

18.7.4 **Axles**

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 pounds per square inch (psi), elongation of 20% in 2 in. minimum, reduction of area at 50% minimum, yield strength of 80 ksi (1000 psi) minimum.

18.7.5 **Wheels**

The wheels shall be heat treated, multiple-wear type, 36-inch diameter, Class ‘B’ curved plate, hub stamped in accordance with AAR Standard M-107/M-208 latest revision, including APTA Standard SS-M-012-99, or approved equivalent for the application.

18.8 **Aluminum**

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 Customer upon request and submitted with the vehicle history book as requested.

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. and a minimum coating weight of 21 milligrams per square inch (mg/sq. in.).

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.

Aluminum used for heat sinks shall be nickel plated to minimize contact corrosion and surface pitting.
18.8.1 Fabrication and Fastening

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.

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.

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.

Wood shall not be placed in contact with aluminum alloy except with written permission from the Customer.

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.

18.8.2 Gauge

Aluminum sheet gauge size shall be in accordance with the American or Browne and Sharp Standard Gauge.

18.9 Elastomers

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 Customer 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.

All resilient mounts shall be of natural rubber. Synthetic rubber compounds may be substituted for natural rubber only when approved for a specific application.
All elastomeric parts are to be marked with the date of manufacture and shall not have aged more than 12 months when assembled into the vehicle.

18.9.1 Tests

All tests shall be conducted according to the latest revisions of the specified ASTM test procedures, unless otherwise specified. All resilient, natural rubber 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.

The durometer hardness shall be suitable for the construction and conditions specified.

The manufacturer shall provide test equipment and test specimens and shall perform, at its expense, the following tests at an independent testing facility:

- ASTM C1166-06: Flame Propagation Test
- ASTM E 662: Smoke Density Test

All materials must pass ASTM C1166-06 with a burn length = 4 in. They must also have a smoke density of \( D_s(1.5) = 100 \) and \( D_s(4.0) = 200 \) 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.

Unless otherwise agreed by the Contractor:

- ASTM D412-06ae2 tensile strength shall be 1500 psi (min.)
- ASTM D412-06ae2 elongation for sheet material shall be 300% (min.)
- ASTM D412-06ae2 elongation for extruded material shall be 275% (min.)
- ASTM D573 loss in tensile strength shall be 15% (max.) when subjected to 168 hours at 158°F.
- ASTM D1149-07 shall have no cracks when subjected at 100 parts per hundred million (pphm) at 104°F for 100 hours and a specimen elongation of 20%.

Unless otherwise agreed by, the gas concentrations shall be defined as follows:

<table>
<thead>
<tr>
<th>Gas</th>
<th>Critical Concentration (*ppm) (max.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>3,500</td>
</tr>
<tr>
<td>CO2</td>
<td>90,000</td>
</tr>
<tr>
<td>NO + NO2 (Nox)</td>
<td>100</td>
</tr>
<tr>
<td>SO2</td>
<td>100</td>
</tr>
<tr>
<td>HCl</td>
<td>500</td>
</tr>
<tr>
<td>HF</td>
<td>100</td>
</tr>
<tr>
<td>HBr</td>
<td>100</td>
</tr>
<tr>
<td>HCN</td>
<td>100</td>
</tr>
</tbody>
</table>

* parts per million (ppm)

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.

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, and a specimen elongation of 20%. The elastomer shall not exhibit any cracks during the test period.

18.9.2 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.

18.9.3 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.

18.9.4 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.

18.9.5 Truck Parts

Truck bumpers and snubbers shall be made of natural rubber or approved equal. They shall be compounded to be resistant to abrasion, oil, grease and acid.

18.9.6 Glazing Strips

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.

Window glazing sections shall be service proven and constructed of high-quality elastomeric compounds containing neoprene subject to approval by the Customer. 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

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.
Glazing used shall meet the following material criteria:

- **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, 49CFR 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. thick. The glazing’s maximum solar energy transmittance shall not exceed 70%.

- **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, 49CFR Part 223, including Appendix A. The glazing shall be clear tint. The glazing shall be 0.560-inch thick. The glazing maximum solar energy transmittance shall not exceed 90%.

- **Side door window glazing** shall be a single-glaze, certified FRA Type II clear laminated safety glass, meeting all applicable requirements of ANSI Z-26.1 and U.S. Code of Federal Regulations 49CFR Part 223, including Appendix A. The glazing shall be clear. The glazing shall be 0.375 inch thick. The glazing’s maximum solar energy transmittance shall not exceed 90%.

- **Cab car control station sliding window assemblies** shall be double-glazed. The outer pane shall be 0.250-inch thick, clear laminated safety glass. The inner pane shall be 0.250-inch thick, clear laminated safety glass. The double-glazed assembly shall have a 0.250-inch 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, 49CFR Part 223, including Appendix A. The double-glazed assembly shall be clear tint. The double-glazed assembly’s maximum solar energy transmittance shall not exceed 85%.

- **Side (non-emergency) window assemblies** (emergency and non-emergency) shall be double-glazed. The outer pane shall be 0.250-inch thick, gray-tinted tempered safety glass unless specified otherwise by the Customer. The inner pane shall be 0.375-inch thick, clear tempered safety glass. The double-glazed assembly shall have a 0.375-inch 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, 49CFR Part 223, including Appendix A. The double-glazed assembly shall be a gray tint unless specified otherwise by the Customer. The double-glazed assembly’s maximum solar energy transmittance shall not exceed 50%. The double-glazed assembly’s visible light transmission shall be 24%. The double-glazed assembly’s maximum solar energy transmittance shall not exceed 50%.

### 18.10.1 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 per linear foot.

### 18.10.2 Dimensional Tolerance

The overall dimensions of any window supplied shall not exceed ± 0.060 in. dimensional deviation.
18.10.3 Overlap Tolerance

The overlap of one laminate of the window with respect to the other at an edge shall not exceed 0.03125 in. Corners and burrs shall be ground smooth and all edges shall be treated in accordance with SAE Z26.1, Section 6.

18.10.4 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.

18.10.5 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.

18.10.6 Specks and Scratches

Occasional specks of foreign material and scratches are permissible, provided such specks do not exceed 0.020 in. in greatest dimension and scratches do not exceed a total of 3 in. in length and neither are within the central three-quarters area of the window. The Customer reserves the right to determine which windows are to be rejected.

The visual inspection criteria for laminated glazing shall be submitted for a Customer approval as part of the glazing design review.

18.10.7 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.

18.10.8 Marking

All safety glass shall be marked with proper identification in accordance with FRA 49CFR Part 223 requirements. The window shall be installed so that the identification marking can be read from the inside lower right hand corner.

Each window shall be marked for identification by the supplier in legible letters 0.125 in. to 0.25 in. 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. 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 49CFR Part 223. The window shall be installed so that the identification can be read from the inside.
18.10.9  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

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.

18.11.1  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:

- Maximum Size - 0.030 in. (0.8 mm) height, 0.80 in.² (5.2 cm²) area with longest dimension of 2 in. (51 mm).
- Maximum Population - 3 blisters in a 12 in. (30.5 cm) by 12 in. (30.5 cm) area, and there shall be only one other blister within 3 ft (0.91 m) of this area.
- Repair Method - using a hypodermic needle, apply just enough Super Bond 420 or Bostik 1685 to bring to a flush surface.

18.11.2  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:

- Maximum Size - 0.030 in. (0.8 mm) height, 0.80 in.² (5.2 cm²) area with longest dimension of 2 in. (51 mm).
- Maximum Population - 3 blisters in a 12 in. (30.5 cm) by 12 in. (30.5 cm) area, and there shall be only one other blister within 3 ft (0.91 m) of this area.
- Repair Method - no repair authorized.
18.11.3 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:

- Maximum Size - 0.030 in. (0.8 mm) height, 0.80 in.² (5.2 cm²) area with longest dimension of 2 in. (51 mm).
- Maximum Population - 3 lumps in a 12 in. (30.5 cm) by 12 in. (30.5 cm) area, and there shall be only one other lump within 3 ft (0.91 m) of this area.
- Repair Method - no repair required.

18.11.4 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.

18.11.5 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:

- Maximum Size - 0.030 in. (0.8 mm) deep at the lowest point, 3 in.² (19.4 cm²) area with the longest dimension of 5 in. (127 mm).
- Maximum Population - one thin area in a 40 in. (1 m) by 40 in. (1 m) area, and there shall not be another thin area within 3 ft (0.91 m) of this area.
- Repair Method - rub with #00 steel wool to blend this area into the normal thickness material and then buff to a normal surface finish.

18.11.6 Color and Marbling Distribution

Tolerances for color and marbling variation shall be submitted to the Customer for approval during preliminary design review. 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

18.12.1 Lumber

Lumber shall be thoroughly air seasoned or kiln dried before using and shall be dressed on all surfaces to full dimensions and treated to meet the testing requirements of 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.

Except where specified, the use of wood in the car shall be limited to specifically approved applications.

Melamine shall be pressure bonded to marine grade plywood using industry approved adhesives. No contact bonding of melamine to plywood is permitted.
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).

Such panels must comply with United States Department of Agriculture Forest Products Laboratory Report No. 1937, *Shear-Fatigue Properties of Various Sandwich Construction*.

### 18.12.2 Plymetal

The term "plymetal" as used in this Specification covers metal-faced plywood and shall conform to the following requirements:

<table>
<thead>
<tr>
<th>Test Conditions</th>
<th>Minimum Metal to Wood Average Shear Value (or 80% Wood Failure)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry shear</td>
<td>250 lbf/in.² (1.7 MPa*)</td>
</tr>
<tr>
<td>Boil shear, 3 hour boil, tested wet at room temperature</td>
<td>150 lbf/in.² (1 MPa)</td>
</tr>
<tr>
<td>Soak shear, 48 hour soak wet at room temperature</td>
<td>150 lbf/in.² (1 MPa)</td>
</tr>
<tr>
<td>Creep or cold flow, under static load for 48 hour, at room temperature</td>
<td>250 lbf/in.² (1.7 MPa)</td>
</tr>
</tbody>
</table>

*Megapascal*

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.

### 18.12.3 Plywood

All plywood shall be manufactured to conform to the requirements of Grade - Structural I of the National Bureau of Standards Voluntary Product Standard (American Plywood Association) PS 1-85, 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.

### 18.12.4 Honeycomb Panels

The term "honeycomb panels" as used in this Specification refers to an assembly of honeycomb material bonded to melamine-faced metal panels or to metal panels. Aluminum honeycomb material shall be commercial-grade meeting the requirements of MIL-C-7438G. Bonding shall be sufficient to develop the full strength of the honeycomb material. Stainless steel honeycomb panels shall be constructed in accordance with the requirements of MIL-A- 9067C. The adhesive bond strength of the honeycomb core to the stainless steel face shall not be less than 15 lbf/in.² (2.68 kg/cm) climbing drum strength when tested in accordance with SAE-AMS-STD-401. The adhesive bond strength of the integral stainless frame to stainless steel face shall not be less than 30 lbf/in.² (13.6 kg/2.5 cm) climbing drum strength when tested in accordance with SAE-AMS-STD-401. Stainless steel honeycomb panels shall be tested in accordance with SAE-AMS-STD-401 to demonstrate the following requirements. Test results shall be subject to Customer review and approval.

- Core shear yield at 200°F (93°C) 250 lbf/in.² [1.72 Megapascal (MPa)]
- Flatwise tension at 200°F (93°C) 250 lbf/in.² (1.72 MPa)
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- Beam flexure at 200°F (93°C) 75,000 lbf/in.² (517.13 MPa)
- Core shear fatigue at R.T. 150 lbf/in.² @ 106 cycles (1.03 MPa)
- Flatwise tension at R.T. 250 lbf/in.² @ 106 cycles (1.72 MPa)
- Beam flexure at R.T. 50,000 lbf/in.² @ 106 cycles (344.75 MPa)

Honeycomb panels meet the relevant flammability and smoke emission requirements. Results shall be subject to Customer review and approval. No other honeycomb materials will be permitted.

18.12.5 Melamine-Faced Aluminum

Melamine-faced aluminum panels shall be constructed by laminating melamine to aluminum sheets as follows: The melamine impregnated papers shall be directly molded to the aluminum sheets at temperatures of no less than 270°F (132°C) and pressure no less than 1000 psi (6.9 MPa). The surface characteristics, after manufacture, shall be no less than that required of type GP (General Purpose) in the NEMA Standards Publication No. LD-3-2005, or latest revision. The melamine and the required binder sheets shall be 0.020 ± 0.005 in. (0.51 ± 0.13 mm) thick. The aluminum sheets shall not be less than 0.025 in. (0.64 mm) in thickness when used as a facing on plywood. The aluminum sheets shall not be less than 0.081 in. (2.1 mm) in thickness when not laminated to a substrate such as plywood. Aluminum sheets shall be properly cleaned by etching, sanding or other approved process to insure full, permanent, acceptable adhesion.

The use of any adhesives to bond the melamine sheets to the aluminum backing will not be acceptable. The bond between the melamine and aluminum sheets shall, as a minimum, meet the following requirements:

<table>
<thead>
<tr>
<th>Test Method</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM D952 Internal Bond</td>
<td>2,600 lbf/in.² (17.9 MPa)</td>
</tr>
<tr>
<td>ASTM D790 Flexural Strength - (S)</td>
<td>with grain: 26,500 lbf/in.² (183 MPa)</td>
</tr>
<tr>
<td>ASTM D790 Modulus of Elasticity - (E)</td>
<td>with grain: 2.8 x 106 lbf/in.² (19.3 GPa)</td>
</tr>
<tr>
<td>ASTM D638-08</td>
<td>Tensile strength with grain: 22,300 lbf/in.² (154 MPa)</td>
</tr>
</tbody>
</table>

18.12.6 Melamine Panels

Unbacked melamine panels may be used in the vehicle interior. The panels shall be a minimum of 0.125 ± 0.005 in. (3.2 ± 0.1 mm) thick. The surface characteristics shall be no less than that required of type GP (General Purpose) in the NEMA Standards Publication No. LD-3-2005, 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.

18.12.7 Phenolic Composite Floor Panels

Phenolic composite floor panels shall be designed to withstand the following physical requirements with no visible or audible indications of delamination of the panel skin from the core and permanent deformation of the top surface shall be less than 0.010 in. (0.25 mm) unless otherwise specified. There shall be no puncture or damage to fibers of the top surface. There shall be no separation of any internal core from the top or bottom skin. There shall be no fracture of the balsa core.
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- Indentation Resistance – The floor panel shall withstand a concentrated load of 300 lbs (136 kg) applied to a test dowel that has an overall 0.375-sq in.\(^2\) (242 sq mm\(^2\)) surface area, with a 0.0625-in. (1.6 mm) radius on bottom edge of test dowel.

- Static Load Test - Average Loading – A representative sample section of the flooring (without rubber floor covering attached) shall be supported on beams spaced at the maximum spacing used on the car using production bonding and fastening techniques. A uniformly distributed load in accordance with 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. (2.2 mm) deflection.

- Static Load Test – Maximum Loading – Using the identical floor panel-mounting configuration as described above, a uniformly distributed load of 200 lb/ft\(^2\) (976 kg/m\(^2\)) shall be applied to both sides of the joint (butt or shiplap).

- Small Area Static Load Test – Using the identical floor panel mounting configuration as described above, a 300 lb (136 kg) load shall be applied to a 1.0 in. (25.4 mm) by 3.0 in (76 mm) contact area directly over the midspan, 6 in. (152 mm) from the outer car body sidewall edge. The footprint shall be machined flat within 0.010 in. (0.24 mm) and the edges shall have a radius of not more than 0.125 in. (3.17 mm). There shall be less than 0.200 in. (5.08 mm) deflection as a result of the load applied.

- Small Object Impact Test - Using the identical floor panel mounting configuration as described above, a 16 lb (7.26 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. (1500 mm). Permanent deformation of the top surface shall be less than 0.0625 in. (1.587 mm).

- Large Object Impact Test - Using the identical floor panel mounting configuration as described above, a 150 lb (68 kg) load shall be dropped upon a 3.0 in. (76 mm) by 8.0 in. (200 mm) contact “footprint” pad located directly over the midspan, 24 in. (610 mm) from the edge of the panel and dropped from a height of 12 in. (305 mm). The “footprint” pad shall have a rubber pad on the downside surface with a Shore D 70 minimum, at a 1.00 in. (25.4 mm) thickness machined flat within 0.060 in. (1.524 mm) with edges having a radius of not more than 0.030 in. (0.762 mm). Permanent deformation of the top surface shall be less than 0.030 in. (0.762 mm). Some damage to the top phenolic composite skin will be allowed.

- Rolling Load Test - Using the identical floor panel mounting configuration as described above, a fourwheeled cart with a load of 200 lbs (91 kg) per wheel shall be rolled on the panels laterally, longitudinally and in a circular path 24 in. (610 mm) radius. The wheels shall be 3 in. (75 mm) in diameter, 1 in. (25.4 mm) wide with a 0.125 in. (3 mm) radius on each edge with a Shore A durometer of 80.

- Flammability and Smoke Emission Tests – Floor panels meet the relevant flammability and smoke emission requirements.

18.13 Seat Cushion and Fabric

18.13.1 Cushion Material

The bottom seat cushion shall be molded polyurethane foam. It shall meet Amtrak Specification 967. Indentation Force Deflection (IFD) measured at 25% compression of 50 ± 5 lbs, 3.5 +/-0.4 lbs/cubic ft. density with a support factor of 2.1 min.

The back cushion shall be molded polyurethane foam meeting Amtrak Specification 967.
Materials and Workmanship

IFD measured at 25% compression of 33 ± 3 lbs, 3.1 ± 0.3 lbs/cubic ft. density with a support factor of 2.1 min.

18.13.2 Seat Fabric

18.13.2.1 Primary Fabric

<table>
<thead>
<tr>
<th>Content</th>
<th>90% Wool/10% Nylon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>15.0 oz/sy (+/- 10%)</td>
</tr>
<tr>
<td>Backing Material</td>
<td>GoreTex</td>
</tr>
<tr>
<td>Width</td>
<td>54 in.</td>
</tr>
<tr>
<td>Ends per Inch</td>
<td>88.8</td>
</tr>
<tr>
<td>Picks per Inch</td>
<td>55.0</td>
</tr>
</tbody>
</table>

18.13.2.2 Companion Fabric

<table>
<thead>
<tr>
<th>Content</th>
<th>90% Wool/10% Nylon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>16.4 oz/sy (+/- 10%)</td>
</tr>
<tr>
<td>Width</td>
<td>54 in.</td>
</tr>
<tr>
<td>Ends per Inch</td>
<td>88.8</td>
</tr>
<tr>
<td>Picks per Inch</td>
<td>55.0</td>
</tr>
</tbody>
</table>

18.13.2.3 Armrest Material

<table>
<thead>
<tr>
<th>Supplier</th>
<th>Uniroyal Engineered Products, or approved equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content</td>
<td>100% Naugahyde</td>
</tr>
</tbody>
</table>

18.14 Carpet and Wainscot

18.14.1 Carpet

The carpet shall be tufted, 100% solution dyed nylon with a gauge of 1/10, 11 SPI, a minimum of 34 oz/yd², and a pile thickness of 0.250 in. maximum. The primary backing shall consist of woven polypropylene. The carpet will have a stain resistant chemical applied.

The carpet will have a secondary, moisture resistant backing applied that will not delaminate. The thickness shall be nominally 0.09375 in. with a density of 18 lb/ft³, and a weight of 30 oz/yd². The compression resistance shall be 5 lb/in.

18.14.2 Wainscot Fabric

<table>
<thead>
<tr>
<th>End per Inch</th>
<th>45.4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Picks per Inch</td>
<td>32.0</td>
</tr>
<tr>
<td>Weight</td>
<td>24.0 oz/sy (+/- 10%)</td>
</tr>
</tbody>
</table>

18.14.3 Counter Surfaces

All counter surfaces shall be made from Customer approved materials. All countertop material shall be made from FDA and NSF approved non-porous material.
18.14.4 Decorative Countertops

Decorative countertops shall be made from 100% acrylic based material. The material shall be not less than 0.5 in. thick, solid, non-porous and fully sealed. Material shall naturally resist damage from heat, mold, mildew and stains. Material shall be assembled with non-porous, waterproof seams.

18.14.5 Stainless Steel Countertops

All stainless steel countertops shall be made from type 304 stainless steel with a thickness of at least 14 gauge. Stainless steel countertops shall have a brushed satin finish. All seams shall be finished to match the counters brushed satin finish. Counters shall be built in a manner that doesn’t flex, deform, rattle or “oil can”.

18.15 Welding and Brazing

18.15.1 Responsibility

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.


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 Customer’s approval. Requirements and recommendations of the AWS for new bridges shall have precedence over those for new buildings.
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 Customer 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.

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.

18.15.2 Test Welds

The Customer 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 Customer 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.

Weld heat-affected zones (HAZ) and weld metal shall be limited to maximum allowable stress values in ASME Section VIII, Table UHA-23, for UNS S20100 stainless steel and Table UW-12 rating of welds.

Fatigue allowable stresses shall not exceed the lesser of fatigue limits in AWS Standard D1.1, Section 2.20.6, or 50% of the joint strength level calculated from ASME maximum allowable stress values. Higher values shall only be used if qualified by Contractor tests.

18.15.3 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.

18.15.4 Support

All parts which shall be joined by welding shall be adequately supported during welding by tables, jigs or fixtures.

18.15.5 Welding Rod

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 and the specification, diameter, and net weight of the material.
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.

The ferrite number for austenitic stainless steel welds shall be between WRC4 and WRC10, or as proposed by the Contractor and approved by the Customer.

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.

18.15.6 *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.

18.15.7 *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 0.030 in., whichever is less.

18.15.8 *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.

18.15.9 *Intermittent Weld Spacing*

Intermittent fusion-weld spacing pitch shall not exceed 5 in. for 2-in. (minimum) weld lengths, such that a minimum weld length of 40% of the overall joint length is achieved.

18.15.10 *Fusion Welding*

Manual fusion welding by the gas process may only be used on sheets more than 0.09375 in. in thickness. Any other application of this process must be approved by the Customer.

18.15.11 *Resistance Welding*

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.
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:

- Operator
- Material, material thickness, or combination of thicknesses
- Electrodes
- Settings

Spacing of resistance and spot welds shall be appropriate to the design. Spacing shall not exceed 2 in. 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.

Surface indentation shall not exceed 20% of material thickness (t) or 0.01 in., 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., 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 Special Welding**

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.

Austenitic stainless steel electrodes or wire shall be used to join carbon or HSLA steels to stainless steels.

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*.

Standards that may apply to selected processes include:

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.

**18.15.13 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 of absorbed energy at the lowest specified operating temperature. The Customer shall have the right to require impact tests to verify the specified toughness.

**18.15.14 Torch Brazing**


**18.15.15 Torch Soldering**


**18.16 Exterior Marking Films and Graphics**

Graphics shall be transportation grade materials, printed on opaque background with clear, vandal resistant overlayment. All graphics materials are to be approved by Customer. Application techniques shall be in accordance with manufacturer’s recommendations.

**18.16.1 Physical Properties**

- Shall be able to withstand long-term exposure to all environmental and operating conditions specified in Amtrak Specification 963.
- Lettering film shall be sufficiently opaque so that, when applied, films shall completely hide any contrasting background and shall be readily legible.
- There shall be an initial 60-degree gloss value of 40 when tested in accordance with ASTM Standard D523-08.
- Films shall retain adhesive properties after one week of continuous exposure to a temperature of 66°C (150°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.
- Overall thickness of processed film shall be between 0.10 mm and 0.20 mm (0.004 and 0.008 in.).
• Films shall withstand immersion in either distilled water or SAE No. 20 motor oil for 24 hours at temperatures from 21°C to 32°C (70°F to 90°F) without any appreciable degradation in adhesion, color or general appearance.

• Marking films shall withstand effects of detergents and brushes used in washing procedures for removal of graffiti.

• Films shall use a removable grade adhesive that upon removal does not require use of solvents or secondary operations.

• Square or rectangular graphics shall have rounded corners of suitable radius.

18.17 Paints and Coatings

18.17.1 Materials and General Requirements

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.

The surface preparation, primer, paint and graphics applications shall ensure that the car can operate at least eight years between major exterior finish repairs or replacement.

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.

18.17.2 Paint Process Documentation

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, paint type and manufacturers, recommended thickness, and other pertinent information shall also be included. This document shall be included in the maintenance manuals. It shall meet Amtrak Specifications 353 and 354.

18.17.3 Painting Restrictions

Any equipment or parts of equipment which would be damaged or suffer impaired operation from painting shall not be painted and shall be corrosion resistant.

The following items shall not be painted:

- Copper tubing, piping, and fittings
- Wire and cable
- Heat transfer surfaces
- Elastomeric portions of air and refrigerant lines
- Grounding pads and straps
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- Wheels
- Axles
- Brake rotors
- Brake shoes and pads
- Air hoses
- Pedestal liners
- Elastomeric parts
- Grease fittings
- Linkages
- Threaded parts used for adjustments
- Electrical equipment
- Couplers
- Wearing surfaces
- Corrosion Protection

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.

All exposed surfaces shall be suitably finished to prevent corrosion during storage and operation, in accordance with the following requirements:

- 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, suitable sealed, may be used where applicable to protect underframe sections.

- 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.

- 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.

- Any corrosion protection removed for welding shall be replaced after welding is completed.

- Where arc welding is performed on joints between stainless steel and other materials.

18.18 Insulation

18.18.1 Acoustical Insulation

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).
Korfund Vibrodamper Compound, Aquaplas DL-10-HV or Customer 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.

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 it provides 10% of critical damping for the treated surface.

18.18.2 Thermal Insulation

The roof, sides, under floor, and ends of the vehicles, including the inside faces of posts and structural members shall be fully insulated.

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.

18.18.2.1 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.

18.18.2.2 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.

18.18.2.3 Materials

The following materials are acceptable for use on the vehicle:

- Rigid insulation
- Glass fiber preformed board
- Non-rigid Insulation
- Spun glass fiber in flexible rolls or mineral wool batts
18.18.2.4 Insulation Performance

Insulation materials shall be certified to conform to the following requirements:

<table>
<thead>
<tr>
<th>Property</th>
<th>ASTM Test Method</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass Fiber Board</td>
<td>E162 E662</td>
<td>Flame spread 25 max Ds(4.0) – 100 max</td>
</tr>
<tr>
<td>Non-rigid Insulation</td>
<td>E162 E662</td>
<td>Flame spread 25 max Ds(4.0) – 100 max</td>
</tr>
<tr>
<td>Spray-on Insulation</td>
<td>E162 E662</td>
<td>Flame spread 25 max Ds(4.0) – 100 max</td>
</tr>
<tr>
<td>Vapor Barrier</td>
<td>C353 Water Method</td>
<td>2.5 perm at 90°F [32°C] and 50% relative humidity</td>
</tr>
</tbody>
</table>

**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.

The thermal conductivity of insulation materials shall be certified when tested in accordance with ASTM C177-04 at 75°F [24°C] mean temperature.

Insulation separated by a vapor barrier shall be used under the floor. The underfloor insulation shall be protected by stainless steel sheathing, which shall seal the underside of the vehicle against water, dust and debris.

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

The vehicle and its components shall comply with the requirements of 49CFR Section 238.103, Appendix B and APTA Recommended Practice RP-PS-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. For high risk materials, 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 Customer for approval. For low risk materials, test data from these reports that are dated between five and 10 years old shall be accompanied by a letter from the manufacturer stating that the materials included in the test report are identical to the actual materials used in the construction of the vehicles. Materials deemed as low risk shall be approved by the Customer.

There are instances where the Specification calls for use of specific materials, such as Lexan, when it is known that they do not meet all requirements of this section. It is predetermined that use of materials defined by this Specification is acceptable.

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.
Materials and Workmanship

Maximum limits for smoke emission shall be determined using the smoke propagation mode which generates the most smoke.

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 Customer may, at its discretion, require that the current batch of material being provided for this Contract be retested for conformance with these standards.

18.19.1 Electrical Fire Safety

Electrical equipment shall conform to NFPA Standard 130, Section 4-3, except where more restrictive requirements are imposed by this Specification.

18.19.2 Combustible Content

The design of the vehicle shall minimize the total combustible material content of the vehicle.

18.19.3 Toxicity

Those materials and products generally recognized to have highly toxic products of combustion shall not be used.

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. Materials shall meet the following maximum toxic gas release limits (ppm) as determined per BSS-7239.

<table>
<thead>
<tr>
<th>Material</th>
<th>Limit (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Monoxide (CO)</td>
<td>3500 ppm</td>
</tr>
<tr>
<td>Hydrogen Fluoride (HF)</td>
<td>200 ppm</td>
</tr>
<tr>
<td>Nitrogen Dioxide (NO₂)</td>
<td>100 ppm</td>
</tr>
<tr>
<td>Hydrogen Chloride (HCL)</td>
<td>500 ppm</td>
</tr>
<tr>
<td>Hydrogen Cyanide (HCN)</td>
<td>150 ppm</td>
</tr>
<tr>
<td>Sulfur Dioxide (SO₂)</td>
<td>100 ppm</td>
</tr>
</tbody>
</table>

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

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.
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.

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.

### 18.20.1 Air Brake Piping and Fittings

Air brake tubing and piping shall be of good commercial quality, free of burrs and scale.

Car body air line0.5 in. 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. Fittings for stainless steel pipe shall be approved by the Customer.

All air piping on trucks and car body air lines larger than 0.5 in. 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.

Hoses shall be allowed where relative motions are expected such as coupler to carbody, truck to carbody, between truck components, vibrating equipment to its mounting base, and other applications as approved by the Customer.

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.

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.

### 18.20.2 Air Conditioning and Refrigeration System Piping and Fittings

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.

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.

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 a Customer-approved procedure.

The discharge of condensate drains lines shall be directly to the roadbed avoiding car structure, electrical cables and other undercar equipment.

18.20.3 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.

18.20.4 Water Piping and Fittings

Water piping shall be seamless copper tubing in accordance with ASTM Standard B75-02 and sized for the service intended. Piping shall be joined using silver solder. Piping shall be clamped with necessary sound insulation to prevent rattle and be sloped to allow drainage.

Fittings shall be sweat type wrought copper or cast brass in accordance with ANSI Standards B16.22 and B16.18 or “Swage-lok” compression type.

Piping shall be joined using silver solder conforming to AWS Bag-2 for cast brass fittings and to AWS BCup-3 brazing filler metal for wrought copper fittings. The use of solder with lead content is strictly forbidden. The exterior of brazed joints shall be wiped clean after brazing. Flux shall be cleaned from the piping interior of brazed joints.

After installation, the complete water system shall be sanitized. The sanitizing procedure shall be approved by the Customer.

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. This shall be demonstrated during the climate room testing described in Chapter 19. To insure 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 Amtrak Specification 696.

Drains from the water system shall be routed to discharge directly onto the ground, avoiding car structure, electrical cables and all other undercar equipment.

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.
18.20.5 Sewage Piping and Fittings

18.20.5.1 Non-metallic Sewage Pipes and Fittings

A non-metallic 2 in. diameter waste line shall be provided, conforming to Amtrak Specification 759.

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. 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

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 Amtrak Specification 963, be resistant to acids, alkalies and cleaning solutions used by the Customer.

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.

FRP parts shall have a greater thickness at attachment points and edges. Exposed sharp edges will not be allowed on any parts.

18.21.1 Resin

The resin shall be of high-quality, commercial grade, thermosetting, polyester, phenolic or vinylester material selected to meet the requirements of the Contractor and manufacturer molding process requirements.

18.21.2 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.

18.21.3 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. 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 Customer. 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.

18.21.4 Additives

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.

Mineral filler shall not exceed 28% of finished weight for any preformed matched die molding process.

18.21.5 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.

<table>
<thead>
<tr>
<th>Mechanical Property</th>
<th>ASTM Test</th>
<th>Open Moldings</th>
<th>Matched Die Molding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Strength</td>
<td>D638-08</td>
<td>10,000 lbf/in.(^2)</td>
<td>12,000 lbf/in.(^2)</td>
</tr>
<tr>
<td>Compressive Strength</td>
<td>D 695</td>
<td>18,000 lbf/in.(^2)</td>
<td>22,000 lbf/in.(^2)</td>
</tr>
<tr>
<td>Flexural Strength</td>
<td>D790</td>
<td>15,000 lbf/in.(^2)</td>
<td>22,000 lbf/in.(^2)</td>
</tr>
<tr>
<td>Impact Strength</td>
<td>D 256</td>
<td>6 ft lb per in. of notch</td>
<td>8 ft lb per in. of notch</td>
</tr>
<tr>
<td>Hardness</td>
<td>--</td>
<td>45 Barcol</td>
<td>45 Barcol</td>
</tr>
</tbody>
</table>

18.22 Thermoplastic Sheet

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 Customer cleaning solutions. Thermoplastic sheet shall be used as extruded or vacuum-formed.

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.

18.22.1 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 0.010 in., and the population of these defects is greater than one defect in four square feet.
18.22.2 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.

<table>
<thead>
<tr>
<th>Mechanical Properties</th>
<th>ASTM Method</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Gravity</td>
<td>D 792</td>
<td>1.20 to 1.45</td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>D638-08</td>
<td>5,500 lbf/in.² minimum</td>
</tr>
<tr>
<td>Flexural Strength</td>
<td>D790</td>
<td>8,000 lbf/in.² minimum</td>
</tr>
<tr>
<td>Flexural Modulus</td>
<td>D790</td>
<td>3.3 x 10⁵ lbf/in.²</td>
</tr>
<tr>
<td>Hardness Rockwell</td>
<td>D 785</td>
<td>90 to 110 (‘R’ Scale)</td>
</tr>
<tr>
<td>Heat Deflection (annealed)</td>
<td>D 648 @ 264 lbf/in.²</td>
<td>160ºF minimum</td>
</tr>
<tr>
<td>Impact Strength (Fabricated Parts)</td>
<td>D 3029 Gardener Dart Drop 0.5” dia. ball at 73°F</td>
<td>160 in. lb minimum</td>
</tr>
</tbody>
</table>

18.23 Air Filters

18.23.1 HVAC and Equipment Ventilation Filters

HVAC system air filters shall conform to Amtrak Specification 685 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.

18.23.2 High Pressure Air Filters

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 Standard SS-M-011-99. 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:

- Each air brake control assembly
- Waste system
- Door operators (if pneumatic)
- Horn
- Low pressure air filters
Replaceable media type filters shall use resin-bound, spun-glass fiber materials having an uncompressed thickness not less than 3.5 in. 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 150ºF. The filter medium shall be cut not less than 0.5 in. oversize to ensure adequate sealing between the edge of pad and its integral frame.

18.24  Wire and Cable

All wire and cable used shall exhibit the physical and electrical properties for 110ºC rated wire and cable specified in Amtrak Specification 323. High temperature wire, used for heater circuits, shall be as defined as Amtrak Specification 323.

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 Recommended Practice RP-E-009-98 and applicable AAR, ICEA, ASTM or MIL Specifications. The Contractor shall submit to the Customer 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.

In no case shall wire smaller than the following sizes be used:

- Wire on electronic units, cards, and card racks - No. 22
- Wire in control compartment – No. 16, No. 18 with Customer approval
- Wires pulled through conduits and/or wireless – No. 12, No. 14 with Customer approval
- All other wire - No. 12, No. 16 with Customer approval

18.24.1  Wiring - General

All vehicle wiring shall be in conformance with APTA Recommended Practice RP-E-002-98 and RP-E-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.

18.24.2  Data Communications Wiring

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 vendor specified connectors that are suitable for use in industrial communication equipment (RJ45, M12 or similar.). The cable shall have the following characteristics:

18.24.2.1 Construction
- Conductors: Stranded silver-plated copper #22AWG (or .5mm2)
- Insulation: Radiation cross-linked data grade polyolefin 300V
- Component configuration: Wires are twisted or helically cabled to insure electrical performance to Cat 5e standards (see table) – 100Z characteristic impedance on finished cable
- Shielding: Foil and TC braid designed to meet 200MZ/m transfer impedance
- Binders/tapes: As required to enhance integrity
- Jacket: Radiation cross-linked polyolefin (low-smoke, complying with toxicity requirements) 0.8 mm minimum at thinnest point.

18.24.2.2 Electrical Requirements
- Impedance: 100Z+/−5Z
- Shielding effectiveness (30 Mhz- 100 Mhz): 40dB
- Voltage rating: 300V

<table>
<thead>
<tr>
<th>Frequency (Mhz)</th>
<th>Attenuation (dB/100m)</th>
<th>Next (dB) Pr/Pr</th>
<th>Return loss (dB)</th>
<th>Attenuation Unbalance Near End (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Typical</td>
<td>Max</td>
<td>Typical</td>
<td>Min</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3.2</td>
<td>80</td>
<td>65.3</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>6</td>
<td>76</td>
<td>56.3</td>
</tr>
<tr>
<td>10</td>
<td>6.5</td>
<td>9.5</td>
<td>67</td>
<td>50</td>
</tr>
<tr>
<td>31.5</td>
<td>10.5</td>
<td>17.1</td>
<td>60</td>
<td>42.9</td>
</tr>
<tr>
<td>62.5</td>
<td>14</td>
<td>24.8</td>
<td>56</td>
<td>38.4</td>
</tr>
<tr>
<td>100</td>
<td>18</td>
<td>32</td>
<td>53</td>
<td>35.3</td>
</tr>
</tbody>
</table>

18.24.2.3 Environmental Requirements
- Cable jacket will withstand the following tests per AAR RP 585
- Tensile and Elongation Section 5.1 and 5.2
- Oil Resistance 5.3 and 5.4
- Thermal Shock 5.8.4
- Penetration 5.9.4
- Abrasion 5.9.8.2
Materials and Workmanship

- Corrosion resistance ASTM D2671-00(2007)e1
- Temperature -40°C- 90°C

18.24.2.4 Mechanical Requirements

- Bending radius: 6x OD (fixed)
- 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.

18.24.2.5 Smoke and Flame

- NFPA 130 (UL1685) or equal i.e. UL 1581 (tray) or IEEE 383 1974
- Amtrak Specification 352, *Smoke Flame and Toxicity*

18.24.3 Wire Handling

All wiring shall be performed by qualified, experienced wiring personnel using appropriate tools for stripping insulation, cutting, tinning, soldering, harness making, attaching terminals and other wire fabrication tasks. All wiring tools and equipment shall be used as recommended by the tool and equipment manufacturer.

Wire shall be protected from damage during all phases of equipment manufacture. Wire shall not be walked on, dragged across sharp or abrasive objects, kinked or twisted, or otherwise mishandled. The ends of wire shall not be permitted to lay on wet floors or other damp areas where moisture may be absorbed into the conductors.

When removing insulation, wire strands shall not be nicked or broken in excess of the requirements of FAA Specification No. AC 43.13-1A, Section 449, *Stripping Insulation*. Additionally, the following criteria apply:

<table>
<thead>
<tr>
<th>Wire Size</th>
<th>Maximum Number of Nicked Strands*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wires smaller than No. 10</td>
<td>None</td>
</tr>
<tr>
<td>No. 10 through 1/0</td>
<td>7.4 percent</td>
</tr>
<tr>
<td>Above 1/0 through 1600/24</td>
<td>4.4 percent</td>
</tr>
<tr>
<td>Above 1600/24</td>
<td>graduated scale</td>
</tr>
</tbody>
</table>

*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.

18.24.4 Wire Harness

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.
Alternative methods for fabricating and installing wiring, which are standard carbuilder practice, will be submitted for consideration at the appropriate design review.

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.

### 18.24.5 Circuit Separation

Circuits shall be physically separated to reduce the possibility of unsafe conditions, electrical interference or equipment damage.

The following major circuit groups shall not be harnessed or bundled together, shall not run in the same conduit, and shall be physically separated and secured in enclosures, wire ducts, junction boxes, or other wire routing devices:

- 480Vac HEP trainline
- 27 point communications trainline
- 27 point MU trainline
- IITS/Cab Signal circuits
- AC power circuits
- DC control circuits
- Communication circuits
- Unprotected wiring (eg, battery or HEP trainline to circuit breaker)
- Data communications (Ethernet) wiring even though it might be in the same car to car 27 point communications trainline jumper

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 Customer approved otherwise.

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.

### 18.24.6 Wire and Cable Runs

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.
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.

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.

Conduit shall be attached to the carbody employing clamps; welding shall not be used under any circumstances.

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.

Wiring run in loom shall not be carried over a potential chafing hazard.

Wires entering any removable box shall be harnessed and secured to facilitate removal of the box.

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.

### 18.24.7 Undercar

The 480Vac trainline conductors shall be cleated in place; No. 6 AWG and larger may be cleated in place or run in rigid conduit.

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.

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.

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 length, completing the run.

Flexible conduit shall not be used for any application on the exterior or underside of the car without Customer approval.

Open undercar wiring shall be protected over the trucks by running the wiring through RGS conduit, with suitable protective bushings applied at the ends.

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.
18.24.8 Exterior of Roof

All wiring to roof-mounted equipment shall be run in electrical metallic tubing steel or rigid galvanized steel conduits within the carshell.

Wires or cables exposed or in conduit shall not pass over or near heat generating equipment.

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.

18.24.9 Interior

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. above the floor level to ensure water cannot enter the conduit from above, such as from a wet floor.

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., of flexible conduit may be employed to make final connections to equipment.

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 Amtrak Specification 352. All flexible non metal conduits shall be installed in protected areas only, unless specifically approved by the Customer. In wire ducts, wire shall be secured within and including each entrance and exit point, to prevent chafing movement.

18.24.10 Cable Cleating and Support

Open-run cable shall be supported by using split-block cleats of molded neoprene rubber, spaced no more than 4 feet apart. Slack shall be allowed in the cable to accommodate both thermal expansion and contraction of cable.

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.

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.

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.
18.24.11 Wire Securement and Termination

All wiring shall be secured and protected against movement, chafing, and any contact with conductive, sharp, or abrasive objects including the inside surfaces of wire runs.

No wiring shall be secured directly to the 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.

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.

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.

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:

<table>
<thead>
<tr>
<th>Wire Size</th>
<th>Number of Terminations</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 10 AWG and smaller</td>
<td>Three re-terminations</td>
</tr>
<tr>
<td>No. 8 AWG and large</td>
<td>Two re-terminations</td>
</tr>
</tbody>
</table>

A drip loop shall be provided on all exposed wires and cables to prevent fluid runoff into connected equipment.

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.

Wire tying devices shall not be used:

- For any external undercar application
- To support wire under its own weight
- To support/secure any type of conduit

All wire bundles and cables within an enclosure shall be supported by the use of tape rails, shall be spaced away from the equipment box structure, metal edges, bolt heads and other interference points and shall have electrical clearance from the covers, regardless of the insulation properties of covers. Wire bundles shall be located above or alongside the apparatus rather than at the bottom of the box wherever possible. In all cases, wire shall be a minimum of 1 inch above the bottom of the box. Wire entry into control or junction boxes shall not be permitted through the bottom of the box.
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.

All jumpers, jumper heads and jumper receptacles shall be sealed in an approved manner to prevent the entry of water at any operational speed.

Any wiring needed to calibrate and test vehicle functions shall be a part of the permanent vehicle wiring to enable the Customer to conveniently maintain the equipment. This wiring shall terminate in approved connectors in the respective control groups and cabinets.

The Customer requires wiring and cabling to be accessible for repairs; the Contractor shall submit a complete wiring plan for evaluation at the appropriate design reviews.

18.24.12 Marking

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 Customer in design review.

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.

18.24.13 Cable and Wire Identification

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.

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 Customer equipment. This naming system will be employed on the following:

- Electrical Arrangement Drawings
- Electrical Schematics
- Wiring Diagrams
- Labels on hardware
- Car Electrical Panels, etc.
- Device names: circuit breakers, indicators lights, switches, relays, contactors, pressure switches, etc.
- Car Wiring
• The above categories on drawings provided by different vendors (for example, air brake schematic and electrical schematics)

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 hardware.

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.

It shall be the Contractor's responsibility to ensure that:

• All equipment suppliers conform to this Specification;
• A consistent numbering system is used throughout the vehicles; and
• Component device and wire names are not duplicated.

At a minimum, the following major electrical system components shall be identified:

• Electrical panels
• Contactors and motor starters
• Relays and timers
• Switches and circuit breakers
• Electronic components
• Terminal blocks
• Connectors
• Each wire
• All labels shall be permanent and expected to be legible for the life of the vehicle.
• 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.

• 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.

• 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.

18.24.14 Pulling Compound

Pulling compound shall be non-conductive, non-hygroscopic, non-odorous, and shall not attract vermin.
18.24.15 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.

18.24.16 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

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.

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.

Conduit shall be attached to the carbody employing clamps; welding shall not be used under any circumstances.

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.

Wiring run in loom shall not be carried over a potential chafing hazard.

Wires entering any removable box shall be harnessed and secured to facilitate removal of the box.

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.

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.

18.25.1 Terminal Boards and Terminal Points

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.

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 35mm wide DIN-rail in 7.5mm, 15mm and 58mm 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 metal body shall contain a high strength spring steel spring element that will provide a gas-tight connection with the conductor.

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 3mm slot size screw driver.

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.

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.

Jumpers between terminal board points shall be brass or plated steel. Wire jumpers between adjacent terminals of terminal boards will not be permitted.

Terminal blocks located outside the carbody or operating at 480V or above will employ closed bottom blocks.

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. CDRL

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.

**18.25.2 Wire Terminations**

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.

All wire terminations shall be accessible to remove or replace. Wire terminations shall not be covered by other wires.
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.

Spade and hook-type terminals shall not be used. Corrosive protection shall be provided for all base materials.

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.

18.25.3 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.

18.25.4 Cable Connectors

All cable connectors shall conform to MIL-C-5015, or an equivalent standard as approved by the Customer. 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 0.000030 in. of gold over a minimum of 0.000050 in. of low stress nickel. For high current applications, the connector contact area shall be plated with a minimum of 0.00010 in. 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.

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.

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.

Plastic bodied connectors shall not be used.
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.

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.

18.25.5 Quick-Disconnect Terminals

Only Customer-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 Customer for that unique application.

18.25.6 Grounding/ Bonding Connections

Grounding and bonding shall be done in accordance with APTA Standard SS-E-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.

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.

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.

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.

18.25.7 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

18.26.1 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.

18.26.2 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. without bends of more than 15° is used between enclosures, a maximum fill of 60% will be permitted.

18.26.3 Installation

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.

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.

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.

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.

18.26.4 Conduit Fittings and Junction Boxes

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. All conduit fittings and junction boxes shall be provided with gasketed covers.

18.26.4.1 Boxes

All exterior junction boxes shall be fabricated of steel with a minimum wall thickness of 14 gauge. 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. 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.

18.26.4.2 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.

18.26.4.3 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.

18.26.4.4 Wireways

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.

All wireways shall be “Panduit”, meeting Amtrak Specification 352, 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.

Wireways shall be located to provide access to the harnesses contained within for maintenance action.

Bends in wireways shall be avoided; however, if they are required, approved protection shall be provided to avoid insulation chafing at the bends.

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.

All wire and cable shall be securely fastened within wireways to eliminate movement and resultant chafing.

18.27 Electrical and Electronic Designs

18.27.1 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.

### 18.27.2 Ability to Repair

All electrical devices including such items as PC boards, relays, contactors, and filters shall be capable of being repaired by the Customer in its electronics laboratory. It is recognized that some equipment, due to its complexity, cannot be economically repaired by the Customer. In preliminary design reviews, the Builder shall identify all situations where this could be the case, for ruling by the Customer, whose decision shall be final.

Units shall not be sealed, potted or constructed to prohibit repair by the Customer. Units that must be potted or sealed by design other than Lowest Level Replaceable Units (LLRUs) shall have a minimum 10-year warranty.

### 18.27.3 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.

### 18.27.4 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.

### 18.27.5 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

All electrical devices shall be service-proven. Electrical connections shall use either captive screws or captive nuts, with crimp terminals.

#### 18.28.1 Contactors and Relays

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 Amtrak Specification 528, section 4.3- 4.5.
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 Amtrak Specification 528, section 4.3-4.5.

All contactor and relay coils shall be suppressed with a solid state device to prevent transients being generated onto the low-voltage network.

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.

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.

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.

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.

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.

Bifurcated contacts shall be used in low voltage applications whenever necessary due to dry contacts or low current switching requirements.

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.

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.

18.28.2 Switches

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 Customer. All switches provided shall be of high quality and shall be fully suitable for the rigors of the Customer’s service environment, including cycle life. The design and selection of all switches shall be subject to review and approval.

Switches shall be provided with a "keying" feature such that after installation, the body of the switch will be constrained from mechanical rotation.
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.

There shall be a maximum of two wires connected to each terminal of the device.

Switches shall be individually replaceable without disconnecting or removing anything other than the mounting fasteners and electrical connections of the switch to be replaced.

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.

## 18.28.3 Circuit Breakers

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 Customer's material control system shall be subject to review and approval.

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.

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.

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.

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.

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.

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.

Each circuit breaker pole shall be equipped with adequate means of arc extinction to prevent flashover.

Circuit breakers shall not be intended for use as on/off switches. All circuits requiring on/off switches shall be so equipped.
18.28.4 Fuses

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:

- To protect solid-state equipment from catastrophic damage.
- Where current or voltage levels prohibit circuit breakers.

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.

Fuses shall be readily accessible. All fuses mounted in exterior equipment boxes shall be accessible without going under the vehicle.

Fuse holders shall contain fuse retention devices at both ends.

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.

The use of current limit-type fuses is prohibited.

18.28.5 Bus Bars

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.

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 30°C. Current densities in joints shall not exceed 150 amperes per square inch.

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 200psi. Bolting hardware shall be plated steel with Belleville washers to maintain connection pressure.

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.

18.28.6 Capacitors and Resistors

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.

Commutating capacitors shall be a paper or plastic film type, shall incorporate a non-toxic impregnant, 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.

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 85°C.

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.

Use of trim potentiometers or adjustable resistors shall not be permitted without Customer approval. Generally, the need for adjustments shall be avoided by use of the appropriate circuitry, and stable precision components.

18.28.7 Transformers and Inductors

Transformers and inductors shall be rated at 20% over the maximum specified current level.

18.28.8 Switch, Circuit Breaker and Fuse Panels

All switch, circuit breaker and fuse panels shall conform to Amtrak Specification 498, with dead front, mounted in the specified equipment enclosures and switch/ electric lockers.

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.

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 controls 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.

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.

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.
18.28.9 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 Customer.

18.29 Semiconductor Standards

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.

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.

18.29.1 Rating

Discrete semi-conductors shall have the following minimum voltage breakdown rating, dependent on the use:

- 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.

- 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.

- 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.

- 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.

Semiconductors shall be placed in a clean and ventilated environment which shall favor easy replacement.

All semiconductor junction temperatures shall be limited to 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.

All semiconductors shall be operated at less than 50% of the maximum continuous current rating or maximum continuous power rating, whichever is more restrictive.
Materials and Workmanship

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.

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.

Integrated circuits shall be soldered into the printed circuit board; plug-in connectors are not permitted.

All gallium arsenide and similar optical semi-conductors shall be rated for operation over the temperature range of –40°C to +85°C.

All semiconductors shall be rated “industrial or automotive grade” for reliable operation over the temperature range of -40°C to +85°C, except for discrete power semiconductors (>=1 Watt) which shall be rated for temperature range of -55°C to +125°C. Exceptions shall not be taken without proper identification and written authorization from the Customer prior to first article tests.

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 Customer prior to the first article inspection.

18.29.2 Availability and JEDEC Registration

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.

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.

18.29.3 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 Customer inspectors.
18.30 Printed Circuit Board Standards

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 10°C temperature rise. Run spacing shall conform to MIL-STD-275.

Circuit board material shall be per MIL-P-13949, with a minimum thickness of 0.0625 in. 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.

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.

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 shall be centrally stiffened.

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.

All printed circuit boards shall be of the "plug-in" type, with positive support against vibration, except where approved otherwise.

Not more than one PC board shall be stacked on each PC card.

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 0.000050 in. thick gold plating.

18.30.1 Marking

All circuit boards shall be labeled with a part number, serial number and descriptive nomenclature.

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.

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.
For boards whose component density is greater than 2.25 components per square inch, the Contractor may submit an alternate marking plan for possible approval. Such a plan should include board marking, augmented by layout drawings.

18.30.2 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.

18.30.3 IC and Device Sockets

IC and device sockets shall comply with MIL-S-83502 and MIL-S-83734, as is applicable for the device.

18.30.4 Conformal Coating

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.

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.

All IC sockets, connectors and test points shall be masked when the coating is applied.

18.30.5 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.

18.30.6 Circuit Board Connectors

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 Customer prior to commencing design.

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.

The connector contact area shall be plated with a minimum of 0.000050 in. of gold over a minimum of 0.000050 in. of low stress nickel.

Card edge connectors are prohibited.
All connectors within one panel assembly shall be keyed to prevent damage or malfunction due to incorrect insertion.

18.30.7 Testing

Sufficient clearance shall be provided between components to allow testing, removal and replacement without difficulty due to lack of space.

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 0.080 in. 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.

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.

18.30.8 Plated-Through Holes

In addition to the general guidelines of the Institute of Printed Circuits (IPC), the following requirements shall be met:

- **Plating Holes** - Copper plate shall be a minimum of 0.001 in. minimum average thickness, and 0.003 in. maximum average thickness. Solder plates shall be 0.0003 in. minimum average thickness and 0.0015 in. maximum average thickness.

- **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.

- **Enclosures**

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.

The rack and enclosure shall provide environmental and EMI shielding necessary to meet the requirements of this Specification.

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.

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.
18.30.9 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 Microprocessor-Based Systems

The microprocessor-based control systems shall be based on an established family of microprocessors in wide use in the control system industry. They shall be supported by a full range of software development languages and diagnostic programs.

Should the Contractor elect to use multiprocessor bus architecture, the architecture shall be based on the Intel Multibus, Motorola VME or similar bus used widely in industrial process control equipment. Alternative bus structures may be submitted for the Customer approval.

Program code and fixed data shall be stored in Programmable Read-Only Memory (PROM) or Erasable Programmable Read Only Memory (EPROM). Either static or dynamic Random Access Memory (RAM) or EPROM may be used for temporary data storage. All EPROM windows shall be covered with labels that are opaque at the Ultraviolet (UV) erasing wavelengths.

Battery-backed RAM may be used only to store fault information. 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. Battery life shall be no less than five years, regardless of type.

At least 30% additional memory space shall be installed and available for future modifications to program code, fixed data space and temporary data space.

18.31.1 Software

Software may be written in a high or low level language. The language, and its implementation for the selected microprocessor system, shall be commercially available in English.

All software, whether interrupt based or polled, shall always assign the highest priority to safety-related tasks.

Software shall perform the following basic functions:

- Implement the desired control scheme such that the specified performance is achieved;
- Monitor all inputs for unsafe, erroneous, or unknown conditions or combinations of conditions;
- 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;
- Limit all output commands to safe levels regardless of any combination of input conditions;
• Perform self-diagnostic routines and respond promptly, safely, and predictably to detected faults;
• 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 re-initialize all affected routines and temporary data. Detection of power interruptions may be by hardware.
• Permit thorough interrogation of all input, output and internal conditions by external diagnostic equipment.

18.31.2 Isolation and Interfacing

Any microprocessor-based control system shall be powered by dedicated isolated power supplies driven from the vehicle battery circuit.

All control system input and output signals shall be through isolation buffers unless specifically approved by the Customer. High voltage inputs and outputs shall be isolated external to the microcomputer card rack unless specifically approved by the Customer. Low voltage (battery and logic voltage level) inputs and outputs shall be isolated via buffer cards in or external to the microcomputer card rack.

The isolation buffers shall:
• Protect and isolate the control system from damage due to overvoltage, undervoltage, transients, shorts and open circuits.
• Perform necessary voltage transformations.
• Remove noise and undesired signals.
• Limit, pre-process, discriminate and format those signals that would otherwise require excessive processor time.
• Consist of optical isolators, transformer isolators, and other circuits appropriate to the application.

18.31.3 Software Documentation

The Contractor shall submit, for approval, a software quality assurance plan in accordance with ANSI/IEEE Standard 730-2002. For reference, this Standard has the following minimum software documentation requirements:
• Software requirements specification
• Software design description
• Software verification and validation plan
• Software verification and validation report
• User documentation
The Software Design Description (SDD) shall be in accordance with ANSI/IEEE Standard 1016-1998. The final Software Design Description shall include details are summarized below only for information:

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>Computer description and operation</td>
</tr>
<tr>
<td>Level 2</td>
<td>Software architecture, basic program and functions</td>
</tr>
<tr>
<td>Level 3</td>
<td>Detailed flow information</td>
</tr>
<tr>
<td>Level 4</td>
<td>Annotated compiler/assembly listing</td>
</tr>
<tr>
<td>Level 5</td>
<td>Detailed memory map and listing</td>
</tr>
<tr>
<td>Level 6</td>
<td>Input/output port map</td>
</tr>
</tbody>
</table>

At its option, the Customer will participate in both the Software Requirements and the Preliminary Design Review, as defined by ANSI/IEEE Standard 730-2002. Following these reviews, the Contractor shall submit, for approval, the Software Requirements Specification and the Software Design Description. All subsequent changes to these documents shall also be submitted and approved prior to implementation.

The Contractor shall provide at the final design review a hardware and software safety plan in accordance with 49CFR Section 238.105.

### 18.32 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.

### 18.33 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.

* End of Chapter 18 *
Chapter 19

Test Requirements
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19.0 Test Requirements

19.1 Overview

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 49CFR Section 238.111(b) for Tier I equipment, for submission by the Customer 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 Customer observation, and the FRA may also observe such tests. All contractual tests shall be conducted in accordance with Customer approved test procedures. Testing activity scheduled and/or conducted before test procedure approval will be at the Contractor's risk.

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 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 Customer 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.

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.

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.

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 Customer'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.
19.2 General Requirements

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 ten days notice to the Customer prior to the start of any test referred to herein. In the case of pre-revenue service tests per 49CFR Section 238.111 (b) (2), 45 calendar days notice shall be given to the Customer in order to assure timely notification of the FRA.

Except as provided herein, the Customer, 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 accept this as showing conformance with the requirements of this Technical Specification.

19.3 Test Plans and Reports

The Contractor shall prepare and provide to the Customer as specified the following test documentation. See Chapter 22 for additional details regarding submittal of documents to the Customer.

19.3.1 Master Test Plan

The Contractor shall submit to the Customer 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 Customer 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.

The master test plan shall include, but is not limited to, all tests as required to be performed by the Contractor and suppliers:

- Material certification tests;
- Proof-of-design tests, including all required carshell, truck and suspension and ride quality tests;
- Production tests; and
- Acceptance tests.

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.
19.3.2 Test Procedures

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.

Tests procedures shall be submitted for approval in advance of the anticipated test dates as follows:

<table>
<thead>
<tr>
<th>Test Type</th>
<th>Approval Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplier Qualification, Proof of Design and Production</td>
<td>No less than 60 days prior to start of testing</td>
</tr>
<tr>
<td>Contractor Qualification, Proof of Design Tests</td>
<td>No less than 60 days prior to start of testing</td>
</tr>
<tr>
<td>Contractor Production Tests</td>
<td>No less than 45 days prior to start of testing</td>
</tr>
</tbody>
</table>

All required testing shall be conducted in accordance with the Customer-approved master test plan and approved test procedures.

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, Customer 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.

Each car and system shall be tested in exact accordance with the Customer-approved revision of the test procedure. All test and inspection instruments shall be properly calibrated.

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 Customer may, at its sole discretion, determine that portions of the failed test need not be repeated.

Each test shall be a separately controlled document and identified by its own number, title and revision. All revisions shall be submitted to the Customer 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.

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 Customer representative.
19.3.3 Testing Notification

In the case of pre-revenue service tests per 49CFR Section 238.111(b)(2), the Contractor shall provide no less than 45 calendar days notice to the Customer in order to assure timely notification of the FRA. For other tests, each detailed test procedure shall be submitted to the Customer for review far enough in advance of the planned test date to allow the Customer at least 15 working 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 Customer, to have approval a minimum of three working days prior to any testing covered by the procedure. The Customer shall witness all tests. Under no circumstances will the Customer accept the results of a test performed without approved procedures.

19.3.4 Test Documentation

The Contractor shall be responsible to provide the Customer with written test reports for all tests performed on the cars and their components, including supplier test reports.

Upon the completion of each test, the Contractor shall submit a written report of each test, including copies of all test data, to the Customer 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 Customer (and the FRA, as required) has approved its final written test report.

Should the test procedure or reports be inadequate and not meet the requirements of the Technical Specification of the FRA, the Customer 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 Customer does not in any way relieve the Contractor of responsibility for the adequacy of the test program within the scope of this technical specification.

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 Customer in a single volume.

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 Customer 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 Customer prior to acceptance of the first car of each type.

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For production tests, which are performed on all cars or all components, a separate volume shall be submitted to the Customer 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 Customer for review before each car shall be released for shipment to the delivery site.
All Contractor and Customer in process inspection sheets and test data records for that car shall be contained in this test log.

19.3.5 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 Customer’s designated maintenance facility, or at another location as approved by the Customer. 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.

19.4 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:

- All exterior glazing shall be certified to conform to 49CFR Part 223 requirements.
- All interior materials shall be certified to meet smoke, flame and toxicity requirements.
- All subfloor panels shall be certified to meet strength and impact resistance requirements.
- All stainless steel and carbon steel used in production of the carshell shall be certified to meet material strength, composition and performance characteristics.
- All components used in the manufacture of truck, suspension and coupler assemblies shall be certified to meet all applicable strength, composition and performance requirements.
- All insulation materials shall be certified to meet applicable insulation performance standards.
- All materials used in food preparation areas of the café-lounge car, potable water systems and trash storage shall be certified to meet all applicable Public Health Service sanitation requirements.
- All interior and exterior emergency signage materials shall be certified to meet FRA emergency exit signage requirements.
- All emergency power sources shall be certified to meet FRA emergency exit pathway.
- All emergency equipment shall be certified to conform to all applicable FRA regulations and other requirements as necessary.
- 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.
19.5  Proof-of-Design Tests

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.

19.5.1  Carbody Structural Tests

19.5.1.1 General

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.

One of the first four cab car bodies 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, 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 Customer.

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.

The test carshell shall be structurally complete, including all structural parts and fiberglass ends (if part of the design), 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 locations. All structural tests shall be conducted on the same carshell.
The carshell shall be weighed and the weight recorded 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.

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.

The Contractor may conduct preliminary tests, but 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.

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 in proper engineering units (micro-strains) and a plot of load vs. gauge reading for critical gauge locations shall be given to the Engineer or his representative for review. The Contractor shall obtain approval of the Engineer or his representative after every load step before proceeding with the next step. The Contractor shall not break down the test fixtures until the Engineer or his representative has reviewed and accepted all data.

The Contractor shall prepare a color photographic record of the test. This record shall include photographs of the car in the several test fixtures, installation of critical strain gauges, repairs or modifications, deviations from the drawings, and any areas found to be non-compliant. The entire procedure shall be video recorded by the Contractor with a sound-equipped VHS color video camera or other suitable digital video equipment. The camera shall rove to view and record key areas. All videotapes taken during this test shall become the property of the Authority.

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 Customer 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 Customer'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.

19.5.1.2 Test procedures

A procedure shall be prepared for each test. 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 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 clarify the text. 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 signature of the test supervisor and a space for recording the authorization to proceed obtained from the Engineer or his representative. Test procedures
shall be submitted not less than 60 days in advance of the proposed test date; approvals of the test procedure and stress analysis are prerequisites for the start of testing.

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.

Tables shall be included to give the maximum allowable reading for each gauge and loading condition. Other tables shall be included to provide the requirements for all other test criteria. Each test procedure shall contain a table of predicted strain (or stress) and deflection at selected gauge locations. This table shall list the strain or deflection gauge number, the location of the gauge, the predicted strain (or stress) or deflection from the stress analysis, spaces to enter the actual gauge readings, and a space to enter the calculated percent difference, defined as:

\[
\% \text{ difference} = \frac{\text{Actual} - \text{Predicted}}{\text{Actual}} \times 100
\]

19.5.1.3 Strain gauges

A minimum of 160 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 160 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.

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.

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.

Drawings and sketches showing the location of each strain gauge shall be prepared by the Contractor and submitted for approval as part of the test procedure. These drawings shall dimension the location of each gauge, showing their distances from edges, connections and bends. Their locations on the upper or lower, inner or outer surface shall be noted on these drawings.

The strain gauges shall be bonded resistance (SR-4) type or other approved gauges suitable for the application. The gauges shall be calibrated in accordance with the manufacturer’s instructions for the material being measured. The gauges shall be compensated for temperature.
19.5.1.4 Deflection gauges

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., and the deflections shall be considered as the average of the readings recorded on both sides of the car.

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.

For the diagonal jacking test, an additional deflection gauge shall be applied at the jack that is lowered or raised to measure the vertical movement at jack location.

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 additional deflection gauges shall be applied in one of the side door openings closest to the center of the car to measure the change in the diagonal dimensions of the opening during the tests.

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.

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 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.

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.

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. An indicator shall be located next to the lowering jack during the diagonal jacking test. A dial indicator shall be mounted at the center of the post during each post tested. These dial indicators shall be read and manually recorded at each load step.

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.
19.5.1.5 Load cells

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.

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.

19.5.1.6 Vertical load test

19.5.1.6.1 Test description

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 170 lbs for each seated passenger in seats and an additional 15 lbs “luggage” for each seated passenger in overhead racks, uniformly distributed, shall be applied to the car in 4 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.

At each step of the load, the all car doors shall be exercised to verify they continue to operate normally, with normal cycle times.

19.5.1.6.2 Test criteria

The car shall be considered compliant with this Specification if all of the following conditions are met:

- Stresses are in accordance with the requirements of APTA Standard SS-C&S-034-99.
- Vertical deflection readings plotted against load do not vary by more than ± 5% from a straight line (linear) deflection curve, with one end point at the origin (no load) and the other at that point which represents the measured deflection for maximum vertical load.
- Strain readings plotted against load do not vary by more than ± 5% from a straight line (linear) deflection curve, with one end point at the origin (no load) and the other at the point which represents the measured deflection at maximum load.
- Maximum stresses calculated from stain readings in any structural element do not exceed the allowable stresses approved prior to starting the test program as part of the stress analysis.
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- Recorded residual vertical deflection between bolsters following removal of the maximum vertical test loading does not exceed 0.01 in.
- Recorded residual car transverse width and/or opening diagonal dimensions following removal of the maximum vertical test load do not exceed 0.01 in.
- Indicated residual strains at strain gauges on principal structural elements following removal of the maximum vertical loading do not exceed the maximum error resulting from the accuracy of the instrumentation.
- Carbody 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.
- Door operation is normal, including normally expected cycle times.
- There are no permanent deformations, fractures, cracks or separations in the car structure. Broken welds resulting from the test are to be inspected jointly by the Contractor and Customer to determine if the failure is the result of weld quality or stress.

19.5.1.7 End sill compression load test

19.5.1.7.1 Test description

A compression test load as defined in APTA Standard SS-C&S-034-99 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.

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.

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.

19.5.1.7.2 Test criteria

The car shall be compliant with this Specification if all of the following conditions are met:

- Stresses are in accordance with the requirements of APTA Standard SS-C&S-034-99.
- The vertical deflection of each side of the test structure is within ± 10% of the value determined by the analysis.
- The force measured at the reaction load cell is within 1.0% of the force applied at the ram.
- 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.
• 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.

• There are no permanent deformations, fractures, cracks or separations in the car structure. Broken welds are to be jointly inspected by the Contractor and Customer to determine if the failure is the result of weld quality or stress.

19.5.1.8 Compression load test at the draft stop

19.5.1.8.1 Test description

A compression test load of 800,000 lbs 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.

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.

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.

19.5.1.8.2 Test criteria

The car shall be compliant with this Specification if all of the following conditions are met:

• Stresses are in accordance with the requirements of APTA Standard SS-C&S-034-99.

• The vertical deflection of each side of the test structure is within ± 10% of the value determined by the analysis.

• The force measured at the reaction load cell is within 1.0% of the force applied at the ram.

• Vertical deflection readings plotted against load do not vary by more than ± 5% from a straight line (linear) deflection curve, with one end point at the origin (no load) and the other at the point which represents the measured deflection at maximum load.

• Strain readings plotted against load do not vary by more than ± 5% from a straight line (linear) deflection curve, with one end point at the origin (no load) and the other at the point, which represents the measured deflection, at maximum load.

• Maximum stresses calculated from strain readings in any structural element do not exceed the allowable stresses approved prior to starting the test program as part of the stress analysis.

• Recorded residual vertical deflection between bolsters following removal of the maximum vertical test load does not exceed 0.01 in.
• The residual horizontal deflection between ends following removal of the maximum load does not exceed 0.04 in.
• 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.
• There are no permanent deformations, fractures, cracks, or separations in the car structure. Broken welds are to be jointly inspected by the Contractor and Customer to determine if the failure is the result of weld quality or stress.

19.5.1.9 Diagonal jacking test

19.5.1.9.1 Test description

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.

The amount of torsional deflection or twist shall be measured.

19.5.1.9.2 Test criteria

The car shall be compliant with this Specification if all of the following conditions are met:

• Passing criteria for the test shall have a factor of 1.25, when compared to yield stress values.
• Maximum stresses calculated from strain readings in any structural element do not exceed the allowable stresses approved prior to the start of the test program as part of the stress analysis.
• Strain readings plotted against load do not vary by more than ± 5% from a straight line (linear) deflection curve, with one end point at the origin (no load) and the other at the point that represents the measured deflection at maximum load.
• Indicated residual strains at strain gauges following return to original level do not exceed the maximum error resulting from the accuracy of the instrumentation.
• There are no permanent deformations, fractures, cracks or separations in the car structure.
• Broken welds are to be jointly inspected by the Contractor and Customer to determine if the failure is the result of weld quality or stress.

19.5.1.10 Collision post elastic test

19.5.1.10.1 Test description

The ability of the carbody structure to resist the collision post longitudinal loads specified in APTA Standard SS-C&S-034-99 shall be tested.
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.

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.

A longitudinal test load as specified in APTA Standard SS-C&S-034-99 shall be applied to, and centered on, the collision post at an elevation 18 in. 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. in height.

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.

19.5.1.10.2 Test criteria

The car shall be compliant with this Specification if all of the following conditions are met:

- 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.

- Strain readings plotted against load do not vary by more than ± 5% from a straight line (linear) deflection curve, with one end point at the origin (no load) and the other at the point which represents the measured deflection at maximum load.

- Maximum stresses calculated from strain readings in any structural element ~ exceed the allowable stresses approved prior to starting the test program as part of the stress analysis.

- Indicated residual strains at strain gauges on principal structural elements following removal of the maximum loading do not exceed the maximum error resulting from the accuracy of the instrumentation.

- There is no permanent deformation, fractures, cracks or separations in the car structure.

- Broken welds are to be jointly inspected by the Contractor and Customer to determine if the failure is the result of weld quality or stress.
19.5.1.11 Corner post longitudinal load test

19.5.1.11.1 Test description

The ability of the carbody structure to resist the primary side corner post longitudinal compressive loads specified in APTA Standard SS-C&S-034-99 cab cars and coach cars shall be tested.

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.

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.

Longitudinal test loads shall be applied to, and centered on, the corner post at an elevation of 18 in. and 30 in. above the top of the underframe as specified in APTA Standard SS-C&S-034-99. 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. in height.

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.

19.5.1.11.2 Test criteria

The car shall be compliant with this Specification if all of the following conditions are met:

- Deflection readings plotted against load do not vary by more than ± 5% from a straight line (linear) deflection curve, with one end point at the origin (no load) and the other at the point which represents the measured deflection at maximum load.

- Strain readings plotted against load do not vary by more than ± 5% from a straight line (linear) deflection curve, with one end point at the origin (no load) and the other at the point which represents the measured deflection at maximum load.

- Maximum stresses calculated from strain readings in any structural element do not exceed the allowable stresses approved prior to starting the test program as part of the stress analysis.
• Indicated residual strains at strain gauges on principal structural elements following removal of the maximum loading do not exceed the maximum error resulting from the accuracy of the instrumentation.

• There is no permanent deformation, fractures, cracks or separations in the car structure. Broken welds shall be jointly inspected by the Contractor and the Customer to determine if the failure is the result of weld quality or stress.

19.5.1.12 Corner post transverse load test

19.5.1.12.1 Test description

The ability of the carbody structure to resist the corner post transverse load specified in APTA Standard SS-C&S-034-99 shall be tested.

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.

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.

Longitudinal test loads as specified in APTA Standard SS-C&S-034-99 shall be applied to and centered on the corner post at an elevation of 18 in. 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. in height.

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.

19.5.1.12.2 Test criteria

The car shall be compliant with this Specification if all of the following conditions are met:

• Deflection readings plotted against load do not vary by more than \( \pm 5\% \) 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.

• Strain readings plotted against load do not vary by more than \( \pm 5\% \) 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.
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- 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.

- Indicated residual strains at strain gauges on principal structural elements following removal of the maximum loading do not exceed the maximum error resulting from the accuracy of the instrumentation.

- There are no locations of permanent deformation, fractures, cracks or separations in the car structure. Broken welds are to be jointly inspected by the Contractor and Customer to determine if the failure is the result of weld quality or stress.

19.5.1.13 Collision post elastic-plastic test

19.5.1.13.1 Test description

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 SS-C&S-034-99 shall be tested.

This test shall also verify the structural energy absorption requirement outlined in APTA Standard SS-C&S-034-99, Rev 2.

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.

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. 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. in height.

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.

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.

The strain gauge readings and deflections measured during this test shall be within 5% of the gauge readings for the same load and location measured during the collision post elastic test. If difference between the two test results, the fixture and/or the model shall be corrected until agreement within 5% between the two tests is obtained.
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.

The ultimate load carrying capacity of the post shall be defined as the condition where the post cannot support an increased load or the center of the post has deflected more than its full depth. This deflection shall be measured at the middle of the post from a string connected between the top and bottom of the post.

19.5.1.13.2 Test criteria

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.
- The connections between the collision post and all other structural members are not completely broken.
- The collision post and supporting structure have absorbed energy as per APTA Standard SS-C&S-034-99, Rev 2.

19.5.1.14 Corner post elastic-plastic test

19.5.1.14.1 Test description

The ability of the connections between the corner 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 SS-C&S-034-99 shall be tested. This test shall also verify the structural energy absorption requirement outlined in APTA Standard SS-C&S-034-99, Rev 2.

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 corner 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.

The specimen shall be instrumented in the same manner in which it was instrumented in the corner post elastic test (longitudinal), 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 corner post at an elevation of 30 in. 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 by 6 in. in height.

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

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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 initial load shall be applied in increments of the same magnitude as those used during the corner 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.

The strain gauge readings and deflections measured during this test shall be within 5% of the gauge readings for the same load and location measured during the corner post elastic test. If difference between the two test results, the fixture and/or the model shall be corrected until agreement within 5% between the two tests is obtained.

After agreement between the two tests is demonstrated, the corner post shall continue to be loaded in stroke increments of 20% of the full depth of the corner post until the load carrying capacity of the corner 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.

The ultimate load carrying capacity of the post shall be defined as the condition where the post cannot support an increased load or the center of the post has deflected more than its full depth or 10 in., whichever is greater. This deflection shall be measured at the middle of the post from a string connected between the top and bottom of the post.

19.5.1.14.2 Test criteria

The corner 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 corner post elastic load test for 0% to 100% as tested in the elastic test.
- The connections between the corner post and all other structural members are not completely broken.
- The corner post and supporting structure have absorbed energy as per APTA Standard SS-C&S-034-99, Rev 2.

19.5.1.15 Crash energy management

A series of tests shall be conducted to validate the Crash Energy Management (CEM) design. This shall include dynamic or quasi-static testing as appropriate of each type of coupler and structural absorber to validate the design of each of the absorbers. The principal objective of these tests shall be to measure the force/crush characteristics of the coupler and structural energy absorbing elements. Full-sized elements shall be tested.

Validation of the analysis models shall be by testing of crush elements and fuse elements. The validated models of these elements or their crush performance characteristics shall be assembled into a model of the crush zone on the end of the car. The assembled model shall be used to perform a full 3D explicit analysis of the car (flat wall for coaches, into a locomotive for cabs) to prove compliance with this specification.
The Contractor shall submit a CEM Analysis as per Sections 6.0 and 7.4 of APTA Standard SS-C&S-034-99, for review and approval by the Customer. The following shall be analyzed:

- Individual energy absorbing structural elements,
- Individual frangible structural elements ("fuses"),
- Each crush zone, consisting of the validated energy absorbing and frangible elements,
- The remainder of the carbody structure occupied by passengers and crew.

19.5.1.15.1 CEM test plan

CEM system design validation shall be provided according to separate CEM System Test Plan that shall be integrated into the Carbody and Truck Stress Analyses and Test Plan of this Chapter. The Contractor shall provide a CEM System Test Plan for review and approval by the Engineer. The CEM System Test Plan shall include, as a minimum, the tests included the CEM System Test Matrix.

**Table 19-1: CEM System Test Matrix**

<table>
<thead>
<tr>
<th>Test</th>
<th>Spec</th>
<th>Type</th>
<th>Car End</th>
<th>Level</th>
<th>Input Parameter</th>
<th>Criterion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural Absorber Energy Absorption</td>
<td>4.21.4 &amp; 4.21.5</td>
<td>Dynamic</td>
<td>All</td>
<td>Component</td>
<td>Energy Absorption</td>
<td>Exceeds Minimum Required Value</td>
</tr>
<tr>
<td>Coupler Energy Absorbed</td>
<td>6.9</td>
<td>Dynamic</td>
<td>All</td>
<td>Component</td>
<td>Energy Absorption</td>
<td>Exceeds Minimum Required Value</td>
</tr>
<tr>
<td>Coupler Initiation Load*</td>
<td>6.9</td>
<td>Dynamic or Quasi-Static</td>
<td>All</td>
<td>Component</td>
<td>Initiation Load</td>
<td>Exceeds Minimum Required Value</td>
</tr>
<tr>
<td>Trigger, Frangible Element, Fuse*</td>
<td>4.21.4 &amp; 4.21.5</td>
<td>Dynamic or Quasi-Static</td>
<td>All</td>
<td>Component</td>
<td>Load and Failure Mode</td>
<td>Within Design Range</td>
</tr>
</tbody>
</table>

* May be combined with the related absorber test into one dynamic test if appropriate for the design of the absorber. Include all necessary details in the Plan.

For each element to be tested, the related part of the Plan shall include description of the element to be tested, description of required test fixtures, the conditions under which the test will be conducted, and the data to be measured.

19.5.1.15.2 CEM test procedure

Prepare a Test Procedure for each element to be tested. The Procedure shall describe the test in step-by-step detail, and shall include details of the test fixtures, instrumentation, data acquisition system and pass-fail criteria. For each test, approval of the Plan and the specific Procedure is required prior to starting the test.

19.5.1.15.3 CEM tests

Perform each test in accordance with its approved Procedure. The primary results shall be force and displacement histories. Sufficient data shall be gathered to determine peak and average force. Photograph each test article before and after testing, and at any intermediate steps. Sufficient additional data and measurements shall be taken to evaluate modes of crush. Each dynamic test shall be documented with high-speed cameras. The record of the test shall be provided on storage media as agreed.
19.5.1.15.4  CEM tests, evaluation of results

Compare force/crush characteristic from test with analytical predictions. Average force, peak force and force and displacement histories shall be compared. Modes of crush shall also be compared.

19.5.1.15.5  Test correlation criteria

Upon completion of test, the contractor shall validate his analytical predictions against the test results. If needed, appropriate parameters in the analytical model may be modified such that the model better reflects actual behavior.

The values specified in the following are the difference between test and validated analytical result with the former as the base:

- Peak force, ± P%,
- Average force, ± A%,
- Force and displacement vs. time, ± T% at any particular time, and
- Modes of crush as predicted by analysis.

The Contractor shall provide meaningful and realistic correlation criteria for P%, A%, and T% for review and acceptance by the Engineer. The criteria must be based on state-of-the-art analysis and testing techniques. The basis of the criteria must be defined by the Contractor and supported by established correlation criteria of other CEM designs that have been analyzed and tested.

Upon satisfactory validation of the CEM element analytical models, the overall 3D model of the car structure shall be updated to reflect the test results and compliance with the CEM section of this Specification shall be verified.

If the above process indicates a need for CEM element or structure re-design, the performance of the redesigned elements shall be verified by test, the CEM element model validated and compliance of the overall vehicle performance re-verified against the CEM specification.

19.5.1.16  Wheelchair lift

If being supplied as part of this procurement, the powered wheelchair lift shall undergo proof-of-design testing to evaluate and verify that the lift meets all specification requirements for:

- Compliance with all applicable ADA requirements;
- Functional and operational performance under all design loads, track conditions as specified, and safety factors without deformation or deflection;
- Rate of travel upward and downward for the lift platform under loaded and unloaded conditions;
- Full range of vertical movement for the lift to adequately reach the range of station platforms as specified;
- Proper operation of all safety provisions and functional interlocks and isolation devices within the unit and with the door system, brakes and indicators;
- Function of lift after loss of power while in mid-travel, then with restoration of power;
- Proper and secure storage of the lift within the car;
• Maintainability and reliability requirements; and
• Manual operation of lift at rated load.

These tests shall include an endurance test in which the lift shall be subjected to no less than 2,500 repeated cycles of deployment and storage.

19.5.2 Trucks

19.5.2.1 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 Customer for approval prior to the start of any truck frame load or fatigue testing.

19.5.2.2 Equalization

The truck shall be tested in accordance with APTA Standard SS-M-014-06, for car type “G”.

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. and then increasing to 3 in. 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 SS-M-014-06. 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.

19.5.2.3 Truck frame load tests

The truck frame and bolster shall be tested to verify that the maximum allowable stresses established by the Contractor and approved by the Customer 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 Customer.

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 Customer, the Customer 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.

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 Customer 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 Customer.

19.5.2.4 Truck frame overload tests

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:

- Vertical load = 1.5 x AW3 car weight per truck.
- Lateral load = 0.3g x AW3 car weight per truck applied at the carbody center of gravity
  (note: this produces additional vertical loads on the truck).
- Longitudinal load = 1g x truck weight.
- Brake loads consistent with maximum specified deceleration, split between tread and
disc mounting locations according to Chapter 7.

All loads shall be applied simultaneously.

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 Customer, the Customer 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.

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 Customer, the Customer
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 Customer 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
Customer.
19.5.2.5 Truck frame fatigue tests

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 RP-M-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.

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 0.2g times the AW1 loaded carbody weight normally carried by the truck with the highest loading. The lateral component shall be plus and minus 0.15g times the above AW1 load and shall vary with it. The longitudinal component shall be plus and minus 0.15g times the above AW1 load and shall vary with it. Accessory loads, as determined by the Customer, 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 Customer, the Customer having the power of decision in the event of disagreement.

The frequency of the load cycling shall be as proposed by the Contractor for approval by the Customer. 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.

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 Customer and the Contractor after which an appropriate correction shall be established and the test repeated.

At the conclusion of the fatigue test, a magnetic particle or dye penetrate inspection shall be made for cracks in the presence of the Customer. 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 Customer.

19.5.2.6 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.
19.5.3 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, including CEM performance requirements, range of motion, vertical loading, draft and buff loads and operations.

19.5.4 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.

19.5.4.1 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 pounds/square inch increments, from 0 pounds per square inch to the maximum used, and from application of the handbrake.

19.5.4.2 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 Customer.

19.5.4.3 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. 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 Customer.
19.5.4.4 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 Customer defined train schedule service for speeds up to 125 mph. Any elevation grades exceeding 0.2% shall also be taken into account. The complete dynamometer procedure, dynamometer facility and test protocol shall be provided by the Contractor and approved by the Customer. This procedure is an amendment to the qualification of brake shoe and disc brake materials as specified in Amtrak Specification 80-276. All other attributes of friction brake material performance shall be in accordance with Amtrak Specification 80-276. 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 Customer. The test shall be coordinated according to the planned operating pattern.

19.5.4.5 Handbrake tests

Handbrake performance shall be verified for compliance to the specification as well as APTA Standard SS-M-006-98 using new and fully worn brake shoes/pads.

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.

The “handbrake-applied” indicator light shall also be tested.

19.5.5 Door System

The side and end door systems shall be subjected to extensive testing to confirm that the systems and components meet all requirements for:

- System integrity
- Safety
- Functionality and operation
- Opening and closing times and speeds
- Trainline controls, indicators and interlocks
- Compliance with regulations, recommendations and standards
- Reliability
- Maintainability
- Sustained and compliant performance under all specified operational and environmental conditions

All door system components shall be tested through rigorous multiple-cycle operation that simulates the actual installation, hardware and climatic conditions as specified.
19.5.5.1 Side door system reliability test

A set of side door panels and operators, 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 that 500,000 full cycles, so demonstrate the durability of the operators, hangers, 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 Customer, 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.

Once the first car has been completely assembled, and the entire side door system has been installed and the functionality has been verified, the side doors shall be operated for 14,400 continuous trouble-free cycles each. 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.

If procurement calls for cars with passenger (standard opening) and baggage (wide opening) side doors, both styles shall be tested independently as outlined above.

19.5.5.2 Side door safety test

Once installed in a completed car, the side door system, including all side doors, shall be functionally tested to verify that the door system design conforms to all applicable safety requirements, including:

- Trainline and local control, door summary circuit and zero-speed operation
- Obstruction detection and recycle operation
- Interlocks, isolation and manual locking
- Interior, exterior and trainline door status indicators
- 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
- 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.
19.5.5.3 End door reliability test

An 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 that 100,000 full cycles, so 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 Customer, 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.

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.

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.

19.5.6 Interior

19.5.6.1 Overhead luggage bins

A complete overhead luggage bin, mounted on simulated carbody structure, shall be tested to verify it meets the 250 lb load requirement. A complete overhead luggage bin, fully loaded with actual weighted luggage and mounted on simulated carbody structure, shall be tested to verify it meets the 8/4/4g crashworthiness requirements. A complete overhead luggage bin, mounted on simulated carbody structure, shall be tested to verify the door and associated hardware meet the 50,000 cycle endurance requirement. The door shall be cycled to simulate opening and closing by passengers, with force and speed representative of actual passenger use applied to the latch and moving the door open and closed. Failure of a component, component coming off (such as hinge, damper or self-opening device), failure of latch to engage, hold door closed or release each constitutes failure.

19.5.6.2 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 SS-C&S-016-99 and submitted to the Customer with a detailed test report. This test result must be approved by the Customer before additional seats can be ordered and assembled into the pilot cars for pre-delivery testing.
19.5.6.3 Seat tests

Seat cushions selected twice at random by the Customer during cushion production shall be
tested to verify compliance with section requirements.

Seat cushions (both foam and upholstery) shall be tested to verify compliance with
requirements.

19.5.7 HVAC

19.5.7.1 Heating and air-conditioning unit tests

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 Customer.

The actual HVAC control system, with actual temperature sensors, shall control all system
operations during the test, unless indicated otherwise for specific tests.

Tests shall be conducted at nominal voltage and frequency, except where otherwise specified.
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.

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.

19.5.7.2 System pre-test requirements

Prior to any cooling and heating system test, an air balance test, control scan test and a vehicle
heat transfer test shall be conducted. 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.

The pre-tests shall be satisfactorily completed before continuing to further climate room
testing.

19.5.7.3 Air balance test

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.
Each car to be tested shall be measured and the results recorded to verify specification requirements are met for air distribution and balance, including:

- Fresh air flow rate
- Return air flow rate
- Exhaust air flow rate
- Air flow rates into cab
- Car pressurization: cab, car interior, restrooms, baggage room
- Pressure differential of restrooms relative to adjacent car interior
- Uniformity of supply air flow
- Interior car noise levels after balancing with blowers on

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.

19.5.7.4 Temperature control tests

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.

Under steady state operation at design conditions, the control voltage shall be varied between the limits allowed by Amtrak Specification 963. The system shall operate steadily without malfunction.

19.5.7.5 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 Customer. The criteria shall include the following, at a minimum:

- Level of superheat at the evaporator outlet;
- Level of superheat at the compressor suction valve;
- Compressor suction and discharge pressures;
- Level of liquid refrigerant sub-cooling at condenser outlet;
- No air bubbles in liquid line sight glass;
- Compressor(s) working at full load/capacity.
19.5.7.6 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 to 130°F 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 variation from 24 in. above top of rail to 24 in. 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.

After all testing is completed; the Contractor shall remove a sample of the refrigerant from each system for analysis by an independent laboratory. Contaminants level shall not exceed the allowable requirements of AHRI Standard 700.

19.5.7.6.1 Data requirements

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:

Temperatures - °FDB:

- Return air at both HVAC units;
- Mixed air at both HVAC units;
- Fresh air at all air intakes (for both HVAC units);
- Distributed air throughout the car;
- Condenser air inlet at both units;
- Liquid at the filter-drier outlet on both units;
- Suction at evaporator on both units;
- Suction at compressor(s) on both units;
- All temperature sensors and thermostats;
- Exterior temperature at 24 in. above the rail at both ends of the car;
- Exterior temperature at 24 in. above the roof at both ends of the vehicle;
- Interior temperature at 14 seats at 6 in. and 48 in. above the floor;
- Interior temperature at 4 aisle positions at 6 in. above the floor and 12 in. below the ceiling;
- Cab compartment on both sides of the car at 6 inches and 48 in. above the floor and 12 in. below the ceiling;
- Toilet room 6 in. and 48 in. above the floor and 12 in. below the ceiling;
- Heater guard temperature at all heater locations;
- Overheat heater compartment at all overheat protection devices;
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- Wet bulb temperatures at a minimum of two ambient locations next to the fresh air intakes.

Pressures:
- Compressor(s) discharge on both units;
- Compressor(s) suction on both units;
- Liquid leaving condenser/sub-cooler outlet on both units;
- Suction at evaporator at each evaporator circuit on both units;
- Evaporator air pressure drop on both units;
- Condenser air pressure drop on both units;
- Vehicle pressurization (inches of water gauge).

Electrical Data:
- Input Voltage;
- Blower motor current, power, and speed on both units;
- Compressor(s) motor current, and power on both units;
- Condenser fan motor current, power, speed on both units.
- Fresh air damper motor current, power, and position on both units,
- Supply air Diversion damper motor current, power, and position an all dampers.

Relative Humidity Data:
- Relative Humidity (RH) sensors at 3 aisle positions at 12 in. below the ceiling.

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.

The data acquisition system shall have the capability to add channels, if required.

19.5.7.7 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 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.
19.5.7.8 Vehicle heat transfer test

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 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 1200 BTU/hr/°F.

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.

19.5.7.9 Cooling system tests

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, during all tests.

19.5.7.9.1 Pull down and steady state operation at design conditions test

Prior to this test, the car shall be “soaked” at 110°F Dry Bulb/76°F 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.

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.

The time required for the system to reduce the interior air temperature to 74°F ± 2°F 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 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.

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, while maintaining 110°F Dry Bulb/76°F 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.
19.5.7.9.2 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 of the required interior car temperature within 3 minutes maximum after each door closing.

19.5.7.9.3 High ambient temperature test

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. After 130°F 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 recorded at one minute intervals during the entire test.

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.

19.5.7.9.4 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.

19.5.7.9.5 Condensate carry over test

With the Climate Chamber temperature at 80°F Dry Bulb/75°F 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%.

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.

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.

19.5.7.9.6 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.

19.5.7.9.7 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.

19.5.7.10 Heating system tests

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 ± 3°F, during all tests.

19.5.7.10.1 Layover verification test

This test begins with the car in a stabilized automatic heating condition with an ambient temperature of 60°F. The car is then placed in its layover mode and the ambient temperature reduced to -30°F at a rate of change not to exceed 20°F/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.

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.

19.5.7.10.2 Steady state heating at design conditions test

Following the layover verification test, the nominal voltage supply is reapply and the car is placed in its normal mode, with all car doors and windows closed. Fresh air dampers shall operate per control logic.

The time required for the system to raise the interior air temperature to 70°F ± 2°F 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 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 during the entire test.
19.5.7.10.3  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 ± 2°F. 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, during the entire test.

19.5.7.10.4  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 of the required interior car temperature within three minutes maximum after each door closing.

19.5.7.10.5  Steady state heating tests

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, during the entire test.

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.

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. Allow the system to stabilize the interior air temperature to 70°F ± 2°F. 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, during the entire test.

19.5.7.10.6  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, 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.

19.5.7.10.7 Freeze protection tests

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. The car is then placed in its layover mode and the ambient temperature reduced to -30°F at a rate of change not to exceed 20°F/hour, no internal loads and the antifreeze protection circuit energized.

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°F onto the lower half of at least one pair of doors and the door threshold.

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.

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.

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. 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.

19.5.7.10.8 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.

19.5.7.10.9 Equipment room heater test

The operation of the equipment room heater system shall be demonstrated in the climate chamber.

19.5.8 Lighting

The function and intensity of all lighting systems shall be tested in the first car to verify compliance with the requirements.
19.5.8.1 Lighting fixture performance

- Light level of each fixture shall be measured and compared to the design requirements.
- Temperature of surfaces exposed to passengers/crew shall be measured to verify compliance with specification.

19.5.8.2 Ballast qualification

Performance of all electronic ballasts shall be verified.

19.5.8.3 Independent power sources (for emergency lights)

Performance shall be verified in all modes of operation. Charge and discharge time shall be measured.

19.5.8.4 Marker light certification

The marker lights and fixture shall be tested to verify compliance with FRA 49CFR Part 221.

19.5.8.5 Lighting intensity-interior

Test shall verify light levels are in accordance with APTA Recommended Practice RP-E-012-99 and this specification under all lighting modes as specified.

19.5.8.6 Lighting intensity-exterior

Test shall verify headlight and auxiliary light levels comply with 49CFR Section 229.125 and 229.133 respectively.

19.5.8.7 Emergency lighting intensity and duration

The test shall verify light levels and duration of each car type are in accordance with APTA Standard SS-E-013-99, 49CFR Section 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.

19.5.9 Communication/OTIS

The communication system shall be tested on the first car of each type to verify that it functions in accordance with the requirements. 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 Central Diagnostics Terminal (CDT) and the wireless Local Area Network shall be tested. Testing shall be conducted to ensure that car faults can be downloaded over the network and that the AVL system database can be updated, the CDT and wireless LAN systems shall be fully functionally tested.
19.5.9.1 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:

- System selector switch function and indication
- PA announcements to the car interior only
- PA announcements to the car interior and to other cars in the train
- PA announcements received from other cars in the train
- PA interface with the CCU and the passenger information system
- Intercom function between IC stations within the car and between the car and other cars in the train
- Speaker volume, including interior and exterior speakers

19.5.9.2 Destination sign system performance

The performance of the sign system shall be verified for specification compliance on each car type. 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.

19.5.9.3 EMI/EMC

The test plan shall meet the requirements of APTA Standard SS-E-010-98, plus any additional requirements of the specification. All modes of operation shall be tested.

19.5.9.4 Wayside equipment tests

Each wayside and Control Center component of the communications system installed under this Contract, including the radio system, GPS, automatic vehicle location system, the wireless local area network 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 CDT and the wireless local area network shall be fully tested. Testing shall be conducted to insure that car faults can be downloaded over the LAN and that the AVL system database can be updated.

Each component of the communications system, including the GPS, automatic vehicle location system and wireless local area network, shall be tested to verify that they function in accordance with the requirements. Wayside simulations shall be performed as approved by the Customer to fully verify all functions. All equipment which is installed under the Contract on the Customer wayside or the Customer 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.
19.5.10  Electrical

19.5.10.1 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.

19.5.10.2 Trainline tests

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.

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.

19.5.10.3 Battery and battery charger tests

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.

19.5.10.3.1 Battery capacity

Battery on each car type shall be tested to demonstrate specification compliance.

19.5.10.3.2 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-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.

19.5.10.3.3 Battery tilt and shock

Verify each battery type complies with the 45 degree tilt and 8/4/4g acceleration requirements of 49CFR Section 238.115.
19.5.11 Food Service

The following food service equipment tests shall be required:

19.5.11.1 Structural performance

Verify crashworthiness structural requirements for retaining carts, chillers and appliances are met.

19.5.11.2 Refrigeration system performance

A complete car set of equipment, including carts and chillers, shall be assembled and connected to operate. The following shall be verified:

- Pull down capacity at rated conditions with nominal condenser inlet air temperature of 70°F and 110°F
- Hot-soak pull down: boxes soaked > 95°F rated high ambient
- Operation at light load
- Operation of condenser environmental controls
- Ability to maintain carts/boxes to required values, including minimal temperature gradient within cart/box
- Ability of thermometer on units to accurately track air temperature
- Operation of protective devices, such as pressure switches.

Instrumentation shall include inlet and outlet temperature of each galley cart

All chillers shall be instrumented to measure:

- Evaporator temperature top and bottom of coil
- Expansion valve bulb temperature
- Chiller inlet and outlet temperature
- Chiller condenser inlet and outlet temperature
- Chiller suction and discharge pressures
- Activation of chiller thermostat
- Activation of chiller defrost cycle

All food service galley equipment shall be installed and shall be operated in a test simulating revenue service to verify the proper operation of the appliances, power distribution system (including proper operation of the battery and inverter for backup power for chillers and freezers), chillers and HVAC, lighting, and the water and waste systems.
19.5.12 Water and Waste

19.5.12.1 Water and waste system performance

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.

The proper operation of the following shall be verified:

- Performance of all system components and controls in normal and standby mode
- System pressures, temperatures and flow rates
- Safety controls
- Backflow prevention devices
- Tank level indications
- Vacuum levels attained and maintained
- Flush valve life cycle

19.5.13 Cab and Controls

19.5.13.1 Train control, event recorder, train data system and video camera

The train control system, event recorder, forward-facing camera, 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.

19.5.13.2 Operation of positive train control

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:

- Accurate determination of train location, speed, direction of travel and status of all operating systems;
- Communication to wayside signal systems and railroad data centers;
- System monitoring of train performance;
- Display of graphic data as received from the railroad;
- Initiation of service or penalty brake applications and locomotive PKO functions;
Test Requirements

- Interface between the PTC system and on-board systems, including event recorders, train monitoring systems and others;
- Data recording, security and download requirements; and
- Compliance with all applicable regulations, standards and system requirements.

Additional railroad-specific data transfer and uploading to the system may occur after the cars have been delivered to the Customer if necessary. The PTC system as designed and installed shall be subject to review and approval by the Customer, the FRA, Amtrak and representatives of the host railroads over which the cars will operate.

19.5.13.3 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.

19.5.13.4 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 analogue inputs shall be shown at zero, midscale and maximum values, which will include applying pneumatic pressure to those inputs by manipulating the brake system. 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 analogue 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. A disk of the download, labeled for car number and date, shall be provided for each car.

19.5.13.5 Event recorder-video performance

Tests shall verify operation of the entire integrated system hardware and software. They shall show correct interpretation of each input. Video focus and resolution, 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.

19.5.13.6 Horn and bell performance

The horn shall be tested to verify compliance with FRA 49CFR Part 229 loudness requirement. The bell shall be tested to measure loudness and proper continued operation.

19.5.14 Pilot Car and Pilot Train Testing

19.5.14.1 Roll angle tests

The first pilot car, simulated to be at AW3 load, shall be placed upon a superelevated track to determine compliance with the clearance requirements by verifying the Contractor’s clearance.
Test Requirements

Diagram despite any body roll and lateral shifting of the car body. The test shall be made at superelevation of 7 in. 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. and 6 in. to measure body roll and wheel unloading to verify compliance with 49CFR Section 213.57(d). The Contractor shall provide a test report providing all data required by 49CFR Section 213.57, and shall fully support Customer’s submission to the FRA with additional information as requested by the FRA.

19.5.14.2 Pilot cars

Pilot car testing refers to the test of the first three cars (one of each type) 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.

19.5.14.2.1 Pilot train testing

After the pilot cars have undergone and passed all applicable proof-of-design and production testing requirements, the three cars shall be combined to form the pilot train for car-to-car operational, compatibility and coupler tests.

All trainline functions shall be tested and verified, including:

- Door control, door system status and traction inhibit
- End of train identification
- Locomotive control
- PA, IC and PIS communications and data transfer
- HEP and power distribution
- Air brake application and release

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:

- Carbody clearance
- Truck swing
- Coupler swing
- MU, COMM and HEP cables
- Brake pipe and main reservoir air hoses
- Diaphragms, buffer plates and diaphragm curtains

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
Test Requirements

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.

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.

19.5.14.2.2 Pilot train compatibility testing

After the three pilot cars have undergone and passed the above, an existing single-level car will be coupled between two of the three pilot cars. The single-level car can be a Viewliner, Amfleet I, Amfleet II, Horizon car or a previously built car to this Specification.

All trainline functions shall be tested and verified, including:

• Door control, door system status and traction inhibit
• End of train identification
• Locomotive control
• PA, IC and PIS communications and data transfer
• HEP and power distribution
• Air brake application and release

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:

• Carbody clearance
• Truck swing
• Coupler swing
• MU, COMM and HEP cables
• Brake pipe and main reservoir air hoses
• Diaphragms, buffer plates and diaphragm curtains

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.
19.5.14.2.3 High-speed testing

The Pilot Train shall be tested in accordance with the applicable requirements of 49CFR 213.345 for vehicle testing at speeds up to 125 mph on the track of a qualified test facility to be selected by the Contractor. Testing shall begin at a speed of up to 50 mph 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 Customer before the decision is made to proceed to the next higher speed increment. The maximum test speed shall be 130 mph 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.

As track class, signal, propulsion and other required infrastructure becomes available on the route intended for service to support speeds of 125 mph, the equipment shall be tested in accordance with 49CFR Section 213.345. Should the infrastructure to achieve 125 mph (test speed of 130 mph) become available at the time of delivery of the vehicle order, the Contractor will be responsible for the conduct of these tests.

19.5.14.2.4 Test instrumentation

Test instrumentation shall be provided by the Contractor to record all data necessary to demonstrate compliance with the acceleration limits identified in 49CFR Section 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.

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.

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.

19.5.14.2.5 Data collection and reporting

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 Customer 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 to 5 miles.

The reporting software shall be capable of generating the following for each data package:

- A time and date stamp.
- A graphical depiction of train location and speed by railroad milepost.
- 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.
- 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.

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.

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 Customer in both paper and electronic media which shall include all software required to format, process and graphically view the test data.

19.5.14.2.6 Test reports

The Contractor shall prepare the required final test reports for submission to the FRA by Customer. 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 Customer 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, or if additional dynamic behavior which may present a safety issue is observed.

19.5.14.2.7 Noise and vibration tests

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 in an open area, from standstill to 70 miles/hour and back to zero speed using full service braking. 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.

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 Engineer’s ear. Measurements with an audio dosimeter shall be conducted in accordance with manufacturer’s procedures as to microphone placement and orientation.

In conducting exterior 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 Engineer’s ear. Measurements with an audio dosimeter shall be conducted in accordance with manufacturer’s procedures as to microphone placement and orientation.

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 feet 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.

Vibration tests shall be made with all car subsystems operating, with the car stationary.

19.5.14.2.8 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 Customer will be required for final approval of the friction brake system.

19.5.14.2.9 Ride quality tests

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 Customer 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 Customer's revenue service environment may, at the sole discretion of the Customer, be accepted in lieu of additional ride quality testing.

Alternately, a test can be performed which compares ride quality test results of an existing vehicle to the new vehicle on the same track conditions. The purchaser will provide a completed test report for the existing car for testing.

The results of these tests shall be compared to the results from the modeling performed as specified in chapter 5.

Instrumentation capable of measuring and charting (for permanent record) the magnitude and frequency of the vertical and lateral shocks expected, up to 1.0g and 0.5 to 50 Hertz, shall be provided and operated by the Contractor, who shall reduce the raw data for presentation to the Customer. 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.

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 Customer, within 60 calendar days, a program containing mathematical analysis of the problem and a course of action for its correction. If the Customer 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.
19.6 Production Tests

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 Customer. 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 Customer to a minimum.

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.

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 Customer inspectors, have been suitably resolved to the Customer’s satisfaction.

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.

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.

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 Customer. 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 Customer 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.

19.6.1 Carbody

19.6.1.1 Watertightness tests

Each car shall be tested for watertightness in both the completed shell and assembled car stages prior to pre-shipment.

Water shall be sprayed from nozzles which are spaced no more than 3 ft from, and aimed directly at, the roof and sides of the car, with the side wall nozzles continuing in a vertical plane to 1 ft above top of rail. Not less than 0.625 gpm shall be delivered to each square foot of...
surface being tested, and the nozzle velocity of the water shall not be less than 150 feet per second. All spray applications shall run for 10 minutes before the inspection for leaks, and shall run continuously during the inspection.

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.

19.6.1.1.1 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 Customer approval.

19.6.1.1.2 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.

19.6.1.2 Wheelchair lift

- Verify all functions, interlocks, safety features and timing
- Demonstrate lifting range
- Demonstrate manual operation of lift

19.6.1.3 AEI tag

A tag reader shall be used to verify that each AEI tag on each car operates correctly and contains the correct data.

19.6.2 Truck Tests

19.6.2.1 All trucks

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 Customer 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 Customer. 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.

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. Magniflux 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 Customer for approval (for castings, typically one casting out of each 25 produced shall be inspected). If determined by the Customer 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 Customer, 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.

19.6.2.2 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.

19.6.2.3 Carbody leveling and floor height

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.

19.6.2.3.1 Truck attachment, leveling and coupler height tests

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.

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. End-to-end differences in height shall not exceed 0.5 in.

19.6.3 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.
19.6.4 Brakes

19.6.4.1 Single car brake and pneumatic system operation

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 SS-M-005-98 (current revision on date of test) shall be met.

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.

19.6.4.2 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.

19.6.4.3 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.

19.6.5 Door System Tests

All doors and their operating systems shall be checked and adjusted on all cars to assure smooth functioning, proper fit, attainment of the specified speed of operation and proper functioning of controls, signals and interlocks. This shall also include all body end doors, except the F-end frame door. All power operated side 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.

19.6.5.1 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.
19.6.6 Interior

19.6.6.1 Interior doors and hardware

- 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.
- Proper engagement of the ceiling hatch safety catches shall be checked.

19.6.6.2 Seats

Operation of each movable function of each seat on each car shall be tested to verify:

- Recline, foot rest, tray table, etc. Tray table shall be level when in the fully extended position.

19.6.6.3 Overhead luggage storage bins

Each overhead luggage bin shall be tested to verify:

- Proper door alignment
-Latch operation
- Hinge operation

19.6.7 HVAC

19.6.7.1 Heater circuit tests

Each heater circuit shall be high potential tested in accordance with IEEE Standard number 16.

19.6.7.2 Heating tests

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.

19.6.7.2.1 Duct heater operation

Duct heat of each car shall be verified for function, uniform temperature distribution and correct current draw.

19.6.7.2.2 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.
19.6.7.2.3 Floor heat operation

Floor heat of each car shall be verified for function, uniform temperature distribution and correct current draw.

19.6.7.3 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.

19.6.7.4 Air conditioning system tests

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.

19.6.7.4.1 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:

- Blower fan
- Condenser fan(s)
- Compressor
- Exhaust fan(s)

19.6.8 Lighting

19.6.8.1 Lighting operation

Proper function of all interior and exterior lighting fixtures and all their controls shall be verified on each car. 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.

19.6.8.2 Marker lights

Proper operation of marker lights shall be verified.
19.6.9  Communication/OTIS

19.6.9.1  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), AVL, wireless LAN and all other communications equipment shall be exercised. The Contractor shall provide as approved by the Customer a suitable simulation of the wayside as necessary to test all communications systems.

19.6.9.2  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, IC communication between stations, trainline communications into and out of the car, and integration of the PA/IC system with the CCU and passenger information system.

19.6.9.3  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.

19.6.10  Electrical

19.6.10.1  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 Customer. Tests shall be in accordance with IEEE Standard number 16 for control apparatus as appropriate.

19.6.10.2  Battery tests

19.6.10.2.1  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)

19.6.10.2.2  Battery capacity

Verify battery meets 5 hour name-plate rating.
19.6.10.2.3 Battery/battery charger performance

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 das-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:

- Sustained low input voltage
- Loss of input phase
- Reversed phase rotation
- Overload or shorted battery charger output
- Battery ground fault
- Temperature sensor fault
- Reversed battery connections
- System overload
- Fault coordination between battery charger system, battery and main DC circuit breakers
- Ability to support large step loads on car, such as door operators cycling

Each battery shall be given a capacity test at the point of manufacture in accordance with APTA Standard RP-E-007-98R1.

19.6.10.2.4 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)

19.6.10.3 Car wiring tests

19.6.10.3.1 Continuity

On each car, all wiring shall undergo a continuity test in which wire labeling, continuity of conductor and proper connection point are verified.

On each car, all wiring shall undergo a continuity test in which wire labeling, continuity of conductor and proper connection point are verified.

19.6.10.3.2 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.
19.6.10.3.3 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.

19.6.10.4 Insulation testing

All wiring on each car shall undergo a megger and high potential test, in accordance with APTA Standard SS-E-001-98.

Insulation resistance tests shall be conducted before high potential tests are conducted.

On items with double insulation, such as grid resistors mounted on an insulated frame, each set of insulation shall be individually tested. (i.e., resistors to frame and frame to carbody.)

19.6.10.5 Trainline tests

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.

19.6.10.5.1 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.

19.6.10.5.2 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.

19.6.10.5.3 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.
19.6.10.6 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.

19.6.10.7 Auxiliary circuits and equipment tests

All auxiliary circuits and equipment shall be tested for proper operation, and adjusted or corrected as required.

19.6.11 Food Service

19.6.11.1 Doors and hardware

All food service doors, hatches and ¼ turn latches shall be functionally checked on each car to verify: smooth movement, latching, locking, correct latch engagement/release, non-interference, freedom from sticking or excessive looseness (rattles) and proper switch activation. Secure gates and latching mechanism shall be tested for correct operation.

19.6.11.2 Food service appliance operation

Each appliance shall receive a functional test to verify operation. Coffee makers shall operate through a complete brew cycle.

19.6.11.3 Elevator

The unit shall be tested to verify proper operation of all controls, limit switches, timing and safety functions.

19.6.11.4 Refrigeration/chiller

Refrigeration equipment shall undergo testing to verify:

- Freedom from refrigerant leaks (evacuation and “sniff test” if split system)
- Operation/calibration of each control device: pressure switches, thermostat, etc - operation of each device in the defrost function: thermostats, heaters, timer, etc -correct superheat setting
- No-load pull down time for each refrigerated space
- Correct thermostat settings for each refrigerated space
- Correct tracking of chiller thermometer with chilled space
- Correct operation of environmental controls for the condenser (if split system): damper, room exhaust fan, etc.
19.6.12 Water and Waste

19.6.12.1 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 and drinking water spigots shall be tested for correct temperature adjustment range, water flow rate and freedom from splashing. All sinks and drinking water alcove shall be tested for proper operation.

19.6.12.2 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.

19.6.12.3 Water cooler operation

Correct operation shall be verified, including chilled water temperature, and operation of the circulation loop and controls, if equipped.

19.6.12.4 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.

19.6.12.5 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. Cab and Controls

19.6.13 Cab and Controls

19.6.13.1 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.

19.6.13.2 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.
19.6.13.3 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.

19.6.13.4 Event recorder-video performance

Tests shall verify operation of the entire integrated system hardware and software. They shall show correct interpretation of each input. Video focus and resolution, 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.

19.6.13.5 Positive 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.

19.6.13.6 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.

19.6.13.7 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 SS-M-011-99.

- Calibration of air pressure gauges shall be verified and values recorded
- Verify operation of each mode of operation shall be demonstrated, in accordance with OEM brake supplier test code, including but not limited to:
  - Passenger mode, freight mode, cutout, test (if equipped)
  - Parking brake, including effect of cutting out automatic brake and penalty brake
• Calibration of brake valve settings of release, min, suppression, full service and
• Emergency measured on brake pipe and brake cylinder. Values shall be recorded.
• Penalty application; non-suppressible and suppressible
• Emergency application; local and remote (all sites on car + remote in consist)
• PCS function
• Operation of pressure switches

19.6.13.8 Cab indicator operation

The test shall verify proper operation of all indicator lights and audio alarms.

19.6.13.9 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.

19.6.13.10 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, noise and freedom from air leaks. Also test proper operation of washer.

19.6.13.11 Defroster/heated windshield operation

Proper function of the defroster and heated windshield, their controls and indicators shall be verified.

19.6.13.12 Horn and bell operation

The test shall verify proper operation of devices and all controls, including automatic sequencer and speed input to it.

19.6.13.13 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.

19.6.13.14 Headlight and crossing light tests

The headlights and crossing lights on each cab/baggage car shall be tested and adjusted in accordance with 49CFR Section 229.125 for proper illumination, orientation, aim and operation.
19.6.14  Completed Car

19.6.14.1.1  Weighing

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 Customer and copies thereof included in the vehicle history book.

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.

Any total car weight deviation of greater than 300 lbs 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 Customer prior to shipment. The Customer may require that the Contractor reduce the weight of any cars exceeding the overall weight or weight distribution limits.

19.6.14.1.2  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.

19.7  Acceptance Tests

19.7.1  Car Acceptance Tests

The tests specified in this section are to be performed by the Contractor on the Customer railroad, or as otherwise designated by the Customer. 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 Customer.

After receipt of each car at the Customer site and before it is operated, it shall be carefully inspected jointly by the Customer 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.
19.7.2 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 Customer 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.

19.8 Post-delivery Testing of Pilot Train with Other Equipment

After the Pilot Cars have been delivered to the Customer’s facility and have undergone and passed all applicable acceptance inspections and tests, the three cars shall be combined with other rail equipment as designated by the Customer to verify car-to-car operational, compatibility and coupler tests with other car types that may constitute part of the Customer’s existing rail service. The specific types of rail equipment with which the Pilot Train shall be tested for compatibility includes:

- P32, P40 and P42 locomotives, as owned by Amtrak
- F59PHI locomotives, as owned by Amtrak, Caltrans, North Carolina DOT and others and used in intercity rail passenger service
- Viewliner rail cars, as owned by Amtrak
- Amfleet I and II rail cars, as owned by Amtrak
- Horizon Cars, as owned by Amtrak
- Other equipment as may be specified by the Customer

All trainline functions shall be tested and verified, including:

- Door control, door system status and traction inhibit
- Locomotive control
- PA, IC and PIS communications and data transfer
- HEP and power distribution
- Air brake application and release

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:

- Carbody clearance
- Truck swing
- Coupler swing
- MU, COMM and HEP cables
- Brake pipe and main reservoir air hoses
Test Requirements

- Diaphragms and diaphragm curtains

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.

19.9 Reliability and Post-Delivery Tests

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 of service shall be included in the data collection activity.

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) found to be causing and/or related subsystem and/or whole car 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.

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 Customer shall resolve any outstanding issues in accordance with the Contract terms and conditions.

* End of Chapter 19 *
Chapter 20

Tools, Consumables and Spare Parts
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20.0 Tools, Consumables and Spare Parts

20.1 Overview

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 and repair the vehicles to be delivered to the Customer.

All information required in this chapter shall also be included in the appropriate operating and maintenance documentation as identified in Chapter 22, including:

- Operating Manual
- Running Maintenance Manual
- Heavy Maintenance Manual
- Illustrated Parts Catalogue
- Troubleshooting Guide

20.2 Specialized Tools

The Contractor shall provide to the Customer five 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 the Customer at a specified location, and shall be delivered to the Customer prior to the acceptance of the first car. All specialized tools shall be included in the base warranty as specified.

As part of the design review process, the Contractor shall submit a list of specialized tools and diagnostic equipment that will be provided to the Customer.

This list shall identify the item description, manufacturer, part number and purpose, and shall include a cross-reference to the maintenance manuals as to the tasks that require the use of the tools. This list shall include all specialized tools and diagnostic equipment required to operate, maintain and repair the vehicles throughout their design life, and shall include:

- Specialized tools for inspecting, repairing, removing, installing, maintaining or measuring components and systems on the cars;
- Diagnostic equipment to troubleshoot problems, determine component or system status or condition, or interpret diagnostic information;
- 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
- All cables, connectors, software, power supplies, carrying cases and peripherals as required for use with the portable computers. All diagnostic, download and programming software shall be provided in Windows operating system format with no use restrictions so that the Customer can install the software on additional computers as needed.
The Contractor shall provide drawings, schematics, specifications, part numbers and prices for all special tools and maintenance equipment to enable the Customer to purchase additional quantities.

### 20.3 Consumables

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.

This list should include items such as:

- Brake pads
- Filters - Heating, Ventilation and Air Conditioning (HVAC), air, water
- Windshield wiper blades
- Lamps/Light Emitting Diodes (LEDs)
- Fuses, Diodes and Resistors
- Air hoses
- Rubber seals and Gaskets

This list shall include the following information as it relates to these parts:

- Contractor part number
- Part description
- Manufacturer name
- Manufacturer part number
- Quantity required by car type
- Frequency of replacement

### 20.4 Spare Parts

As a part of final design review, the Contractor shall provide to the Customer a list of strategic spare parts that the Customer should acquire and maintain to support the fleet of equipment after the end of the warranty period.

This list shall include, but is not limited to the following:

- Parts that are critical to the safe operation of the equipment;
- Parts with a high failure rate, based on the Contractor's reliability analysis (see Chapter 19);
- Parts located on the vehicle exterior and therefore subject to damage from debris strikes or accidents;
- Parts installed in a high-wear environment; and
Tools, Consumables and Spare Parts

- Parts that require troubleshooting and repair off of the car, such as electronic components.

This list shall include the following information as it relates to these parts:

- Contractor part number
- Part description
- Manufacturer name
- Manufacturer part number
- Quantity required by car type
- Shelf life/maximum storage period
- Recommended quantity to have on hand

The Contractor shall be responsible to provide replacement parts for those failing under the terms of the warranty. The Customer shall not be responsible to supply replacement parts to the Contractor for the purposes of fulfilling warranty provisions.

* End of Chapter 20 *
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Chapter 21

Shipping Preparation
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21.0 Shipping Preparation

21.1 Overview

This chapter describes the requirements for preparing completed vehicles for shipment to the Contractor's field site where vehicle acceptance will take place.

All vehicles must receive approval for shipment from the Customer before they can be shipped to the field site.

The Contractor is responsible for all costs and arrangements associated with the shipment of the completed vehicles to the Contractor's field site.

21.2 Requirements for Shipping Vehicles

All completed vehicles shall be prepared for shipping as follows:

- All hoses and inter-car cables shall be connected between vehicles, if more than one car is shipped at a time.
- Brake control valve selector plate shall be set to graduated release if being moved in passenger service (see Chapter 7).
- Cab/baggage car brake valve shall be in the cutout position (see Chapter 16).
- 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).
- New air filters shall be installed in Heating, Ventilation and Air Conditioning (HVAC) system (see Chapter 10).
- All required inspections must be complete, including inspections and approvals from the FRA, the FDA and Amtrak. 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/baggage car as applicable (see Chapter 16):
  - Amtrak MAP 816/FRA F6180-49, Locomotive Inspection and Repair Record ("Blue Card")
  - Amtrak MAP 100, Equipment Condition Report
  - Amtrak MAP 101, FRA Rule No. 229 Inspection Record
  - Amtrak MAP 1173, Class 1 Brake/Calendar Day Test
  - Amtrak MAP 10C, Passenger Car Daily Inspection
- Waste system shall be drained (see Chapter 15).
- All doors and windows shall be closed.
- The Contractor shall perform other shipping-related tasks as required by the Customer.
The following shall be set up at the discretion of each Customer in accordance with the requirements for each shipment of cars:

- 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.

- All circuit breakers shall be on. The main 480VAC Head End Power (HEP) breaker may be on if power will be needed while the car is in transit, or shall be off if no power will be required.

- Diaphragms shall be removed if necessary. If removed, diaphragms shall be properly prepared for shipment by the Contractor to the Contractor’s field site, where they will be reinstalled by the Contractor prior to Customer acceptance of the car.

* End of Chapter 21 *
Standardized Technical Specification

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Chapter 22

Training and Documentation
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22.0 Training and Documentation

22.1 Overview

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.

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.

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 Customer 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, Amtrak and others.

22.2 General Requirements

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 Customer. Sharp, clear drawings shall be used throughout the documents for illustration. Photographs may be used only where explicitly approved by the Customer. 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, vertical format. All other documents shall be 8.5 in. wide by 11 in. 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. Plastic coated tabs shall be used to segregate sections within each publication.

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 Customer for approval. Chapter numbers shall be consistent for all documents.

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 Customer. Each updated information submittal shall be accompanied by a file containing a revised list of effected pages for the manual set being changed.

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 Customer to control ECSBs, such as using note tools on the existing electronic PDF versions and/or the development of master lists of outstanding ECSBs.

22.2.1 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 Customer 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:

- Operation
- Service and inspection
- Troubleshooting
- Running maintenance
- Heavy repair/overhaul (vehicle and system/component level)
- Part identification (to the lowest repairable level)
- Wreck repairs
- Modification of equipment (documenting as-built configuration)

22.3 As-Built Drawings

The Contractor shall provide the Customer 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 a Customer-approved 3-D CAD format and shall meet the requirements of Amtrak Specification 700. 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 these items.

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.
22.3.1 Drawing Availability

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

A complete set of as-built drawings shall be delivered within 30 days after the delivery of the first car of each type. CDRL

A complete bill of material for the car, in standard 8.5 in. by 11 in. size, and on Compact Disk (CD), 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

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 Customer to conduct equipment modifications, conduct overhauls or make extraordinary repairs, such as those arising from accidents, etc.

22.3.2 Drawing Originals

The Contractor shall submit to the Customer 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 Customer at no cost. Likewise, if the Contractor terminates operations, all drawings pertaining to this project CAD files or any other Customer approved media, shall be provided to the Customer free of charge.

22.3.3 Compact Disks (CDs)

Within 30 days of the delivery of the last car of the base order of equipment, the Contractor shall provide four sets of CDs 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. CDRL

22.3.4 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., showing the progression of construction of the first car of each type. The images shall also be supplied in digital format. CDRL

22.3.5 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., 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
22.3.6 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 Customer within 30 days following completion and acceptance of the first car of each base type.

22.4 Conformed Specification

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 Customer review and approval. One reproducible hard copy and four CD copies of the approved version shall be provided.

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.

22.5 Manuals

The Contractor shall provide a complete family of operating and maintenance manuals. The following manuals are required:

- Operator’s Manual
- Service and Inspection Manual
- Troubleshooting Guide
- Running Maintenance Manual
- Heavy Maintenance Manual
- Integrated Schematic Manual
- Illustrated Parts Catalog

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.

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.

All manuals shall have, at a minimum, the following information on the front cover:

- Contractor name
- Customer name
- Type of equipment
• Car numbers and reporting marks
• Date and level of revision

Contractor manuals shall be provided electronically in an editable word format or other Customer approved language.

22.5.1 Manual Review and Availability

The Contractor shall develop a master plan and schedule for the development and completion of the manuals. This manual development plan shall be submitted to the Customer 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.

A full set of draft manuals, including those provided to the Contractor by suppliers, shall be submitted for Customer review no less than 90 days prior to the release of the first car. If the manuals require revision, as determined by the Customer, 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 Customer has approved the final draft of the manuals. The Contractor shall provide 10 full sets of manuals to the Customer prior to Customer acceptance of the first car.

22.5.2 Manual Updates

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 Customer. Upon the completion of the warranty period, the Contractor will issue 10 sets of finalized manuals to the Customer, reflecting all changes made to the vehicles during production, delivery and operation, and the status of all cars at the time of warranty expiration.

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.

22.5.3 Work Management System

If specified by the Customer, the manuals will be used electronically in Amtrak’s Work Management System (WMS). The Contractor shall work with the Customer and Amtrak to ensure that this is implemented successfully.

22.5.4 Operator’s Manual

The Contractor will develop operating manuals for use by train operating personnel, including the Engineer, Conductor and food service Lead Service Attendant (LSAs). 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.

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.

The operator's manual shall be divided into chapters as follows:

1. Introduction
2. Communications
3. Inspecting
4. Operating
5. Fault Isolation
6. On-the-Road Repair
7. General Description

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:

- Index
- Safety instructions
- Instructions for communications during fault isolation
- Authorized fault isolation procedures
- Authorized on-the-road repairs
- Equipment location diagrams

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.

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.
22.5.5 Service and Inspection Manual

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, Amtrak and the FRA for all periodic inspections including those occurring daily, every 30 days, every 120 days and annually (every 368 days). Additional or differing intervals such as 92 days and 184 days shall be included if used by the Customer's maintenance provider. Inspections and servicing activities occurring on an interval that is not used by the Customer's maintenance provider shall be included in the tasks shown for the next more frequent interval.

The inspection tasks described in this manual shall include, but are not limited to the following:

- Item or system requiring inspection
- Frequency or period of inspection
- Inspection procedure, including location and description of system being inspected
- Pass/fail criteria for inspection
- Special tools, conditions or other requirements for inspection to be performed
- Source of inspection requirement (Contractor, Amtrak, FRA, etc)
- Reference for inspection requirement (CFR, maintenance manual, etc)

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.

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:

- Fresh water filling
- Waste tank draining
- Removal of trash and recyclables
- Installation and replacement of consumables
- Inspection and replacement of filter elements
- Cleaning and lubrication
- Replacement of brake shoes and pads

This manual shall be provided in a comb-bound format approximately 5 in. wide by 8 in. 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.
22.5.6 Troubleshooting Guide

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:

- Carbody
- Trucks
- Coupler and Draft Gear
- Brakes
- Door System
- Interior
- HVAC
- Lighting
- Communications
- Electrical System
- Food Service
- Water and Waste
- Cab and Controls
- Emergency Equipment

This manual shall provide procedures for the identification, diagnosis and proper correction of car failures and malfunctions. Procedures shall be organized so that maintenance personnel can isolate faults down from consist to car, from car to system, and from system to subsystem, assembly, subassembly or component. 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. Troubleshooting procedural format shall include fault codes for each system with built-in diagnostics and fault information and corrective actions displayed by the diagnostic system. All fault codes are to be included, and diagnosed, in the troubleshooting manual. 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.

Each chapter of the troubleshooting procedures shall contain the following sections:

- Introduction, including general information, safety precautions, and definition of warnings, cautions, and notes with specific details
- Operational and functional system descriptions
- Troubleshooting
- Corrective maintenance procedures

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. The troubleshooting and corrective maintenance procedures shall contain:

- Identification of the system covered
- A concise explanation of the troubleshooting format and how to use the procedure
- Test equipment and tools required
- Safety precautions that must be taken
- A reference to the supporting block diagrams
- Preliminary tasks that must be performed prior to initiating troubleshooting

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.

22.5.7 Running Maintenance Manual

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.

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.

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:

- 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.
- 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.

- 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.

22.5.8 Heavy Maintenance Manual

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 Repair Manual shall contain a detailed description and analysis of all mechanical, electrical and electronic assemblies/subassemblies so that Caltrans 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 Customer.

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.

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.

The manual shall include descriptions of how each assembly/subassembly operates within the car system. Each shall include:

- Block diagrams
- Signal flow diagrams
Training and Documentation

- Simplified schematics
- Functional wiring and piping diagrams
- Completely detailed overhaul procedures
  - 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 Customer all such specialized test equipment.
  - Rewinding procedures in full detail for all rotating and wire-wound apparatus, except as agreed to otherwise by the Customer.
  - 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.
  - 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.
  - 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 Caltrans equipment. The rebuild operation allows returning to zero those age measurements including, but not limited to, hours and miles, considered in classifying the Customer’s equipment and components.
  - Complete instructions for use, drawings and parts information for all special tools that are required to be provided to the Customer by the Contractor.
  - The weights of all components and assemblies that weigh more than 50 lbs. In addition, the weights of major component assemblies shall be supplied such as the truck, air conditioning compressor, air compressor, etc.
  - Maintenance, calibration and adjustment, repair and overhaul of all diagnostic test equipment.

22.5.9 Integrated Schematic and Wiring Manual

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 Amtrak Standard 700. The manual shall provide schematic and wiring diagrams including (but not limited to) the following:

- Electrical power distribution
- Trainline assignments and connections to car-borne equipment
- Door control system
- Lighting system (interior and exterior, in normal, standby and emergency modes)
- Communications system, including PA, intercom and passenger information system
Training and Documentation

- HVAC system, including chiller units in the café-lounge car (electrical, refrigerant and air flow schematics)
- Brake system (electrical, mechanical and pneumatic)
- Main reservoir air distribution system
- Fresh water distribution and waste retention systems (electrical, pneumatic and water routing)
- Wheelchair lift (electrical and hydraulic, if used)
- Food service galley equipment, including the elevator and all galley appliances (electrical, water distribution)
- Cab and controls

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.

The integrated schematic manual shall be supplied in tabloid format, 11 in. tall by 17 in. wide, horizontal format, spiral bound with a protective laminated cardstock front and back cover.

22.5.10 Illustrated Parts Catalog (IPC)

The Illustrated Parts Catalog (IPC) shall enumerate, illustrate and describe every item used on the cars, along with the diagnostic test equipment and special tools with its related parts, down to the Lowest Level Replaceable Unit (LLRU). The LLRU is defined as the lowest level of component assembly which consists of a separate individually fabricated part, including all hardware items required to assemble, disassemble, repair or overhaul the component. Each listing shall include the accepted generic modified noun name description, the original supplier, the original supplier’s part number and name and the Contractor’s part number. An appendix giving the original supplier’s complete address and telephone numbers for their offices responsible for parts ordering shall be included. Each component that can be disassembled included all printed circuit board components and items which may have been purchased by the Contractor as a subassembly, must be broken down in illustrations to fully indexed parts. The Customer shall have the right to make direct purchase from the sources listed by the Contractor. If provided to the Contractor, all Customer part numbers will be included in the IPC.

Identical parts, regardless of where used in the car, shall use only one part number. Each part or other item shall be identified as being part of the next higher assembly. In the case of hardware such as nuts, bolts, washers, etc., information relative to material, coating if any, all dimensions and types shall be included. All assemblies shall be listed alphabetically by name with reference to corresponding figure number.

The IPC shall include two cross-reference lists that sort all listed parts as follows:

- Sorted alphanumerically by part number
- Sorted alphabetically by part name
These cross-reference lists shall include the part name, manufacturer part number, manufacturer or supplier, contractor part number, and the page and illustration number where found in the IPC.

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. If the same drawing is used in both the illustrated parts catalog and either the running maintenance or heavy repair manual, the reference index in both manuals must identify the same parts.

### 22.5.11 Manual Quantities to be Provided

<table>
<thead>
<tr>
<th>Name</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operator’s Manual</td>
<td>200</td>
</tr>
<tr>
<td>Service and Inspection Manual</td>
<td>50</td>
</tr>
<tr>
<td>Running Maintenance Manual</td>
<td>10 sets</td>
</tr>
<tr>
<td>Troubleshooting Manual</td>
<td>10 sets</td>
</tr>
<tr>
<td>Heavy Maintenance Manual</td>
<td>10 sets</td>
</tr>
<tr>
<td>Illustrated Parts Catalog (IPC)</td>
<td>10 sets</td>
</tr>
<tr>
<td>Integrated Schematic Manual</td>
<td>10 sets</td>
</tr>
</tbody>
</table>

Manual quantities are subject to change.

### 22.6 Vehicle History Books

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.

The vehicle history book shall contain original documents unless specified otherwise.

All documents shall be marked with the carshell serial number, the production sequence number or the road number for the completed vehicle.

The Contractor shall provide one electronic and three paper sets of the vehicle history book for each car; one that contains the original documents, and two copies. 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.

At a minimum, each vehicle history book shall contain the following:

- Table of contents
- Production control cross-reference sheet, listing:
  - Carshell serial number
  - Shop order/production sequence number
Final car reporting marks and road number

Production schedule for each car showing start and end dates for each major stage of manufacturing

List of all production drawings by number and revision status (release date, current revision, and outstanding engineering change requests at time of production)

List of all parts by supplier and part number (bill of material)

List of all serialized components

Truck records (separate set of records for each truck)
  - Inspection records
  - Truck assembly sequence
  - Truck assembly weight certificate
  - Wheel/axle pressing graphs
  - Truck to carbody attachment record

Log of all non-conformances including status

Component test certificates

Test records:
  - Master test plan
  - Test procedures
    - Production tests
    - Acceptance tests
  - Record of measurements and results

Critical dimensional inspection report
  - Carshell dimensional inspection (prior to production)
  - Carbody leveling, balancing and centering record
  - Carbody overall dimension measurement, including compliance with clearance diagram
  - Coupler height measurement
  - Scale certificate for completed car (dry weight)

Records of all required inspections

USPHS Certification

FRA documentation
  - Copies of required cab/baggage car inspection forms (originals are to be installed in the appropriate form holders in the cab of the cab/baggage car)
  - Record of compliance with FRA regulations

Completed pre-shipment checklist

Shipping approval form

Customer acceptance form
Training and Documentation

- Transfer of title of the car from Contractor to Customer (with original wet-ink signature of Contractor’s representative).

The vehicle history book shall be produced in an electronic format as either as a Microsoft Word, Excel, FileMaker Pro or an Adobe PDF file on a CDROM. Procedures, electronic signatures and controls shall be established to ensure the validity of information in this document at all times.

Each vehicle history book shall be presented to the Customer prior to the car being released from the Contractor’s facility.

22.7 Training

The Contractor shall organize and present formal instruction programs for personnel who will operate, maintain, repair and troubleshoot the rail cars. In addition, the Contractor shall provide instruction and training materials for personnel who shall train others in the future.

The Contractor shall submit to the Customer for approval a minimum of 60 days prior to completion of the first of the pilot cars a detailed outline of the training program, and a schedule for its presentation. This submittal shall include the hours of classroom and “hands-on” training projected per subset, final course content, the qualifications of the instructors, a listing of training aids to be used and a description of the scope of instruction, on an individual subset level, to fulfill the program requirements.

The Contractor may assume that maintenance personnel have the basic skills pertinent to their crafts. The manuals shall be used as the major element of the training program.

The Customer shall advise the Contractor as to how many individuals of each discipline are to be trained at each location.

The Contractor shall provide a program to train and educate personnel in all details of the equipment as required to enable the Customer to satisfactorily operate, service, and maintain the vehicles. The program shall include up to 300 Contractor hours of classroom training at each designated site, up to four sites; 160 of which shall be for operations and the remainder for maintenance. A primary objective of the program shall be to develop within the Customer the capability to perform similar training under its own training program subsequent to the Contractor’s involvement. The training shall be designed to be delivered by an instructor in the classroom and, when appropriate, in the field or shop when actual equipment is used. The Customer shall have the right to videotape any classroom training sessions. The Customer will retain ownership of the videotapes, following a final editing as mutually agreed with the Contractor and will have the right to use videotapes for future training sessions.

The Contractor’s program shall include formal and informal instruction, mockups, models, manuals, diagrams and component catalogs. All materials used in the programs, such as models, manuals, mock-ups, video cassettes and drawings, shall be of durable construction and shall become the property of the Customer. Training materials shall be updated as required during the course of instruction. The Contractor shall assume no knowledge of the features of the supplied equipment on the part of the Customer personnel. However, the Contractor may assume that maintenance personnel have the basic skills pertinent to their crafts.

The training programs shall take place at up to four maintenance locations as designated by the Customer. Field instruction may be provided in locations approved by the Customer using...
actual cars or mockups to provide hands-on instruction in the maintenance and operation of the rail cars.

Before delivery of the first pilot car of each type, the Contractor shall provide the Customer with a proposed training plan incorporating the following elements:

- Description of the training program, including program goals and objectives, sequence of activities, course outlines, evaluation methods, required resources and time required for each part of the program.
- Schedule of instruction, based on 300 hours of instruction at each location.
- State of the Contractor’s experience in organizing and delivering similar training programs and qualifications of the designated instructors.
- List of training materials to be provided by the Contractor to support the training program.
- Instruction guides for each course to be taught within each program.
- Student workbooks for each course, each workbook including a syllabus, objectives, schedule, outlines, figures, lesson summaries and any other appropriate instructional information.

All informative material, audio and video training aids and notes shall be supplied beyond that given in the instruction manuals to clearly explain all systems and subsystems that the work force will maintain. All instructional materials will become property of the Customer.

22.7.1 User Training

The Contractor shall provide a user training program, designed for Customer operating, maintenance and training personnel. This is to acquaint them with the equipment in order to provide sufficient working knowledge to safely operate, inspect, service and maintain it. The training program shall include formal classroom instruction, as well as practical demonstrations and activities on the actual new vehicles. The Contractor and/or suppliers shall provide appropriate training aid in the classes as required.

Class audience will be:

- Operating personnel
- Maintenance personnel
- Food service personnel
- Supervisors and management
- Training department personnel
- Customer representatives
- Others as required

22.7.2 Training Requirements

The courses listed below shall be accompanied with training manuals, guides, training aids, student and instructor workbooks, and operator and maintenance manuals. It is the desire of the Customer that the content and structure of the manuals be used as direct input into the training course materials where applicable.
22.7.2.1 System Operation Instruction Training Course (Course #1)

This course shall include:

- General vehicle familiarization;
- Location, function, and operation of pertinent controls, gauges, indicators, and switches;
- Subsystem inspection, setup, and shutdown procedures;
- Trouble symptoms diagnostic and troubleshooting procedures for isolating and correcting minor faults including, at a minimum, techniques for the following:
  - Release of brakes;
  - Door isolation and cut-out;
  - Breaker and/or fuse reset or replacement;
  - Head End Power (HEP) failure recovery;
  - Any other techniques that would assist operators in quickly bypassing non-critical safety subsystems, allowing trains to safely depart the main line to a convenient service location.
- Towing
- Emergency Procedures including, at a minimum, techniques to respond to fire on board or emergency evacuation.

This class shall be conducted four times (twice for operations personnel, twice for maintenance personnel). The first class shall be conducted at the time of the arrival of the first pilot car. Subsequent classes shall be scheduled as approved by the Customer. This class shall include at least 40 hours of training.

22.7.2.2 Repair and Maintenance Training Course (Course #2)

Course #2 shall include and expand on the information furnished in course #1, and shall include basic schematic and block diagrams to provide fault diagnosis information and training appropriate for in-service maintenance.

Course #2 shall provide the training needed for the following:

- Troubleshooting in-service failures as described in course #1
- Performing running maintenance including:
  - General servicing
  - Lubricating
  - Inspecting
  - Adjusting

The training shall include maintenance instructions on the use of the integrated wiring diagrams.

Participation shall include up to 20 electricians, mechanics and foremen. This class shall be conducted twice. The first class shall occur immediately following course #1 and be attended
Training and Documentation

by maintenance personnel. The second class shall be scheduled as approved by the Customer. This class shall include a minimum of 80 hours.

22.7.2.3 Workshop Training (Course #3)

The workshop training course shall provide the training for in-shop repair and trouble diagnosis of each LLRU to the level of the lowest replaceable component. The training shall contain detailed explanation of flow charts, schematic drawing and detailed analyses related to each LLRU so that the Customer maintenance personnel will be able to effectively service, inspect, maintain, adjust, troubleshoot, repair, replace and overhauled the LLRU. The flow charts, schematic drawings and detailed analyses shall be included in the training manuals.

The training shall include maintenance instructions on the use of the integrated wiring diagrams and shall include reference to the manuals.

The major sections of the workshop training course will address, at a minimum the following subsystems and products, as defined above:

- Friction brakes
- HVAC
- Carbody
- Auxiliary electrical/Electrical/Power distribution
- Trucks
- Door controls and operators
- Coupler and draft gear
- Communications
- Waste and water
- Cab controls
- Microprocessor-based products

This course shall also provide Customer maintenance and stores personnel instruction on the use of the illustrated parts manual.

Participation shall include, up to 25 electricians, foremen, and purchasing/storekeepers. This class will be conducted twice. It shall follow the first course #2; others shall be conducted at dates to be scheduled as approved by the Customer. Each class shall include a minimum of 120 hours.

22.7.2.4 Diagnostic Test Equipment (DTE) and Special Tools Course (Course #4)

This course shall provide instruction on the proper use of DTE and special tools during application, operation, usage, adjustment, inspection, maintenance, troubleshooting, repair and storage instructions.

It shall be conducted twice. It shall be conducted upon the delivery of the test equipment and special tools and as agreed upon by the Customer. It shall be a minimum of 20 hours.
Subjects addressed shall include:

- Introduction
- General description of the equipment
- Description of controls and indicators
- Operation of equipment
- Operation of safety and emergency equipment
- Troubleshooting
- Introduction and use of operator and maintenance manuals
- Review

22.7.3 Training Materials

Draft copies of the training materials shall be provided for Customer review and approval, with sufficient time to allow review and Contractor revision. Open discussion is encouraged early in the development process between the Suppliers, Contractor and the Customer.

The Contractor shall provide materials to support each course in the training program, including: instructor guides, training aids, student workbooks, and operator and maintenance manuals. Instructor guides and student workbooks shall be submitted for Customer’s approval 60 days in advance of the start of the first class for each category of training. All training materials shall become the property of the Customer. The instructor guides and student workbooks shall be submitted as camera-ready copy in a form that allows easy reproduction; such as, loose-leaf bound, black ink on 8.5 in. by 11 in. white paper, printed on both sides and numbered sequentially within units of training. Any viewgraphs used in training will be supplied along with camera-ready, paper copy. Master copies of slides and other audiovisual materials shall also be provided to allow for reproduction as necessary.

22.7.3.1 Instructor Guides

The Contractor shall provide an instructor guide for each training course. The guides shall include course agendas; course objectives; procedures for managing training sessions; resources and facilities required; guidelines for preparing for training; detailed lesson plans, including scripted or outlined presentations and discussion guides; training aids and job aids; pre-tests and post-tests; criteria and methodology for measuring performance in the classroom and in the shop/field; instructions for using any audiovisual support, mockups, and scale models; and detailed instructions for managing any on-the-job training.

22.7.3.2 Training Aids

The Contractor shall provide training aids, such as mock-ups, scale models, overhead transparencies, videotaped demonstrations, diagnostic testing equipment and any special tools required. These training aids shall become the property of the Customer upon the completion of the training program.
22.7.3.3 Student Workbooks

The Contractor shall provide, for each course, a student workbook, which shall include course agenda, course objectives, schedule of sessions, paper copies of overhead transparencies, lecture outlines, lesson summaries and any other information that will facilitate the learning process.

The training program shall be conducted prior to the start of the new equipment in revenue service. The Contractor shall develop a training action plan and schedule and submit it to the Customer within 90 days of Notice to Proceed (NTP), and shall update it periodically, to be submitted with program meeting minutes.

Paper and electronic (editable and PDF) copies of all training materials shall be provided at the completion of the training program, and shall become the property of the Customer for unrestricted use for future training purposes.

* End of Chapter 22 *
Chapter 23
Customer Variables
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23.0 Customer Variables

23.1 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.

23.2 Supplemental Regulations, Standards, Specifications and 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.

23.2.1 Specifications

[THIS SPACE RESERVED FOR SUPPLEMENTAL SPECIFICATION DOCUMENTS THAT MAY BE USED BY THE CUSTOMER FOR SPECIFIC VARIABLES.]

23.3 Exterior Graphics

The Customer 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.

All decals, graphics and signage shall be specified and designed to function in the operational, environmental and climatic conditions specified in Amtrak Specification 963 with no fading, material degradation, delamination, discoloration, shrinkage or expansion, wrinkling or peeling.

All paint shall include, at a minimum, a primer coat, color coat and clear coat, applied in accordance with manufacturer specifications.

23.3.1 Paint and Styling

The exterior of the cars shall be painted and styled in accordance with [CUSTOMER SPECIFICATION]. The Customer shall provide paint chips to be used for precise color matching for all paint application.

23.3.2 Car Numbers, Reporting Marks and Names

The Customer shall provide the reporting marks, road numbers and other car-specific identifiers to the Contractor no more than 45 days after Notice to Proceed (NTP).
23.3.3 Decals and Exterior Arrangement

Customer-specific decals and graphics shall be installed in accordance with the Customer’s standards for service name, logo and identity.

All decals shall be retro-reflective unless specified otherwise.

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.

Emergency-related decals and signage shall conform to all applicable APTA standards and FRA requirements.

23.4 Seats and Interior Arrangement

23.4.1 Seat Specification

Passenger seats shall be supplied that conform to the requirements of [CUSTOMER SPECIFICATION].

23.4.2 Seat Pitch and Interior Configuration

Seats shall be installed using a nominal seat pitch as specified by the Customer. Seats, workstation tables and intermediate windscreens shall be installed in the arrangement and orientation as shown in Chapter 9. Seats shall be located to match window pillars so that all seats are located at a window and do not have an obstructed view. No seat shall be located adjacent to a blank wall. Overhead reading light units shall be located over each seat.

23.5 Interior Décor – Additional Customer Requirements

The Contractor shall develop color palettes and storyboards as required by Chapter 9 to provide an interior décor that will be complementary to the interior décor of the fleet of cars owned by the [CUSTOMER]. The Contractor may propose alternate fabrics to those listed below, provided that the interior décor of the new cars presents a comprehensive package of interior components that complements the décor of both new and existing cars.

The major components of the interior décor of the existing Customer fleet are as follows:

23.5.1 Carpet

Refer to [CUSTOMER CARPET SPECIFICATION].

23.5.2 Curtains

Refer to [CUSTOMER CURTAIN SPECIFICATION].

23.5.3 Seat Fabric

Refer to [CUSTOMER SEAT FABRIC SPECIFICATION].

* End of Chapter 23 *