

Amtrak
Mechanical Department
Bureau of Rolling Stock Engineering

SPECIFICATION

for

Diesel-Electric Passenger Locomotives

PRIIA SPECIFICATION No. 305-005
AMTRAK SPECIFICATION No. 982

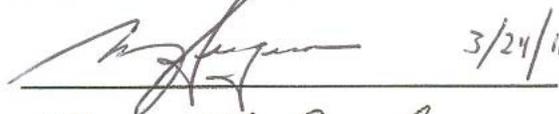
Revision A

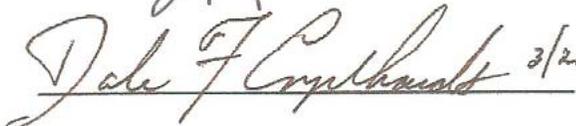
Release Date: July 10, 2012

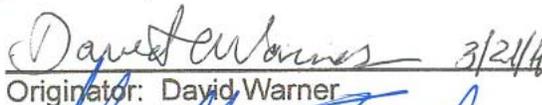
Initial Release: Approved Issue Date: March 16, 2011

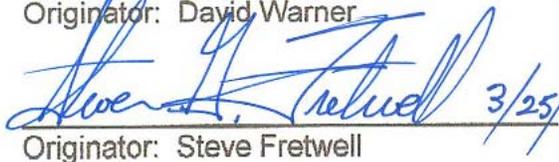
Approved Date

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Specification Change Sheet

* Missing DCR numbers represent submitted DCRs that were not accepted for inclusion or accepted, but superseded by later DCRs.

| From Initial Release to Revision A — July 10, 2012 | | |
|--|--------------|---|
| DCR | Section(s) | Description |
| 005-0001 | 2.1 | Defined acceptable proof of compliance. |
| 005-0004 | 3.5.1.5 | Added statement that the contractor's reliability database be compatible with the customer's own maintenance or reliability database. |
| 005-0005 | 22.0 | Changed "Operator" to "Engineer" |
| 005-0006 | 3.5.1.5 | Added statement that the contractor's reliability database be compatible with the customer's own maintenance or reliability database. |
| 005-0008 | 2.2 | Defined who has to approve a change. |
| 005-0009 | 1.4.5 | Added overall carbody dimensions must include any antennas and any other devices mounted upon the carbody. |
| 005-0010 | 18.4 | Added provisions for using Velcro-like materials. |
| 005-0011 | 18.18.4 | Changed copper tubing to stainless steel tubing. |
| 005-0013 | 2.3 | Added trainset definition. |
| 005-0014 | 18.18.4 | Removed language referring to copper piping. |
| 005-0015 | 3.4.2 | Added bullet regarding proper recycling symbol marking. |
| 005-0016 | 3.5.2.3 | Added wheelchair lifts and elevators to bulleted list. |
| 005-0021 | 3.1 | Added verbiage on interchangeability determination being made in the design review and approval process. |
| 005-0022 | 3.7.6 | Removed "static" and "dynamic" testing. |
| 005-0023 | 22.5.1 | Changed "final" to "draft". |
| 005-0024 | 22.7 | Changed 300 to 600 Contractor hours. |
| 005-0025 | 3.4.1 | Changed who Contractors QA Program report directly to. |
| 005-0026 | 3.4.1 | Added official records may be maintained in HR department. |
| 005-0027 | 3.5.1 | Added the opportunity to use a database other than FileMaker Pro. |
| 005-0028 | 3.4.1.3 | Added verbiage regarding internal audit records review availability. |
| 005-0029 | 18.9 | Changed language regarding labeling. |
| 005-0030 | 2 plus | Changed Amtrak references to PRIIA-related specifications and documents. |
| 005-0031 | Front Matter | Added "FRA Disclaimer Statement" to the "Disclaimer of Warranties and Limitation of Liability" page. |
| 005-0032 | 4.4.6 (new) | Added end frame structure strength requirements. |
| 005-0034 | 1.3 | Modified diesel engine full performance environmental limits. |
| 005-0035 | 13.1 | Clarified HEP requirements. (Note: Associated Requirements Document change made per DCR-005-0054.) |
| 005-0036 | 1.4.6.2 | Modified locomotive compatibility and interface requirements. |
| 005-0038 | 5.5 | Added verbiage to allow other axle designs, if approved by the Customer. |
| 005-0040 | 19.3.21 | Replaced with more precise language. |
| 005-0041 | 7.2 | Removed specific location for placement of single brake system manifold. |
| 005-0042 | 7.4 | Added compliance to APTA Standard SS-M-011-99. |
| 005-0043 | 8.4.2 | Deleted text re: side windows used as an emergency escape function. |
| 005-0045 | 8.10 | Allowed for the option of the HVAC unit to be mounted on the cab roof. |

Specification for PRIIA Diesel-Electric Passenger Locomotives

| From Initial Release to Revision A — July 10, 2012 | | |
|--|-------------------|--|
| DCR | Section(s) | Description |
| 005-0046 | 8.12 | Added metric equivalent of 2 ft ³ (56 liter). |
| 005-0047 | 9.3.7 | Added language for self-testing of multiple-engine locomotives. |
| 005-0048 | 15.3 | Sand box locations: added, “or mounted to the carbody.” |
| 005-0049 | 16.1 | Required synchronized time clocks of specified onboard systems. |
| 005-0050 | 16.3 | Removed “...traction motor current...” as a monitored item. |
| 005-0051 | 18.15.3 | Removed “axles” from bulleted list. |
| 005-0052 | 2.3.1 | Added VVVF – Variable Voltage Variable Frequency |
| 005-0055 | Various | Supplements DCR-005-0030 to complete the Amtrak-to-PRIIA “clone” transition of specifications and documents. |



Disclaimer of Warranties and Limitation of Liability

- (A) User assumes all risk and liability for all loss, damage or injury to persons or property resulting from the use of the Specifications, including in manufacturing processes or in combination with other specifications or otherwise.
- (B) The Section 305 Next Generation Corridor Equipment Pool Committee (NGEC) makes no warranties of any kind, expressed or implied, in relation to this Specification, including but not limited to, any implied warranties of merchantability and fitness for any particular purpose.
- (C) In no event will the NGEC or any members thereof be liable for any damages, lost savings, or other actual, direct, incidental, or consequential damages, including, but not limited to, damages arising from the use, loss of use, or performance of any equipment constructed pursuant thereto, even if the NGEC or any members thereof have been advised of the possibility of such damages, or any claim against any other party arising hereunder.

FRA Disclaimer Statement

- (A) All equipment for intercity passenger rail operation must, at a minimum, comply with the current Federal railroad safety laws and regulations contained in Subtitle V of Title 49, U.S.C., and Chapter II, Subtitle B of Title 49, C.F.R., that are applicable to passenger equipment. Any provision in this Specification that exceeds or is contrary to a requirement of the existing Federal railroad safety laws or regulations, or both, does not constitute an amendment to those laws and regulations in any way.
- (B) The use of third-party standards or specifications in this Specification does not create an exemption from complying with any applicable Federal law or regulation. Before any equipment supplied pursuant to this Specification that is not in compliance with applicable Federal law or regulation can be operated in the U.S., an appropriate waiver must be obtained from FRA's Railroad Safety Board.
- (C) FRA considers the identification of component suppliers and any other commercial entities within this Specification as being illustrative to help describe expected performance, and does not constitute a recommendation or product endorsement by FRA.

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Standardized Technical Specification

PRIIA 305 Next-Generation Equipment Committee
Diesel-Electric Passenger Locomotives

Chapter 1

Executive Summary

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1.0 Executive Summary

1.1 Overview

This Specification defines the system and performance requirements for the design, development, construction and testing of a passenger locomotive. The locomotive shall be diesel-electric powered (related alternative technologies will be considered) for use in intercity corridor and commuter passenger service.

The locomotive shall be capable of operating at a sustained speed of 125 mph.

1.2 Regulatory Compliance

The locomotive shall comply in all respects with the applicable standards and recommended practices of the Federal Railroad Administration (FRA), Association of American Railroads (AAR), American Public Transportation Association (APTA), NRPC (Amtrak) and all applicable Federal and State laws, rules and regulations and all industry recommended practices in effect at the time of the signing of the Contract. These standards and practices shall continue to apply during construction of the locomotive, up to the time of acceptance of the locomotive at the time of delivery.

If a conflict is discovered or arises among any of the above requirements, the following order of priority shall govern:

1. FRA/US Environmental Protection Agency (EPA)
2. Purchase Agreement and Specifications
3. APTA Standards and Recommended Practices
4. AAR Standards and Recommended Practices
5. NRPC (Amtrak) or other railroad specific requirements in accordance to the contract specification

1.3 Basic Features and Characteristics

This section is intended as a quick guide of the basic features, characteristics and requirements for a high reliability, fuel efficient locomotive for passenger rail service. Designed for 125 mph operating speed (as defined by 49CFR Section 238.5/Tier 1):

- Diesel-electric propulsion with Alternating Current (AC) traction motors
- Lowest possible weight and unsprung mass
- Streamlined design
- Full width locomotive cab
- Environmental and operating conditions as specified in PRIIA Specification 305-912. Diesel engine shall produce full rated power at ambient temperatures of up to 104°F and altitudes of up to 1300 ft (approximately 400m) above sea level.
- US EPA Tier 4 emissions (2015)
- High fuel efficiency, in particular with regard to specific passenger service requirements
- Modular design
- Low maintenance and life cycle costs
- Electronically controlled air brake
- Dynamic brake with blending operation
- Push-Pull and Multiple Unit (MU) operation

Main data:

- Traction power sufficient for eight multi-level car train (two locomotives) 125 mph
- Head End Power (HEP) 3-phase 480V 600kW minimum
- Fuel tank size - US gallons 1,800 gal, Estimated Range 1,100 to 1,250 miles
- Operational with 6 in. cant deficiency
- Incorporate Crash Energy Management (CEM) features
- Compliance with Amtrak Clearance Diagram D-05-1355 (latest revision)

1.4 Dimensions, Weights and Environmental Operating Design Considerations

The locomotives built to this Specification shall be suitable in all respects for use over lines throughout the United States. Locomotive weights, dimensions and operating performance requirements are detailed in the paragraphs following.

The minimum design service life shall be 25 years. Life should apply to entire locomotive except consumables as well as planned overhauls and replacements.

1.4.1 Track and Profile

| | |
|-------------------------------|--|
| Nominal gauge | 4 ft 8.5 in. |
| Minimum horizontal curve | 250 ft radius horizontal curve (23 degree curve) for coupled locomotives and for a locomotive coupled to an 85 ft car. |
| Minimum vertical curve | 1000 ft radius (concave or convex) for coupled locomotives and for a locomotive coupled to an 85 ft car. |
| Maximum track super elevation | 7 in. |

Operation may be on all classes of track maintained to FRA standards, for speeds of up to 125 mph.

1.4.2 Clearances

Locomotive design and construction shall conform to the Amtrak Clearance Diagram D-05-1355 (latest revision) and the following:

Within the 180 days following Contract Award, the Contractor shall submit a detailed static outline diagram of the proposed locomotive. This diagram shall also show the dynamic movement of the locomotive and carbody about its center of gravity and roll axis, and it shall indicate the change in vertical height for each of the following conditions:

- New and fully worn wheels
- Full and empty supplies

Also indicated on this diagram shall be:

- Locomotive length and truck centers
- Maximum pilot and mid-point lateral off sets for 2° curvature and 7 in. super elevation
- Location of vertical and lateral center of gravity

1.4.3 Weights

The contractor shall implement a weight optimization program in order to produce the lightest locomotive consistent with the requirements of this specification and with optimal adhesion and tractive effort characteristics. Maximum loaded weight of the locomotive shall be consistent with the track dynamic force limit as specified in Chapter 6. The weight differential

over each truck at the rail of a fully loaded locomotive shall not exceed five percent of the total locomotive weight.

1.4.4 Cant Deficiency

The locomotive shall be capable of being qualified for operations up to 6 in. cant deficiency in accordance with 49CFR Section 213.57 and 49CFR Part 329 (as appropriate)..

1.4.5 Dimensions

The dimensions stated in this section are for guidance only. The contractor shall specify the optimum proposed dimensions based on the parameters established by existing clearances and the dynamic characteristics of its proposed locomotive.

| | |
|---|---|
| Wheel arrangement | 4 axle or 6 axle |
| Overall length over coupler pulling faces | 72 ft maximum, consistent with curving requirements |
| TOR to top of locomotive; new wheels, no supplies | According to clearance diagram |
| Wheel diameter | 40 in. to 44 in. |

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

1.4.5.1 Supplies and Output Characteristics

| | |
|---------------------------------------|---|
| Installed nominal diesel engine power | Consistent with operating requirements |
| HEP output capacity | 480V, 3-phase, 60 Hz, 600 kW + 10%, power factor 0.85 |
| Starting tractive effort (minimum) | 65,000 lbs |
| Fuel capacity, minimum usable | 1,800 US gal |
| Sand capacity | 20 cu ft (4 sandboxes 5 cu ft each) |

1.4.6 Operating Performance

1.4.6.1 Push-Pull Operations

The locomotives shall be designed and constructed to be used in push-pull operations. The electrical and communications systems shall be trainlined using standard 27-pin trainline equipment.

1.4.6.2 Compatibility

The locomotive shall be compatible with other rail equipment owned and operated by the Customer. Interfaces shall be defined by each Customer.

1.4.6.3 Speed

The locomotives shall be designed, constructed and tested to operate at a sustained speed of up to 125 mph on tracks approved by FRA for that speed. Design and test speed shall be as prescribed by regulation

1.4.6.4 Operating Environment

The environmental criteria for the locomotive shall be consistent with Amtrak Specification 963 (latest revision). For the locomotive’s operation and diesel engine performance, EPA conditions for Tier 4 emissions and AAR standard conditions for diesel engine performance shall apply.

Rain, snow, sand and dust as usual in different North American regions shall be considered.

1.4.6.5 Trucks

The truck shall have either a four-wheel or six-wheel design.

The trucks shall be optimized with regard to:

- Minimized dynamic forces vertical and lateral
- Minimized unsprung mass
- High running stability
- Minimized wear
- Minimized load transfer between axles at high traction force
- Easy maintenance and replacement

1.4.6.6 Conventions

All AAR conventions as to the identification of ends, sides, and wheel and bearing locations shall be used. A key plan shall be provided on all drawings to aid in the identification, location and orientation of the items depicted.

1.4.7 Maintenance Intervals

Maintainability and ease of access to locomotive components shall be designed into the locomotive body. No component or system shall require less than 92 day service intervals, except for brake shoes or brake pads, fuel, sand, water, oil and other consumable items.

* End of Chapter 1 *

Standardized Technical Specification

PRIIA 305 Next-Generation Equipment Committee
Diesel-Electric Passenger Locomotives

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 locomotive is accepted. The Customer shall determine if the proof of compliance provided is acceptable.

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 a later revision that is approved by the issuing entity, the later revision shall apply. Unless specified otherwise, the Contractor shall be responsible for acquiring and maintaining copies of all applicable references from the appropriate source. The 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 *Parks, Forests, and Public Property*

1192.99: *Floors, Steps and Thresholds*

1192.113: *Doorways*

1192 Appendix: *Advisory Guidelines*

49CFR *Transportation*

Subtitle A, Figure 4: *Intercity Rail Car (with accessible restroom)*

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 (EPA) of 2005

2.2.1.3 EPA (Environmental Protection Agency)

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 *Food and Drugs*
1250: *Interstate Conveyance Sanitation*
1250.41: *Submittal of Construction Plans*
- 2.2.1.6 FRA (Federal Railroad Administration)
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*

Aluminum Company of America (ALCOA) Technical Report 524, *Specification Covering Use of Aluminum in Passenger Carrying Railway Vehicles*

Aluminum Standards and Data

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*

Z26.1: *Safety Code for Safety Glazing Materials for Glazing Motor Vehicles Operating on Land Highways*

- 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-E-019-99: *27-Point Jumper and Receptacle Hardware for Locomotives and Locomotive-Hauled Equipment*
 - 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-C&S-034-99, Rev. 2: *Standard for the Design and Construction of Passenger Railroad Rolling Stock*
- 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-E-013-99: *Standard for Emergency Lighting System Design for Passenger Cars*
- SS-M-005-98, Rev 2: *Code of Tests for Passenger Car Equipment Using Single Car Testing Device (revision in effect at time of test)*
- 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-002-98, Rev 3: *Standard for Emergency Signage for Egress/Access of Passenger*
- 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)
- 41.1-1986 (R2006): *Standard Method for Temperature Measurement*
- 37-2009: *Methods of Testing for Rating Electrically Driven Unitary Air-Conditioning and Heat Pump Equipment*
- 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*
- B26/B26M-09: *Standard Specification for Aluminum-Alloy Sand Castings*
- 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*
- B108/B108M: *Standard Specification for Aluminum-Alloy Permanent Mold Castings*
- B247-09: *Standard Specification for Aluminum and Aluminum-Alloy Die Forgings, Hand Forgings, and Rolled Ring Forgings*
- B633-07: *Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel*
- C177-10: *Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus*
- C542-05: *Standard Specification for Lock-Strip Gaskets*
- C1166-06: *Standard Test Method for Flame Propagation of Dense and Cellular Elastomeric Gaskets and Accessories*
- D395-03: *Standard Test Methods for Rubber Property-Compression Set*
- D412-06ae2: *Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension*
- D523-08: *Standard Test Method for Specular Gloss*
- D573-04: *Standard Test Method for Rubber—Deterioration in an Air Oven*
- D746-07: *Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact*
- D1149-07: *Standard Test Methods for Rubber Deterioration-Cracking in an Ozone Controlled Environment*
- D2240-05: *Standard Test Method for Rubber Property—Durometer Hardness*
- D3574-95: *Seat Cushion Testing Requirements*
- D3774-96(2008)e1: *Standard Test Methods for Width of Textile Fabric*
- D3775-08: *Standard Test Method for Warp (End) and Filling (Pick) Count of Woven Fabrics*
- D3776/D3776M - 09a: *Standard Test Methods for Mass Per Unit Area (Weight) of Fabric*
- D4956-07: *Standard Specification for Retroreflective Sheeting for Traffic Control*
- E94-04: *Standard Guide for Radiographic Examination*
- E119-10b: *Standard Test Methods for Fire Tests of Building Construction and Materials*

- E162-09: *Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source*
- E165-02: *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

- B2.1/B2.1M: *Specification for Welding Procedure and Performance Qualification*
- B2.2/B2.2M: *Specification for Brazing Procedure and Performance Qualification*
- B2.3/B2.3M: *Specification for Soldering Procedure and Performance Qualification*
- C1.1M/C1.1:2000 (R2006): *Recommended Practices for Resistance Welding*
- C7.2: *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

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

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)
649-A 2004: *National Consensus Standard for Configuration Management*
- 2.2.2.18 European Norms
DIN EN 13452-1: *Railway Applications – Braking - Mass Transit Brake Systems – Part 1: Performance Requirements*
BS EN 50126: *Railway Applications. The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS)*
- 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*

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

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 Seitches)*

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, Convolutd, Polytetrafluoroethylene, 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 PRIIA (Passenger Rail Investment and Improvement Act)

305-900: *Specification for Composition Brake Shoes and Disc Brake Pads*

305-901: *Public Address/Intercom System*

305-902: *Specification for Water Systems for use on Amtrak Passenger Vehicles*

305-903: *Flammability, Smoke Emissions and Toxicity for use on Railway Passenger Cars and Locomotive Cabs*

305-904: *Specification for Vendor Maintenance Manuals*

305-905: *Specification for Builder Operating and Maintenance Manual Family*

305-906: *480, 240, 208, and 120 VAC 72VDC Relay and Contactor Panel*

305-907: *Disposable Air Filter*

305-908: *Valve and Exterior Equipment Identification Tags & Labels and Operating Instructions*

305-909: *National On-Board Signage Manual*

305-910: *Schematic, Wiring and Piping Diagram Drawings*

305-911: *Replacement of Copper Waste Piping with Non-Metallic Pipe*

305-912: *Operational and Environmental Conditions for Rail Rolling Stock*

305-913: *Manufacture and Acceptance of Passenger Seating for Intercity Rail Cars*

305-914: *Side Door Control Panel Design and Function*

305-915: *High Performance Wire and Cable*

305-916: *Environmental & Operating Conditions*

305-917: *480, 240, 208, and 120 VAC and 72 VDC Switchboard Panels*

305-918: *Food Service Carts*

305-xxx: *Linear Induction Motor Door Controllers (to be available at a later date)*

305-xxx: *Plug Doors (to be available at a later date)*

2.2.4 Drawings

2.2.4.1 PRIIA

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

305-800: *Single-Level Clearance Drawing*

305-801: *Bi-Level Clearance Drawing*

305-802: *Standard Trash Container (Amtrak Part No. 24-045-18737)*

305-803: *Speed Sensor and Cable Assembly*

305-804: *Temperature Probe and Connectors*

305-805: *Axle Single Level Program*

305-806: *Power Transformers*

305-807: *Cab/Baggage Car F-end Pilot Assembly*

305-808: *Emergency Equipment Cabinet Arrangement*

305-809: *Seat Track Reference Dimensions*

305-810: *Deleted/Reserved*

305-811: *Food Chiller Units*

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 — 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.

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.

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

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

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 ft² of clear floor space.
4. AW3: Car at crush load.
 - Crush Load is defined as seated load plus one standee per 1.5 ft² 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 |

| | |
|---------------|---|
| 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 |

| | |
|-----------------------|---|
| FCC | Federal Communication Commission |
| FDA | U.S. Food & Drug Administration |
| FDR | Final Design Review |
| FEA | Finite Element Analysis |
| FEM | Finite Element Model |
| FMEA | Failure Mode and Effects Analysis |
| FMECA | Failure Modes and Effects Criticality Analysis |
| FMI | Field Modification Instruction |
| fpm | feet per minute |
| FRA | Federal Railroad Administration (U.S. Department of Transportation) |
| FRP | Fiberglass Reinforced Plastic |
| ft | foot |
| ft² | square foot |
| ft³ | cubic foot |
| foot-candle | Foot candle |
| FTA | Federal Transit Administration (U.S. Department of Transportation) |
| g | Acceleration due to gravity (386.1 inches per second per second) |
| gal | gallon |
| GB | Gigabyte |
| GFCI | Ground Fault Circuit Interrupter |
| GHz | gigahertz |
| gpm | gallons per minute |
| GPS | Global Positioning System |
| HAZ | Heat-Affected Zones |
| HBPS | Holding Brake Pressure |
| HDMI | High Definition Multimedia Interface |
| HEP | Head End Power |

| | |
|-----------------------|---|
| Hg | Mercury (pressure or vacuum – measured in inches) |
| HPPL | High 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 |
| °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 |
| 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 |
| NO | Normally Open |

| | |
|---------------|---|
| NPT | National Pipe Thread |
| NSF | National Sanitation Foundation |
| NTP | Notice-to-Proceed |
| NTSB | National Transportation Safety Board |
| OCU | Operator Control Unit |
| ODBC | Open Data Base Connectivity |
| ODK | Operator Display Keypad |
| OEM | Original Equipment Manufacturer |
| OFE | Oxygen Free Electronic |
| OSHA | Occupational Safety and Health Administration |
| OTIS | Onboard Train Information System |
| oz | ounce |
| p/n | part number |
| PA | Public Address |
| PA/IC | Public Address/Intercom |
| PC | Personal Computer |
| PCB | Printed Circuit Board |
| PCMCIA | Personal Computer Memory Card International Association |
| PCS | Pneumatic Control Switch |
| PDF | Portable Document Format |
| PDR | Preliminary Design Review |
| PHS | Public Health Service |
| PIDS | Passenger Information Display System |
| PIS | Passenger Information System |
| PISCU | Passenger Information System Control Unit |
| PKO | Power Knock/Out |
| 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 |
| SIV | Secondary Impact Velocity |

| | |
|--------------|--|
| SNR | Signal-to-Noise Ratio |
| SQL | Structured Query Language |
| SSP | System Safety Plan |
| SSS | Sign System Server |
| t | Thickness |
| T/L | Trainline |
| T/R | Transmitter/Receiver |
| TB | Terabyte |
| TBD | To Be Determined |
| TCD | Train Communications Data |
| TFT | Thin Film Transistor |
| TIG | Tungsten Inert Gas |
| TLC | Trainline Complete |
| TMS | Train Monitoring System |
| TOR | Top of Rail |
| TSA | US Transportation Security |
| TTCI | Transportation Test Center |
| U.S. | United States |
| UL | Underwriter's Laboratories, Inc. |
| ULSD | Ultra Low Sulfur Diesel |
| UMLER | Universal Machine Language Equipment Register |
| USB | Universal Serial Bus |
| USDOT | United States Department of Transportation |
| USPHS | U.S. Public Health Service of the U.S. Department of Health and Human Services |
| USSC | United States Steel Corporation |
| UTR | Unisex Toilet Room |

| | |
|-------------------------|---|
| UV | Ultraviolet |
| V | volt |
| VAC | Volt Alternating Current |
| VDC | Volts Direct Current |
| VDSL2 | Very High Speed Digital Subscriber Line 2 |
| VVVF | Variable Voltage Variable Frequency |
| VTI | Vehicle Track Interaction |
| W | watt |
| W/ft² | watts per square foot |
| WB | Wet Bulb |
| WCRS | Waste Collection and Retention |
| WiFi | Wireless Fidelity (Wireless Local Area Network protocol, IEEE 802.11b, 802.11g and 802.11n) |
| WLAN | Wireless Local Area Network |
| WMS | Work Management System |
| WPS | Welding Procedure Specifications |
| yr | year |
| Z | Impedance |

* End of Chapter 2 *

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Standardized Technical Specification

PRIIA 305 Next-Generation Equipment Committee
Diesel-Electric Passenger Locomotives

Chapter 3

Project Management

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3.0 Project Management

3.1 Overview

These technical specifications describe and illustrate the criteria to be used for the Contractor's design and manufacture of the locomotive.

The locomotives 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 locomotives 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 locomotives. 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 approved by the Customer as part of the design review process.

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. **CDRL**

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 locomotive. 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. **CDRL**

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 locomotive contract.

The QA Program shall assure that all aspects of locomotive design, component manufacture and testing, locomotive assembly and testing, and locomotive 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 non-conformances.
- 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 fleet-wide 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 fleet-wide 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.

CDRL

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 to a level of authority within the Contractor's organization that is independent from the manufacturing or purchasing responsibilities such as the General Manager, the Contractor's Project Manager or executive level, such as Chief Operating Officer through President position. In any case it must be completely independent of the Contractor's manufacturing or purchasing divisions. The QA personnel shall have complete freedom to identify and evaluate problems; to recommend solutions; to verify implementation of solutions; and to control further processing, delivery, or installation of a nonconforming or deficient item until proper and documented disposition has been obtained.

The Contractor's QA personnel performing inspections and test shall be certified for such work. Certification of personnel shall be 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 the applicable industry standards and practices. Records of personnel certifications shall be maintained and monitored by the Contractors QA department. The official records may be maintained in the Human Resources department for each trained and certified employee. These records shall be made available to the Customer for review through the QA department.

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 locomotive contract to ensure that all QA program obligations are being fulfilled and that all deliverables meet the requirements of the Technical Specification 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 while subsequent warranties are in force. These records, except the internal audit records, shall be made available to the Customer representative on demand, and a complete set of records shall be submitted to the Customer through the project. The Customer shall require that confidential internal audit records are available for reviewing at the Contractor's facility. Evidence of such submittals are to be provided at the end of the warranty period.

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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 locomotive will include an audit of both the Contractor and major subcontractors
- During manufacturing, installation of equipment, and testing
- Before acceptance of the first locomotive

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.
- Plastic car components shall be marked with the proper recycling symbol when practical.

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 locomotive, 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 locomotive 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) or a database agreed upon by the Contractor and Customer

3.5.1.1 Reliability objectives

The Contractor shall provide reliability objectives that identify the Mean Time Between Failures (MTBF) and the Mean Time Between Component Failure (MTBCF) performance levels to be met for its locomotive design and submitted to the Customer for approval. The reliability of the locomotives shall be consistent with the requirements of this specification and the Contractor's maintenance plan.

The reliability objectives shall be based on single locomotive operation at an average speed of 90 mph (145 km/hr) and a utilization of 125,000 miles/yr (201,168 km/yr).

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

- More than 15 minutes late at its destination terminal; or
- Canceled either at its originating point or en route.

3.5.1.2 Component reliability requirements

Providing that the Contractor's specified routine maintenance is performed on the various locomotive sub-systems and components, the following reliability Mean Distance Between Component Failures (MDBCF) requirements shall be met:

| System | Mean Distance Between Component Failure |
|-------------------------|--|
| Friction Braking System | 450,000 miles [724,205 km] |
| HVAC System | 450,000 miles [724,205 km] |
| Main Engine | 850,000 miles (1,367,943 km) |
| Air Compressor | 450,000 miles (724,205 km) |
| Couplers | 850,000 miles [1,367,943 km] |
| Trucks and Suspension | 850,000 miles [1,367,943 km] |
| HEP Power Systems | 850,000 miles [1,367,943 km] |

The Contractor shall provide records illustrating the product history and experience of existing systems and system components to verify that the specified MTBCF 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:

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

Where as "d" equals the total locomotive 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.

3.5.1.3 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 locomotives, 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 locomotive of the base order and shall continue to the end of warranty period of the last accepted locomotive. The reliability demonstration program plan shall be submitted for Customer approval. During the demonstration, the locomotives 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 locomotive 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 locomotives 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.

Locomotives 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.

3.5.1.4 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 locomotive. 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 locomotive 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 locomotive and service mileage of that locomotive, 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.

3.5.1.5 Reliability database

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

- Monitoring of overall locomotive reliability on both a locomotive 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 locomotive

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

- Customer locomotive road number
- Locomotive acceptance date
- Detailed listing of all locomotive 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 locomotive

The computer-based reliability database shall be able to interface with the Customer's existing reliability and maintenance tracking system. Data recorded in the Contractor's computer-based reliability database shall be transferable to the Customer's own maintenance or

reliability database. The fields to be transferred/downloaded and format (e.g., comma-separated variables) shall be the subject of a design review.

3.5.2 Maintainability

The locomotive shall be designed and built so as to minimize maintenance and repair time and overall costs over the locomotive life. The following shall be considered good practice in designing for maintainability and shall be utilized in the locomotive 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 Traction Control, friction/dynamic braking, Heating, Ventilation and Air Conditioning (HVAC), Air Compressor, HEP Generation, Battery Charger, Toilet.
- 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.
- 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 locomotive's intended useful life.

The plan shall include the system MTTRs and locomotive goal for the proposed locomotive. An overall quantitative maintainability requirement goal for the locomotive'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 locomotive shall be demonstrated.

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

- Maximization of locomotive availability
- Minimization of maintenance costs, including cleaning
- Minimization of locomotive 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 locomotive fault and restore the locomotive 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:

| System | MTTR or Replace Major Module (hours) |
|-----------------------------------|---|
| Braking System (Friction/Dynamic) | 2.0 |
| Main Engine | 12.0 |
| HVAC System | 2.1 |
| Couplers | 2.6 |
| Trucks and Suspension | 1.6 |
| Auxiliary Electrical (HEP) System | 10.5 |
| Lighting | 0.5 |
| Wheels and Axles | 4.0 |

3.5.2.3 Maintainability demonstration

The adequacy of the locomotive design for maintainability shall be evaluated to the satisfaction of the Customer using product components and equipment, mockups and actual locomotives 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
- Prime mover (diesel engine)
- Auxiliary electric equipment (HEP, traction motors and all electrical rotating equipment)
- Couplers
- Control equipment
- Wheelchair lift
- Elevators

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

During the demonstration, the locomotives 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. Locomotives so modified shall undertake a further maintainability demonstration to prove maintainability.

3.5.3 Metrication

The designs, components and fasteners used on the new locomotives 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 locomotive 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 locomotive. The locomotive shall present a safe, hazard-free environment to crew members. Passage through the inside of the locomotive shall be easy and safe. Adequate handholds shall be provided where required. The operating cab shall be designed to minimize injury from impact against cab surfaces in a collision.

Crew members shall not be exposed to tripping hazards, exposed electrical voltage, toxic materials or similar hazards.

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 locomotive 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 locomotive 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 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 locomotives, and the operation, maintenance, repair and performance of those components, materials and systems, from the view point of the crews.

The SSP shall identify all hazards related to the locomotive; 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, locomotives, 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 locomotive.

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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.
- Locomotive carbody shell engineering plan, including design, finite elements analysis, quasi-static and dynamic testing, measurement of critical dimensions, acceptance and shipment, and inspection/repair procedures.
- Completed locomotive weight control plan.

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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 locomotive 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.

The locomotive 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 locomotives. This involvement shall include design review and evaluation, supplier selection, QA program review and approval, first article inspection, inspection of all phases of locomotive 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 locomotive. 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. **CDRL**

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 locomotive.
- 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 locomotive design complies with all the related provisions that follow. The guidelines provided by DOD-STD-480A and MIL-STD-483 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 locomotives. Any ECRs not performed on every locomotive must include supporting rationale and shall be subject to the Customer's approval.

Documentation will be generated showing the date when each locomotive 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 locomotives will be retroactively applied to those completed locomotives 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 is 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 locomotives 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 locomotives 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 locomotives. 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 locomotive, 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 first locomotives the Contractor shall submit to the Customer a report on the estimated locomotive weight. This shall include the most recent weights for the locomotive carbody without trucks, each truck and the complete locomotive. It shall also include a list of weights for every subsystem on the locomotive, indicating its percentage of the total locomotive 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 locomotive is at approximately 60% complete. This shall represent an advancement of the design of the locomotives 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 locomotive type, which will be used by the Customer to evaluate the proposed design of the locomotive to a level of detail sufficient that the Contractor shall be able to proceed with the development of the locomotive design to the 95% draft final stage.

Storyboard palettes shall be provided proposing at least two varieties of the cab interior materials and colors.

Customer comments from the PDR stage shall be reviewed, and the Contractor shall provide documentation that the Customer's comments were incorporated into the locomotive 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 locomotives; according to the drawings as reviewed and approved at the IDR, for Customer review and comment:

- Cab and Console, including all gauges, controls, switches, display panels, windows, mirrors, etc. Controls shall have simulated operation to evaluate the range of motion and effort required to operate the control equipment. If practical, the side representative side windows of the size/style proposed for installation shall be included in the mockup. Seats shall be installed to evaluate circulation, ease of getting into and out of the cab, and knee/leg room under desktop.
- Engine Compartment
- Locomotive underfloor components
- Truck arrangement including suspension components and attachment points to the locomotive underframe.

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 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 locomotive 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 locomotive design.

Upon approval of the Customer, the Engine Compartment and Underfloor mockups may be done digitally as long as the ability is retained to accurately determine accessibility to major components for inspection, maintenance, removal and re-installation.

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, locomotive 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 operation of the locomotive. The functional block diagrams shall display the levels of hardware (as defined in Military Specification MIL-STD-280A) 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 locomotive, 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 locomotives, 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 locomotives.

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, the compatibility with other parts and systems in use on the locomotive, 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 locomotives. 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:

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- 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 the maintenance manuals 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 locomotive production and 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:

- Locomotive carbody shell
- Control Cab layout
- Prime Mover (diesel engine and associated auxiliaries)
- Windows – fit and finish
- Trucks-frame
- Trucks-fully assembled
- Wheel and axle assemblies with Traction Motors
- Couplers and draft gear
- Air brake system
- Wheel slide control system
- Cab seats
- HVAC system, controls and temperature controls
- All external and internal lighting systems
- Communication system
- Electrical lockers
- All electrical panels
- Batteries and charging system
- Toilet room and retention system
- Front pilot and snowplow (if equipped)
- Cab seats
- Exterior doors
- Alerter/speedometer/overspeed
- Event recorder system
- Positive Train Control (PTC) system
- Windshield wipers

The final approval of exterior and interior color scheme as applied to the locomotive 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 locomotive. 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 locomotive 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 locomotives.

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 locomotive inspections and will be supplied to the Customer with the delivery of the first locomotive. **CDRL**

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 locomotive 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 locomotive shall become hidden by subsequent work contrary to the specific request of the Customer, that portion of the locomotive 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 locomotive inspection and testing for each locomotive. Likewise, a "traveler" shall be attached to each locomotive to track QA functions as the work progresses through the shop. A copy of the report must be attached to each locomotive 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 locomotive will be released for shipment to the delivery site. All Contractor and Customer in-process inspection sheets and test data records for that locomotive shall be contained in this Log, which will be provided in the locomotive 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 than five days after such notice is given.

3.7.2 Contractor 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 locomotive construction plants, including the final assembly site and the locomotive carbody fabrication site (if a separate facility), as well as similar facilities at any locomotive 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 locomotives.

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 locomotive 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 locomotive before painting
- Each locomotive after painting
- Each truck frame
- Each assembled truck, prior to installation under the locomotive
- Each locomotive underframe area prior to attaching the trucks
- Each locomotive final watertightness test
- Each locomotive interior wiring and components before being covered by panels
- Each locomotive underframe area and connections prior to the attachment of the trucks
- Each finished locomotive interior and 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 locomotive and included in the locomotive history book when all discrepancies have been eliminated.

3.7.6 Locomotive Pre-Shipment Inspection

After all work, including factory testing as per Chapter 19, is completed, the Contractor shall perform the locomotive 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 locomotive 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 Locomotive Shipping Inspection

Following pre-shipment inspection, the Contractor shall ensure the locomotive is properly prepared for shipment in accordance with approved procedures. A Customer representative will then perform a cursory walk through inspection to confirm that the locomotive 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. .

3.7.8 Locomotive Modification Inspection

The Contractor shall provide written procedures for Customer review and approval, for the inspection of any locomotive 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 locomotive history book.

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

* End of Chapter 3 *

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Chapter 4

Locomotive Carbody

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4.0 Locomotive Carbody

4.1 Overview

This chapter outlines the major technical requirements for construction of the locomotive carbody.

4.2 Materials of Construction

The entire body structure, including the exterior sheathing, may be constructed using any one of the materials or material combinations shown below:

- Stainless and Low Alloy High Tensile (LAHT) steels
- Aluminum and LAHT steel
- All LAHT steel
- Composite panels and materials

All locations where aluminum is proposed to be used shall be low stress areas and are to be identified as part of the bid proposal.

The Contractor shall employ methods of joining metals that minimize corrosion or electrolysis at the joints. Such joints shall be designed to drain free of accumulations of moisture such that joints will dry before corrosion can begin. The materials to be used shall be stipulated by the Contractor as part of the structural details to be submitted.

4.3 Carbody Structure

The locomotive carbody structure shall be designed and constructed in full accordance with all applicable FRA, AAR, Amtrak and APTA standards, regulation and recommended industry practices in effect at the time of the bid submission and the requirements of this Specification.

The locomotive carbody shall be equipped with a full-width streamlined cab employing a light-weight, high-strength monocoque structure or semi monocoque structure. The Contractor shall include in its proposal line drawings and renderings depicting its design/style interpretation.

4.4 Structural Elements

4.4.1 Draft Stops

The carbody structure shall resist a static-end load of 800,000 lbs minimum buff applied to the draft stops without permanent deformation of any member of the structure.

4.4.2 Collision Posts

Two vertical collision posts shall be provided at the front end of the locomotive that meet or exceed the requirements of 49CFR Part 229 Subpart D.

An end nose plate assembly shall be attached to the collision posts and meet or exceed the requirements of AAR Standard S-580-(2008) *Locomotive Crashworthiness Requirements*.

4.4.3 Corner Posts

Two full-height corner posts shall be provided at the front end of the locomotive that meet or exceed the requirements of 49CFR Part 229 Subpart D.

An end nose plate assembly shall be attached to the collision posts and meet or exceed the requirements of AAR Standard S-580-(2008) *Locomotive Crashworthiness Requirements*.

4.4.4 Truck Attachments

Truck attachments shall be supplied to permit lifting trucks with carbody. Horizontal ultimate shear of each truck attachment in any direction shall be 250,000 lbs minimum, per AAR Standard S-580-(2008) *Locomotive Crashworthiness Requirements*.

4.4.5 Jacking Pads

The locomotive carbody shall be supplied with four jacking pads integral with side sills at or near outer points of attachment of trucks to mainframe.

Pads are not to be obstructed by conduit, piping or cables.

The jacking pads shall be suitable to lift the locomotive either by means of jacks or overhead lifting devices, e.g. slings.

4.4.6 End Frame

The end frame below the bottom of the platform structure shall be capable of withstanding a 400,000 lb load without yield (200,000 lb on either side of coupler). The load shall be applied as follows:

- 100,000 lb on each side of the coupler distributed so that the bottom 1/3 resists 50,000 lb and the top 2/3 resists 50,000 lb.
- 100,000 lb on the outer edge of each end plate distributed so that the bottom 1/3 resists 50,000 lb and the top 2/3 resists 50,000 lb.
- Suitable bracing shall be incorporated to effectively distribute the load to each main load carrying location should the load be concentrated anywhere on the end plate.

4.5 Carbody Components and Attachments

Locomotive shall meet applicable 49CFR Part 231 safety appliance regulations.

All exterior steps and handholds shall be steel unless otherwise approved by the Customer.

4.5.1 Handholds

Cab entrance doors shall have full-length handholds with a minimum hand clearance of 2.5 in. The handholds shall be recessed where possible to improve the aerodynamics of the locomotive carbody.

4.5.2 Horizontal Grab Handles

Horizontal grab handles needed to facilitate servicing shall be arranged as necessary. Their necessity and arrangement shall be reviewed and approved by the Customer. Every effort shall be extended to provide servicing access from inside locomotive carbody.

A horizontal grab handle shall be located on each side of coupler on the front and rear ends of the locomotive. The geometry and locations of the grab handles shall comply to the maximum extent practicable with 49CFR Section 321.30(g).

4.5.3 Side Steps/Exterior Steps

Side and ladder steps shall be open-grating which will self-clear of snow and ice and of sufficient depth to gain secure foothold.

4.5.4 Grab Handles

Grab handles and handholds shall be of one-piece wrought steel and shall provide at least 2.5 in. minimum radius handhold clearance.

4.6 Roof Hatches, Panel Doors and Floor Openings

Suitable roof hatches and/or detachable sections shall be designed and constructed as integral components of the locomotive body providing the durability consistent with the rest of the vehicle. They shall also permit ready access to equipment and components within locomotive.

Panels, doors and floor openings shall make use of positive-close, quick-release buttons or lever-type latches.

Provisions shall be incorporated in the design of the cab area for emergency exit or ingress by means of a roof hatch, a roof hatch that can be cut out or removable side windows units per 49CFR Section 238.441.

4.7 Floors

The floors in the equipment rooms and compartments shall be diamond or similar plate sheets or as approved by the Customer. Appropriate drainage shall be provided in the floor for cleaning materials. Such drainage shall not be liable to blockage in regular service and will not provide a freezing risk.

4.8 Weatherproofing**4.8.1 Doors, Windows and External Hatches**

Doors, windows and external hatches shall be weatherproofed such that they seal, when closed. Doors and windows must be equipped with a with a robust latching method against entrance of moisture, dust, fine sand, snow, external noise and combustion fumes into the operating cab and compartments. Mechanical means of fastening seals and gaskets shall be provided. Alternative methods of attachment may be proposed.

4.9 Air Intake and Exhaust

Except for cooling air for radiators and dynamic brake grids, cooling air shall be filtered as required by the equipment manufacturers. Provisions for forced cooling of the traction motors shall be provided if recommended by the Contractor.

Electrical compartments, where necessary, shall be vented positively to exclude dust and sand.

Cooling air intakes shall be located at the sides of the carbody or on the roof: Exhausts shall be at a suitable location to ensure that air is not discharged into other locomotive cab compartments, trailing passenger cars or at passenger platform levels.

4.9.1 Insulation

Cab insulating materials, as with paint, sealants and other coatings shall not constitute a potential fire hazard, consistent with 49CFR Section 238.103.

4.10 Passageways

Minimum aisle way/passageways shall be 20 in. unless otherwise approved. Interior aisle ways shall be provided with an anti-skid surface to prevent slipping as approved by the Customer.

Handbrake, fire extinguishers and cable slings shall not be located in the passageways or otherwise restrict free movement through passageways.

All doorway headers and other low clearance areas shall be protected by anti-bump neoprene strips. These strips shall be upholstered if not self-skinning.

4.11 Carbody Painting and Lettering

All painting and lettering schemes shall be discussed during design review and be approved by the Customer.

4.12 Builder's Plate

A builder's plate of approved design with embossed letters shall be attached to each side sill near front end of locomotive using anti-theft attachment. Location of the builder's plate shall be approved by the Customer.

4.13 F-End Marking

A 2.5 in. x 2.5 in. or larger letter "F", either cast metal or decal to mark the front or F-end of the locomotive shall be located on each side of the locomotive near the front of the locomotive in accordance with 49CFR Section 229.11(a).

4.14 Pilot

The Contractor shall apply a snowplow pilot at the front of the locomotive only. MU hose access doors in snowplow, if used, shall have positive hold-down latches. Pilot design shall protect all front end appliances (480V MU, trainline communication, MU air hose connections, etc) with all doors closed. This also includes all air valves behind the pilots that are connected with intermediate hose between end valves and pilot. The snowplow pilot shall be attached to the locomotive with grade 8 bolts. The design shall be approved by the Customer.

* End of Chapter 4 *

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Chapter 5

Running Gear

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5.0 Running Gear

5.1 Overview

The truck may be either a four-wheel or six-wheel design.

5.2 Truck Frame and Components

5.2.1 Design Requirements

- The truck frame shall be of a cast or a fabricated construction
 - The truck frame shall be analyzed for static and dynamic loads and will be tested for static stresses and fatigue stresses
 - The truck frame shall provide a minimum life of 25 years based on proper performance of scheduled maintenance
 - Removal of wheel sets with traction motors using drop tables.
 - Axle-drive, end of-axle wheel-truing access provision, to allow wheel truing while the wheel set is attached to the locomotive
- Either axle-hung or fully suspended drives will be considered

5.2.2 Reliability and Maintainability

Design shall be such that failure of a component shall not cause the locomotive to become unsafe for normal operation. All truck working elements and adjustment points shall be conveniently accessible for inspection, adjustment and repair without requiring the removal of trucks or any other unrelated equipment.

5.3 Brake Rigging

- Pneumatic application will apply brakes at all wheels
- A suitable combination (as required) of disc, cheek or tread brake shall be installed.
- Self-aligning and adjusting brake rigging or approved equal to correct clearances resulting from wear of brake pads, brake discs and wheel surface shall be provided.
- Composition brake shoes/pads shall be used.

5.4 Wheels

Wheels shall be mono-block, wrought steel, class B multiple wear. Wheel diameter shall be 40 in. to 44 in. Wheels shall be supplied by an AAR approved manufacturer. Hub stamped per AAR Figure 5.3, *Wheel and Axle Manual*, reference-groove rims/witness groove. Wheels shall be unpainted and shot-peened as required. Wheel profile shall be APTA standard profile 140M (APTA Standard SS-M-015-06) as required to meet Vehicle Track Interaction (VTI) performance requirements or as specified by the Customer. Hubs shall be drilled for hydraulic-assist wheel removal. Braking energy inputs shall be within requirements of 49CFR Section 238.231.f.

5.5 Axles

Axles shall be AAR, M-101, Grade F. Axle shall be splined at each end, or equivalent solutions can be used, if approved by the Customer.

5.6 Journal Bearings

5.6.1 Type

Journal bearings shall be grease-lubricated, tapered or cylindrical roller, no field lubrication. If inboard bearings are proposed, a hot bearing detection system shall be included. The design shall be approved by the Customer.

5.6.2 Service Life Design

Journal bearings shall have a minimum design service life of one million miles with a rate of failure of no more than 10% in one million miles.

5.7 Suspension System

The suspension system shall be consistent with the overall performance requirements of the locomotive. The Contractor shall demonstrate through test results or simulations that the interfaces and integration of the system has been fully and successfully accomplished and that its dynamic performance under all operating conditions and speeds is in accordance with the requirements of this Specification and the intended services. If simulation is to be used, the Contractor must demonstrate that the model provides correlation with actual test data under a variety of circumstances to justify its use.

5.7.1 Wheel Load Equalization

The suspension system shall meet Class G load equalization requirements per APTA Standard SS-M-014-06.

5.7.2 Static Lean Response

The locomotive and suspension system shall meet static lean requirements as follows:

- For maximum cant deficiency a worst-case wheel load no less than 60% of the static wheel load (see 49CFR Section 213.57 and 49CFR Section 213.329).
- For maximum cant deficiency of 6 in. as per Chapter 1 of this Specification, a worst-case wheel load of no less than 50% of the static wheel load.

5.7.3 Track Dynamic Forces

Track dynamic (P_2) forces shall not exceed 82,000 lbs for a 0.5 degree dip angle and all speeds up to the locomotive operating speed limit. The calculation is to consider nominally stiff concrete tie track and to use the British Rail Equation (as defined in British Railways Board Group Standard GM/TT0088 Issue 1, Rev. A).

The specific equation to be used is as follows

$$P_2 = P_0 + 2\alpha v \sqrt{\frac{m_u}{m_u + m_t}} \left(1 - \frac{\pi c_t}{4\sqrt{k_t(m_u + m_t)}} \right) \sqrt{k_t m_u}$$

Where:

- P_0 Static wheel load in pounds
- α Dip angle in radians
- v Vehicle speed in inches/second

| | |
|-------|--|
| m_u | Unsprung mass per wheel in lbf/in/sec ² |
| m_t | Track mass per wheel in lbf/in/sec ² |
| c_t | Track damping per wheel in lbf/in/sec |
| k_t | Track stiffness per wheel in lbf/in |

Track parameter values are as follows:

| | | |
|----------|---------|--|
| α | 0.0085 | Total dip angle in radians based on ½ degree on both sides of the dip |
| m_t | 1.1335 | Track mass per wheel in lbf/in/sec ² for nominally stiff concrete tie track |
| c_t | 671 | Track damping per wheel in lbf/in/sec for nominal track conditions (from literature) |
| k_t | 392,900 | Track stiffness per wheel in lbf/in for nominally stiff concrete tie track (corresponds to track modulus of 5,100 lb/in/in, assuming a track deflection of 0.084 inches under a 33,000 pound wheel load) |

Calculation of P_2 forces using builder proposed alternative values in the British Rail Equation and resulting change in the value of P_2 forces may be considered by the Customer upon approval of justification for such changes by the Customer and that such calculations are also approved by the owner of the right-of-way or his designated representative.

5.7.4 Dynamic Response on FRA Class 1 through Class 5 Track

Track-worthiness of the locomotive and suspension system shall be verified through test results or simulations over the track inputs defined in Chapter XI of AAR Standard M-1001. This includes the following conditions:

- Constant Curving (M-1001 Section 11.7.3)
- Spiral Negotiation (M-1001 Section 11.7.4)
- Twist and Roll (M-1001 Section 11.8.2)
- Pitch and Bounce (M-1001 Section 11.8.3)
- Yaw and Sway (M-1001 Section 11.8.4)
- Dynamic Curving (M-1001 Section 11.8.5)

Test or analysis is to consider speeds up to 90 mph (where appropriate). Limit values are to be based on criteria defined in Table 11.1 (AAR Standard M-1001).

5.7.5 Dynamic Response on FRA Class 6 and Class 7 Track

Performance of the locomotive at high-speed and high cant deficiency shall be verified through analysis requirements defined in 49CFR Section 213.345. Minimally Compliant Analytical track (MCAT) simulations shall be performed based on the revenue speed limit and maximum cant deficiency defined in Chapter 1 of this Specification. Limit values are to be based on the VTI safety limits table in 49CFR Section 213.333. As a supplement to the requirements of 49CFR Section 213.345, the analyses are to verify vehicle stability for a wheel/rail combination with a minimum conicity of 0.3 (per the calculation method of APTA Standard SS-M-017-06). Dynamic tests with instrumented wheel sets are required.

* End of Chapter 5 *

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Chapter 6

Couplers and Draft Gear

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6.0 Couplers and Draft Gear

6.1 Overview

This section describes the performance requirements for couplers and draft gear for the locomotive.

6.1.1 Strength Requirements

Couplers and their associated apparatus shall be capable of withstanding a compressive load of 800,000 lbs in the line of draft without permanent deformation.

6.1.2 Crash Energy Management (CEM)

This section describes the performance requirements for couplers and draft gear. Coupler and draft gear assembly shall be designed to incorporate Crash Energy Management (CEM) features as defined in this section.

6.1.3 Geometric Requirements

Locomotives, when coupled, shall maintain safe and secure coupling while negotiating the horizontal curves of 250 ft radius (23° curve).

6.2 Couplers

Each locomotive 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 F Tightlock couplers and components conforming to Mechanical Committee of Standard Coupler Manufacturers (MCSCM) drawings. The coupler head and knuckle shall conform to the Type F Tightlock pattern as per corresponding MCSCM drawings and specifications. Couplers shall be equipped with AAR-standard uncoupling mechanism for independent operation from either side of the locomotive. Uncoupling mechanism shall be top operated. Push back couplers with energy absorption shall be used as a component of an integrated crash energy management system.

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.

6.3 Draft Gear and Yoke

Draft gear shall be push back type integrated within the CEM system defined in this Specification.

Draft gear characteristic shall be compatible with force characteristics of the mating push-back coupler for the coach cars.

6.4 Coupler Carriers

Coupler carriers shall meet AAR standards as well as the geometric requirements of Chapter 1. AAR standard lateral swing of coupler (13 in. to each side of center at the coupling line) shall be provided as a minimum. The carrier shall keep the coupler level at all positions of the coupler and a means of shimming to maintain level shall be provided. Clearance shall be

allowed so that carrier is not loaded longitudinally with the unit in maximum draft or maximum buff. Locomotive coupler carriers shall comply with FRA Rule 229.141(a)(3).

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.

6.5 Crash Energy Management (CEM)

Both ends of the locomotive shall be equipped with push-back, energy absorbing coupler assemblies.

The push-back energy absorbing coupler assemblies shall meet the requirements shown in Table 6-1.

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

| Application | Minimum Initiation Load, Pounds | Minimum Energy Absorption, Ft-lbs | Minimum Push-Back Stroke, Inches |
|---------------------|--|--|---|
| F-End and No. 2 end | 600,000 | Determined by available push back stroke | Up to available space |

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 250,000 lbs 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 locomotive 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.

A deformable anti-climber shall be included as part of the overall CEM energy absorption capacity subject to space and weight constraints.

6.5.1 Sequence of Operation of CEM Functions

The sequence of operation of the CEM functions shall be as follows for the condition of a locomotive, cab car, freight car and highway vehicle 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.

1. Coupling mechanisms of locomotive contact
2. Coupling mechanism initiates energy absorption
3. Structure(s) involved in principal load path engage
4. Crush elements initiate

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

6.5.2 Locomotive Front End Interaction Evaluation

The locomotive front end shall be analyzed to show that during a collision with the standard FRA collision-simulation locomotive, 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 Engineer's space, energy absorption of the cab end and the acceptance criteria

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.

6.5.3 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 and Analyses Plans shall include as a minimum the tests 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 locomotive. The assembled model shall be used to perform a full 3D explicit analysis of the locomotive crashing into a standing locomotive to prove compliance with this Specification.

Since CEM is a relatively new criteria for locomotives, a static test procedure shall be developed by the Contractor. The test procedure shall be reviewed and witnessed by the Customer. An actual crash test of a locomotive carbody or coupler assembly will not be required if the Contractor can demonstrate the performance by use of a validated Finite Element Analysis (FEA). Also, elements previously validated may be used as-is without re-test.

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Chapter 7

Braking System

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7.0 Braking System

7.1 Overview

The locomotive shall be equipped with a microprocessor controlled, standard 26L compatible brake system, capable of operating in MU consists. A blended automatic brake system, using an optimal combination of pneumatic and dynamic braking shall be available by means of the automatic brake valve. The control of blended braking is specified in Chapter 9.

Diagnostic capability shall be incorporated. All on-board system time clocks shall be synchronized and integrated at the Engineers control screen, or by other method approved by the Customer.

7.2 System Requirements

The brake system shall provide penalty application and permanent suppression in conjunction with cab signal, overspeed and vigilance/alerter control. In the event of a "Break-in-two," the strategy shall be to drop load and return to idle, apply emergency braking.

A centralized single manifold grouping of the major brake components shall be provided. A layout drawing detailing apparatus location shall be provided at the initial design review and shall be approved by the Customer.

Valves and components shall be tagged or identified by nameplate.

A diagram showing the location of all cutout cocks shall be provided. Cutouts shall be located for easy accessibility by the operating crew and maintenance personnel.

The brake system shall include interface capability for Electronically Controlled Pneumatic (ECP) brake system with appropriate functionality with cab signals, overspeed protection, vigilance/alerter control and the event recorder. The ECP system and its interface with these ancillary devices shall have no single point failures. The ECP control logic and hardware platform shall be compatible with AAR standards. Locomotives shall be equipped with hard conduit ready to accept ECP wire trainline as defined by AAR Standards. Conduit shall be terminated with protective caps adjacent to the brake pipe train line hose connection.

A Failure Mode Effects and Criticality Analysis (FMECA) shall be conducted by the Contractor. The specific systems, including software and interfaces for the FMECA shall be approved by the Customer during design review.

7.3 Pneumatic Schedule

A standard 26L air brake system with graduated release feature or approved equivalent shall be furnished. The system shall have an adjustable feed valve set for 110 psi brake pipe pressure.

Emergency brake provisions shall be as follows:

- Automatic brake pipe charging cut off.
- #8 vent valve or equivalent.
- Emergency valve on Engineer's side in cab.
- Automatic penalty service-rate braking (from cab signal and alertness control with reduced permanent suppression based on a cumulative reduction of 17-19 psi brake pipe).
- Penalty application shall reduce traction power to zero at a rapid but controlled rate.

- Penalty application shall not draw brake pipe to zero, but shall self-lap when a full-service application is achieved.
- Recovery from penalty and penalty feature shall be in accordance with individual apparatus requirements. A full suppression application shall always be necessary.
- All air exhausted from airbrake valvular portions shall be vented exterior of the cab. Exhaust vents shall be suitably protected from contamination or blockage by dirt, snow, ice or insect nesting.

7.3.1 Blended Dynamic Brake

Single-handle blended brake control shall be provided and controlled by the automatic brake handle position. Automatic blending with air shall be provided via automatic brake valve, at any time the throttle is not in a power position or dynamic braking and no independent brake is called for.

Braking rates shall be sufficient to permit operation on the Customer's railroad(s) without the need to adjust existing signal spacing, and be properly coordinated with the rates provided by the trailing cars.

7.3.2 Performance Criteria

- Full-service, air-only for a single locomotive ("light locomotive" movement) from 125 mph, the stopping distance shall not be more than 9,000 ft.
- Emergency, air-only for a single locomotive ("light locomotive" movement) from 125 mph, the stopping distance shall not be more than 8,000 ft.
- Air-only brake shall be used below 5 mph, and immediate motoring shall be available to Engineers between 0-5 mph.
- Blended brake shall be available when throttle is in idle.
- Pneumatic priority shall be given in emergency and dynamic priority on service-rate applications, pneumatic brake shall be fail safe against loss of dynamic brake.
- Wheel slide detection/correction shall be in conjunction with dynamic and pneumatic brake during blending.
- Brake Cylinder Pressure (B.C.P.) shall be limited to emergency maximum when independent brake valve is applied during blending.

7.4 Air Compressor

The air compressor shall be electrically driven or approved equal with the following functions:

- On and off capabilities upon demand.
- Main reservoir pressure shall be maintained at 140 psi (130 psi to 150 psi operating range) with 100 cfm minimum.
- The air compressor shall meet the requirements as specified in APTA Standard SS-M-011-99.
- The after cooler shall be equipped with a separate automatic drain dump valve and shall be designed to avoid condensate traps and dump valve shall be heated as required to avoid freezing.

7.5 Air Dryer

System shall be equipped with regeneration type air dryer system with a coalescing oil removal filter. The air dryer shall meet the requirements as specified in APTA Standard SS-M-011-99. The air dryer unit shall include an air moisture indicator which indicates saturation of desiccant bed, at Customer's option.

7.6 Main Reservoirs

Two 25,000 cubic inch (minimum) steel locomotive air reservoirs shall be provided. Suitable protection against debris damage for #1 main, #1 and #2 drain valves and piping shall be provided. Oil and water content in air to reservoirs shall be sufficiently low to ensure reliable operation of all pneumatic components. Tell-tale drill holes shall be provided per the requirements of 49CFR Section 229.31(b).

The main reservoir drain valves shall be equipped with 75 W thermostatically controlled heaters.

7.7 Accessory Valves

7.7.1 Safety Valves

Safety valves provided shall be J-1 safety valve, 155 psi trip, #1 main reservoir inlet. Contractor's standard intercooler safety valve or approved equal shall be supplied.

7.7.2 Check Valves

Salem 596 or approved double check valves, Prime 301-2 or equivalent orifice check valve main reservoir trainline for break-in-two protection shall be provided. Contractor may propose alternative models for Customer Approval.

7.7.3 Automatic Drain Valve

Salem 880 or equivalent drain valves at #1 and #2 main reservoir flange connections shall be provided. Salem 872 timer or equivalent, nominal 3 minute cycles shall be provided.

7.8 Air Gauges

Suitable gauges shall be provided on the Engineer's console to display air brake functions and status.

If the option for consolidated cab electronics is exercised, the electronic gauges may be incorporated in the screen displays.

7.9 Angle Cocks

Smith, Sloan or equivalent ball-type angle cocks shall be used at each end of brake pipe. Contractor's standard cut-out cocks shall be behind pilots and readily accessible to operating personnel.

7.10 Air Piping

Air piping shall be extra-heavy wrought steel using 300 lb AAR rated fittings (under carbody). Brake pressure and car supply trainline piping shall be 1.25 I.P.S. Contractor's standard piping and tubing shall be approved by the Customer.

7.11 Connections

- Main reservoir hoses shall be Aeroquip 1531-16 with LS4, or approved equivalent.
- Other MU hose shall be WABCO 543006, or approved equivalent.
- All MU trainlines shall be identified by metal tags, or approved equivalent.
- Brake Cylinder hoses, shall be Aeroquip 152110-12-16-32 3/4 wire reinforced, or approved equivalent.
- Brake pipe shall be Contractor's standard 22 in. AAR.
- New hoses shall be furnished, all to be less than one year old from date of manufacturer.
- Dummy couplings shall be furnished to support the hoses when not coupled.

7.12 Independent Brakes

An independent brake valve, set for 72 psi B.C.P. except as otherwise approved (45 psi appl. release trainline) shall be provided.

7.12.1 Parking Brake

A standard mechanical handbrake shall be supplied in addition to a standard independent air brake. The parking brake can be a mechanically-applied type, an electrically-applied type or a spring applied/air release type of parking brake. The parking brake shall be designed to hold the locomotive on 3% grade minimum. The design of the parking brake shall be approved by the Customer.

* End of Chapter 7 *

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Chapter 8

Engineer's Cab

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8.0 Engineer's Cab

8.1 Design and Layout

The locomotive shall have a full width cab. The cab shall feature a clean, safe interior design with console-type control arrangement. Alternative console arrangements, such as the AAR Control Stand, may be specified by the Customer. The entire cab interior area, including console, panels, doors, windows, equipment, etc. shall present an integrated environment consistent with modern design practices. The materials and hardware shall be easy to clean and maintain and shall provide long life and durability. No dirt collecting recesses shall be present.

All required instrumentation is to be mounted in or adjacent to the Engineer's desk console. Contractor's standard control instruments shall be installed. Cab shall be fully insulated throughout to achieve lowest possible cab interior noise level of less than 85 dBA and a maximum of 87 dBA.

The Engineer's cab design and layout shall meet the intention of the Clean Cab design recommendations by the AAR, human factors and industrial design considerations. The design and layout shall provide an environment which shall permit the use of control and operating functions in a safe manner. A work station for the Engineer shall be furnished on the right hand side of the cab and an optional left hand side work station may be required by the Customer's specification.

Layout shall maximize free floor space, shall be ergonomically designed and shall be free of sharp edges, protruding objects, safety hazards. Two fully adjustable, lumbar support locomotive seats shall be provided. A third locomotive seat shall be provided that is either a cab seat or wall mounted jump seat.

The flooring material and the seating material and any other flammable material used in the cab area must meet current smoke and flammability requirements per 49CFR Section 238.103.

8.2 Flooring

The floor in the Engineer's cab shall consist of ply-metal panels or other approved equal material, including subfloor and structure covered with Nora/Endora dimple flooring or approved equivalent.

8.3 Doors

8.3.1 Exterior Doors

- Cab shall have at least a minimum of two suitable doors to the exterior
- Doors shall feature low and high external handles, recessed with sufficient handhold clearance and shall be free of sharp edges
- Doors shall be fitted with rugged, positive lockable latches:
 - Low level for access from Top of Rail (TOR)
 - High level for access from platforms (Cab floor level shall not be lower than the high level platform height)
- Door shall be lockable from the interior and exterior of the locomotive
- One door shall be provided for exiting the engine compartment close to the rear of the locomotive

- Sliding doors may be proposed for approval to simplify cab layout

8.3.2 Interior Doors

- Cab Area: One or more as required reducing the engine room noise from the engine room, opening away from cab area and equipped with a panic release unlocking mechanism
- Door handles shall have adequate handhold clearance and positive latching mechanisms and shall be free of sharp edges
- Sealed against noise, fumes, dust and weather elements
- Sliding doors may be proposed for approval to simplify cab layout

8.4 Windows

8.4.1 Windshield

Glass and frame shall be 49CFR Part 223 Type I certified glazing. Design by spall shield or other approved means to be provided to prevent entrance of glass particles into cab area. The front windshields shall be interchangeable with each other where appropriate. Glass shall be electrically heated with integral heating element and have a minimum tint. All cab windows shall be water tight using seals resistant to weather and sun exposure. Design should minimize glare and reduce the structural obstructions to view of the right of way to the minimum possible consistent with the overall cosmetic and structural requirements of the carbody design.

The windshield shall be oriented so as to provide maximum viewing forward to the horizon, to the near track, and at an angle subject to carbody design to the right and left of track for the Engine Crew. It shall be oriented to reduce glare. Engineer's visibility shall be maximized. The glazing shall be installed so that it is not unduly stressed by frame or carbody flexure.

8.4.2 Side Window

Side windows shall be of 49CFR Part 223 Type II certified glazing. Sideways sliding or drop sash windows shall be incorporated into the design of the cab. The side windows shall be easy to operate and can rest at any desired opening position.

When closed the window shall be properly sealed against noise, fumes, dust and weather.

8.4.3 Wind Deflectors

Retractable wind deflectors with rear view mirrors shall be installed forward of the left and right side windows.

8.4.4 Windshield Defrosting

Electrically heated windshield defroster controls shall be located at the Engineer's station. Windshield defrosting shall be supplied to the front windows only and controlled by a switch on the Engineer's console.

The windshield defrosting function may be an integral part of the cab Heating, Ventilation and Air Conditioning (HVAC) system.

8.4.5 Windshield Wipers

Windshield wipers shall be installed as needed to cover windshield viewing area so as not to restrict the Engineer's viewing area.

Electric wiper motors shall be provided with variable speed controls or two speeds with variable intermittent time delayed sweep with controls located at Engineer's console and at the left side console capable of clearing water and snow at locomotive speeds of up to 125 mph.

8.5 Emergency Egress and Ingress

A means for emergency egress or ingress of the locomotive cab shall be incorporated into the design of the Engineer's cab. The Contractor shall design the layout incorporating provisions for the cab occupants to exit in an emergency. Exit pathways must be considered in the design by not locating other cab equipment in the exit pathway(s). The provisions shall also incorporate a means for outside emergency personnel to enter the cab area.

8.6 Interior Liners and Panels

Interior liners, masks, covers, etc. shall be designed and constructed in an integrated consistent manner and must meet current smoke and flammability requirements per 49CFR Section 238.103. All exposed edges shall be molded, and both moldings and fit finish of panels shall be in accordance with the workmanship requirements of Chapter 18.

8.7 Seats

Two high-back style locomotive seats with adjustable lumbar support shall be provided in the cab. The seats shall contain ergonomic features to reduce fatigue and allow for safe train operation. The seats shall have vertical, horizontal, reclining and rotating adjustments; shall have folding arm rests and shall be upholstered. A suspension system to minimize vibrations shall also be provided. The seats shall be designed to withstand a longitudinal force of $\pm 8g$, a lateral force of $\pm 4g$ and a vertical force of $\pm 4g$ per 49CFR Section 238.435.

As an option, provisions for a third seat or folding, wall mounted jump seat shall be incorporated into the cab design.

8.8 Toilet Room

A low volume water, stainless steel, retention or waste treatment type toilet shall be provided. The toilet shall comply with 49CFR Section 229.137. The toilet type and design shall be approved by the Customer.

No recesses on or adjacent to toilet shrouds shall be permitted which may gather dirt and debris.

Toilet compartment shall be provided in an approved location. Compartment shall be properly vented and have an adequate dam and drain to facilitate cleaning.

If a retention type toilet is proposed, provisions for draining the retention tank shall be provided on both sides of the locomotive. The toilet drain pipe shall be freeze protected.

The toilet shall have a toilet paper dispenser, waste container and suitable handhold located on the wall adjacent to the toilet. Modesty hardware shall be consistent with FRA requirements.

The waste retention system shall be designed to be emptied from either side of the locomotive from fittings easily accessible by personnel standing adjacent to the vehicle. The design shall comply with Federal and local regulations for the safe handling of sewage.

8.9 Electrical Receptacles

Two grounded duplex electrical receptacles for 110VAC power shall be provided in the cab area. All shall be protected to 20 amps.

8.10 Heating, Ventilation, and Air Conditioning (HVAC)

The Heating, Ventilation, and Air conditioning (HVAC) unit shall be designed to provide a climate controlled environment for the locomotive occupants. The design of the HVAC shall incorporate the following features

- Positive air circulation and fresh air ventilation of the cab compartment to prevent the entrance of dust, sand, fumes, liquids or precipitation into the locomotive cab with doors and windows closed.
- Positive ventilation provided in toilet area, vented away from cab and engine compartment.
- Cab air-conditioning shall be capable of maintaining an interior temperature no greater than 75°F (24°C) at external ambient temperature of 105°F (40°C).
- Manual control to be provided for cooler/warmer adjustment.
- Layover power to the HVAC system to be provided either by the HEP or ground power.
- The HVAC unit shall be mounted inside the locomotive carbody or on the cab roof.
- The addition of electric cab floor heaters having two levels of heat/air flow, with independent controls for Engineer and Assistant as a Customer option.
- Sized to maintain the area around the crew comfortably warm under all cold weather conditions, not less than 65°F (18°C) at up to maximum forward speed at minimum ambient temperature of -22°F (-30°C).
- Maximum wind speed as specified by Amtrak Specification 963.

8.11 Cabinet Door Securement

- Suitable recessed or folding latches capable of remaining latched against normal locomotive coupling impacts and vibration as approved by the Customer.
- Doors shall be hinged where possible.
- Where screws or bolts are used for securement, they shall be of the type that remains in the door when unlatched and swung open.
- The cab shall be draft free and secure against air leaks from the outside.

8.12 Refrigerator

A refrigerator shall be provided and have a minimum capacity of 2 cu ft (56 l). The refrigerator shall be capable of operating from the locomotive battery power during Automatic Engine Stop Start (AESS) engine shut down. The capacity and features of the refrigerator shall be subject to Customer approval.

8.13 Rain Gutters

Rain gutters shall be installed over the side windows and cab doors, where appropriate. Consideration must be given to the carbody design to ensure liquid captured in the gutters do not flow on areas of crew access or where maintenance personnel may stand for routine operations.

8.14 Sun Visors

Visors shall be sliding-type or approved equal, one at each windshield. Visor mechanism shall be secure against vibration. Sun visor construction shall be consistent with 49CFR Section 238.103.

8.15 Accessories

8.15.1 Clothes Hooks

Three retractable coat hooks shall be installed. Hooks shall be flush with wall when retracted. Hooks shall be mounted 5 ft. to 6 ft. above the floor in locations approved by the Customer.

8.15.2 Inspection Card and Work Report Holders

Standard Prime or equal card holders with clear plastic inserts shall be installed in the Engineer's cab at a location approved by the Customer. A clip to hold track warrants and other data shall be installed on the Engineer's console, and the left hand console. Card holder construction shall be consistent with 49CFR Section 238.103.

8.15.3 Waste Container

Each waste container that is used for solid or liquid waste in a work place shall:

- Be equipped with a tight-fitting cover
- Be so constructed that it can easily be cleaned and maintained in a sanitary condition
- Be leak-proof
- Shall follow the guidelines outlined in 49CFR Section 238.435(f)

Location and size is to be approved by the Customer.

8.15.4 Cup Holders

Wire-type cup holders with a minimum diameter of 3 in. shall be installed at each one of the two cab work stations. Other types or sizes may be specified by the Customer.

8.15.5 Tool Box

A tool box of an approved size and location shall be supplied with a hammer and wrench for hose change out. The tool box should also be sized to store spare air brake hoses and other small items. The location of the tool box shall be placed to be easily accessible, but not hinder movement of the operating crew, especially in an emergency egress through the door to the engine compartment. Alternative locations outside of the Engineer's cab may be proposed for the tool box.

8.15.6 Supply Box

A supply box of an approved size and location shall be supplied to store fuses and equipped with a flag holder.

8.15.7 Tissue Box Holder

A stainless wall mounted tissue box holder which will hold a standard size 100 count tissue box shall be supplied. The tissue holder shall be within reach of the locomotive Engineer. The tissue holder shall have no sharp edges. The location of the holder shall be approved by the Customer.

8.15.8 First Aid Kit

The cab shall be equipped with a storage location or mounting area to securely hold the first aid kit. The location shall be approved by the Customer.

8.15.9 Cab Appurtenances for Operation in Canada

These requirements will be covered by individual Customer's specifications.

* End of Chapter 8 *

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Chapter 9

Locomotive Propulsion System

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9.0 Locomotive Propulsion System

9.1 Overview

The power plant technology and the components to be used shall be a proven product in successful revenue service operations and capable of providing reliable and efficient performance in intercity passenger rail services in North America. New power plant technologies or designs, i.e., designs proven in other applications such as heavy industry, can be proposed but are subject to Customer approval.

9.1.1 Propulsion System Architecture

The propulsion system architecture shall be subject to approval by the Customer.

The following description of systems analysis shall be applied, as appropriate to all subsystems and assemblies for the diesel engine.

Circuitry associated with all electrical power train components may, depending on the approved architecture, include, but not be limited to, the following components/subsystems:

- Main alternator/prime mover
- Means for connection to the output of the main alternator/prime mover
- Inverters
- Contactor(s)
- Cooling: If blower motors are used all such motors shall be protected from over temperature. The use of imbedded temperature sensors is permitted.
- Filter capacitor charging circuit(s)
- Filter inductor(s)
- Rectifier(s)
- Filter capacitor bank(s)
- Brake chopper(s)
- Three-phase VVVF inverter(s)
- Sensors for control and monitoring (e.g., voltage, current, temperature, speed, as required)
- Protective devices
- Traction motor(s)

Each propulsion unit shall operate independently. Failure or mis-operation of one unit shall not adversely affect operation of the others.

Each propulsion unit shall utilize the traction motors to provide rheostatic braking.

The propulsion control logic unit shall be able to provide a command for friction brake tractive effort to the friction brake system. Alternative division of functions between propulsion and friction braking may be proposed based on equivalent performance.

The propulsion system and its main sub assemblies shall incorporate a Local Diagnostic and Test System (LDTS) to perform self-test, fault detection, relevant signal recording, status logging and self-diagnosis, and shall communicate such information in the on board internal computer stored data logging architecture as proposed by the Contractor and approved by the Customer.

All parameters of propulsion system performance, including friction brake control, if applicable, shall conform to this technical specification and all requirements contained herein.

The Contractor shall ensure the propulsion equipment used is capable of meeting all applicable performance requirements.

The Contractor shall prepare detailed performance calculations and curves to demonstrate compliance with the Technical Specification and, if the Contractor is not the propulsion manufacturer, the manufacturer's requirements.

9.1.1.1 Analysis

The Contractor shall provide an analysis justifying the exact system architecture chosen. The justification shall address such issues as EMC, cost, cooling, complexity, reliability, availability and fault tolerance, weight and maintainability, and shall demonstrate that, considering all factors, the chosen architecture is not inferior to other reasonable alternatives. Alternative arrangements for fault tolerance within the propulsion system will be considered by the Customer as long as the Contractor demonstrates equal to or greater system reliability.

9.2 Service and Performance Requirements

The Contractor shall provide a complete and comprehensive description of the proposed locomotive to be built, including its past performance and experience. At the minimum the Contractor shall also provide plots, charts or tables for the following as part of the bid proposal:

- Locomotive Rail Horsepower 0 - Max Speed
- Dynamic Braking Effort 0 - Max Speed
- Traction Motor Characteristics
- Acceleration with the trailing cars weighing no more than an average of 170,000 lbs (average cab car and coach car):
 - 1 locomotive + 680,000 lbs of trailing load (3 cars + 1 cab)
 - 1 locomotive + 850,000 lbs of trailing load (4 cars + 1 cab)
 - 2 locomotives + 1,360,000 lbs of trailing load (8 cars)

For simulations, train resistance calculations will be based on the Davis equation utilizing the following requirements:

- Coefficient 'A' = 1.3
- Coefficient 'B' = 29
- Coefficient 'C' = 0.03
- Coefficient 'D' = 0.0024
- Coefficient for trailing locomotive = 0.0012
- Base-line surface area for lead locomotive = 141 sf (average)
- Assumed air resistance coefficient for bi-level car = 0.00044 (average)
- Assumed surface area for bi-level car = 145 sf (average)
- 600 kW HEP load for the trainset
- Pneumatic service and emergency braking characteristics from 30, 45, 80, 100, 110 mph and 125 mph
- Blended service and emergency braking characteristics from 30, 45, 80, 100, 110 and 125 mph when applicable
- Route performance calculations based on Customer-specified routes

- The simulations shall provide as a minimum the following:
 - Speed/time and speed/distance graphs
 - Tractive effort/time graphs
 - Power/time graphs
 - Fuel usage graphs
- Sufficient detail of the methods and values used in the simulation calculations shall be provided to enable accurate assessment of the data provided.
- There shall be no rating on the locomotive which is for a period of less than three minutes.
- There should be consideration given to provide a short-term boost in horsepower during acceleration.
- Provisions for layover protection using shore power to bypass the AESS feature.

9.3 Diesel Engine(s)

The locomotive shall be powered by one or more turbocharged diesel engines. The engine shall be certified to EPA Tier 4 standards.

The engine shall be equipped with an AESS system compliant with AAR Standard S-5502 to save fuel and reduce engine exhaust emissions. The diesel engine shall operate only with Ultra Low Sulfur Diesel fuel (ULSD), or other approved alternative fuel. Fuel consumption shall be optimized to allow for the lowest possible life-cycle costs.

9.3.1 Lubricating Oil System

A Contractor's standard lubricating oil system which utilizes engine coolant to reduce oil temperature shall be provided.

9.3.2 Fuel Pre-heater

A Contractor's standard fuel pre-heater utilizing engine coolant as the heat source shall be supplied, if required.

9.3.3 Cooling System Requirements

- The cooling system shall be consistent with EPA Tier-4 operational requirements.
- Shutters, if used, shall be automatic and fully guarded with manual override feature.
- A low coolant level indication shall be provided. Control to provide protection against loss of pump or coolant flow under all conditions shall be provided.
- Manual water drain valve shall be supplied.

9.3.4 Engine Jacking

An engine jacking or rotating device shall be supplied if required for maintenance purposes.

9.3.5 Manual Cylinder Compression Relief

Cylinder relief devices shall be supplied which prevent the possibility of hydraulic lock when starting if required by the engine manufacturer.

9.3.6 Cleaning and Drainage Under the Engine

The space under the engine shall be accessible for cleaning and shall be adequately drained to a holding or retention tank. The tank shall be capable of being drained during locomotive servicing.

9.3.7 Load Testing

The locomotive shall have a self-load test feature with full load capability of the engine without time limit. If a multi-engine solution is used, the self-load test can be done for one engine at a time.

9.3.8 Engine Room

The engine room of the locomotive shall be ventilated to maintain temperatures within consistent operating limits and to avoid hot spots. The engine room ventilation air shall be filtered with inertial filters and have a positive pressure to preclude dirt, rain and snow ingestion.

9.4 Main Alternator

- Rectification by solid state devices
- Class H or other approved insulation
- Auxiliary winding for cooling fans and auxiliary systems, if required

9.5 Traction Motors

AC type traction motors shall be designed for North American Passenger Service.

- If the traction motor is axle hung, sealed-grease lubricated insulated bearings, tapered roller or equivalent shall be incorporated.
- Class H or better insulation with vacuum/pressure impregnation of all coils, armature, field or stator.
- Fitted with disconnect cable leads or approved equal.
- Properly baffled to prevent blowing of sand and debris from rails, and to prevent motors from inhaling non-filtered cooling air, rain or snow.
- One motor shall be given all commercial tests for Institute of Electrical and Electronic Engineers (IEEE) standards and a complete heat run prior to use in first locomotive.
- Motors shall be cooled with clean air supply (if required) using inertial air filters or filter grids as approved by the Customer.

9.5.1 Motor Cutout Switch

A traction motor cutout shall be provided to isolate any one traction motor or a complete truck, controlled from locomotive cab.

9.5.2 Power Semiconductors

- Shall permit easy replacement of semiconductor functional units.
- Shall be of a type which does not require individual grading and selecting of like component for exact pairing or matching.
- Control circuits shall be isolated so as to prevent secondary fault escalation; optical coupling is preferred.

- Insulated Gate Bipolar Transistor (IGBT) semi-conductors shall be furnished.

9.5.3 Resistors

All resistors (including PC-boards) shall only use fixed values of resistors. Calibration shall not use adjustable resistors or trim potentiometers wherever possible.

9.6 Wheel Slip – Slide Detection

A state-of-the-art slip-slide protection system shall be provided by use of speed sensors on the traction motors and protect against both synchronous and differential slips and slides. Salient features shall include the following:

- A wheel slip control system that shall make full use of advantages provided by microprocessor techniques.
- Shall make use of available adhesion and provide protection against all rail conditions and be optimized for use on a lightweight passenger locomotive.
- A positive traction control type system or approved equal shall be provided.
- The slip-slide protection shall function in all operating conditions including dead-in-consist and isolated traction motor. For all in-train acceleration, service braking and slip/slide correction, jerk rate shall not exceed 1.50 miles per hour per second per second (mphpsps).

9.7 Protection

The propulsion system shall incorporate protection functions that prevent damage or incorrect operation resulting from the following causes, at a minimum:

- Main alternator over current or over temperature
- Inverter/converter over current
- Inverter/converter semiconductor and/or heat sink over temperature
- Traction motor overload
- Traction motor over temperature
- Traction motor over speed
- Incorrect connection of traction motor leads (i.e., phase reversal or incorrect phase sequence)
- Wheel diameter differences, up to and including the greatest wheel diameter difference that is physically possible
- Ground fault, sensed as an imbalance of supply and return current, the threshold of which shall be set as necessary to avoid nuisance trips
- Open traction motor phase
- Charging resistor open circuit (if applicable)
- Line or DC link over voltage
- Failure of line contactor(s) to open when commanded
- Actuation of any protective function shall be annunciated to the diagnostic system

Transient abnormal or fault conditions shall be reset automatically. Automatic resets shall be counted and limited; repeated occurrences of the same malfunction over short time intervals may be treated differently to optimize the protection.

Propulsion controls shall be designed and programmed to provide protection of propulsion system power components. The control logic shall not command a power device to interrupt

more current than it is rated for, less margin, nor to operate when its applied voltage is in excess of its rating, less margin. Reception of both forward and reverse commands, or detection of any other invalid command, shall inhibit propulsion or result in some other approved action. Upon detection of an abnormal condition which might result in damage, the controls shall actuate capable circuit interrupter(s) provided in the power equipment. Manual reset of fault condition shall be controlled to prevent equipment damage to any propulsion system component or sub-system.

9.7.1 Equipment Isolation for Failure Modes

In case of equipment failure the failed equipment shall be completely isolated (Both + and – sides) from the remaining good equipment. The idea is to provide maximum redundancy for increased mission reliability. The isolation method shall be automatic and annunciated via suitable display at Engineer's console. The arrangement adopted shall reflect accepted design practices in the rail industry. Axle control propulsion architectures shall satisfy the following criteria:

- No single functional failure of a Traction Motor or Inverter:
 - Shall disable electric traction on more than one axle
 - Shall deprive the locomotive of any of its electric braking power beyond that which can be continuously made up by friction braking within the thermal constraints of the friction braking equipment
 - Shall deprive the locomotive of normal control of service friction braking on any truck
 - Shall deprive the locomotive of adhesion management on any truck
- No two independent functional failures of a Traction Motor or Inverter:
 - Shall deprive the locomotive of normal control of service friction braking on more than 50% of its axles
 - Shall deprive the locomotive of adhesion management on more than 50% of its axles
- No functional failure of any VVVF inverter or traction motor shall disable electric traction on any axle beyond that directly affected
- The Customer does not intend to prohibit brief operational interruptions at the locomotive level during which the equipment protects itself against a failure in progress or reconfigures itself following a failure
- A vehicle architecture wherein the propulsion system shares one or more line converters with the auxiliary power system may be proposed

Alternative propulsion architectures shall demonstrate equivalent functional performance.

9.8 Automatic Speed Limiting Control (optional equipment feature)

The Customer may want the option of having this feature. The automatic speed limiting control shall:

- Regulate propulsion (not braking) to accelerate to and maintain, desired train speed as selected by the locomotive Engineer.
- Acceleration rate shall be dependent upon setting throttle handle.
- Engineer's automatic speed limiting control selector shall have OFF position which will isolate the automatic speed limiting control

* End of Chapter 9 *

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Chapter 10

AC Power Distribution, Communications Trainline and MU Trainline

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10.0 AC Power Distribution, Communications Trainline and MU Trainline

10.1 Overview

Electrical trainline connections for locomotive MU control, communication and the 3-phase head end power shall be made by jumper cables as approved by the Customer. All connections between cars and locomotives and between locomotives shall not pinch or stretch cables. Jumpers shall be color coded for identification of different functions. Spare jumpers shall be provided for all specified functions.

The locomotive shall be designed to operate in multiple with locomotives on the front of the train or in the push-pull concept with a control car and one or more locomotive units at each end of the train.

10.2 AC Power (HEP) Trainline

A 3-phase power distribution system shall be supplied which shall have a total combined transmission capacity of 600 KW. Cables, receptacles and hardware shall meet the requirements of APTA Recommended Practice RP-E-016-99 (480 VAC Head End Power System), or current version and APTA Recommended Practice RP-E-018-99 (480 VAC Head End Power Jumper and Receptacle Hardware), or current version.

The front of the locomotive shall be fitted with four 3/3 pole receptacles. The receptacles shall be standard Anderson Power Products R87 Type or approved equal.

The rear of the locomotive shall be fitted with two 3/3 pole receptacles and two power cables terminated in 3/3 pole free plugs. The receptacles shall be located in positions #1 (extreme left) and #3 and the power cables with free plugs located in positions #2 and #4.

Both receptacles and free plugs shall utilize a design having three main power pins and three smaller low-voltage control pins each. To prevent disconnection of the power jumper under load, the control pins shall break contact first and open a contact in the 480V supply. When connecting the train cabling, a total of four power jumpers are to be used between vehicles.

Copper cable of not less than 4/0 AWG shall be used for connection to each power pin of the power receptacles on the locomotives. Control wiring shall be 10 AWG. Phase rotation is 1, 2, 3, where pin #1 is #1-phase, #2 is #2-phase and #3 is #3-phase. The #1 control pin shall be utilized in the series-control trainline, #2 and #3 control pins are ground and shall not otherwise be used or connected to any locomotive circuit. Control logic shall be defined at the first design review with the Customer.

Four jumper cables shall be supplied for each locomotive which shall be banded and color-coded bright red. Four power cables shall be permanently fixed to the high receptacles of the #1 and #2 end connections. The Contractor shall install suitable supports at each end of the locomotive within the carbody compartment to store four power cables.

Automatic looping at the front of the locomotive shall be provided to complete the series-control loop. This circuit shall operate when the locomotive is in the lead position, and the receptacles at the front of the locomotive shall be dead (no power).

The 3-phase power receptacles and plugs shall be painted bright red for easy identification. When the cables are not in use the free end (plug) is to be plugged into the adjacent receptacle for storage or end-of-train identification.

Provision of ease of change out of the cables as a result of damage shall be provided.

The Trainline Complete (TLC) circuit continuity shall be designed to ignore transient events when the locomotive speed is above 5 mph.

10.3 Communication Trainline

Communications between the cars, control and looping circuits shall be trainlined by means of one 27-point jumper at each end of each locomotive. Two 27-point receptacles, Pyle National Model WWRF-27-AMTR, or approved equal, shall be provided at each end of the locomotive. The location of the communication trainline receptacles located at the ends of the locomotive are to be approved by the Customer during design review.

Jumpers shall terminate at each end using a Pyle National WWRF-27-AMTR receptacle, or approved equal. One jumper shall be supplied with each locomotive.

Jumpers shall be of the minimum length necessary to meet the operating geometry requirements. Communication trainline jumper control heads shall be painted blue in color to distinguish them from other jumper cables with different functions, i.e., MU cables and HEP cables. Shrink fit blue color bands shall not be supplied. Communication receptacles shall be painted blue.

The pin assignments for the communication trainline circuits shall be provided by the Customer. The Amtrak pin assignments are shown in the table below:

Table 10-1: Communication Trainline Pin Assignments

| Pin | PRIIA Standard | Amtrak Standard (for information only) | APTA Standard (for information only) |
|----------------|--|---|---|
| 1 | Shield (Common) | Shield | Shield (Common) |
| 2 | Battery Negative | Battery Negative | Battery Negative |
| 3 | Reserved for digital trainline/passenger information | PA/Tape Music #1 (black) | PA/Tape Music #1 (black) |
| 4 | Reserved for digital trainline/passenger information | PA/Tape Music #1 (white) | PA/Tape Music #1 (white) |
| 5 | Intercom (black)/analog with digital overlay | Intercom (black) | Intercom (black) |
| 6 | Intercom (white)/analog with digital overlay | Intercom (white) | Intercom (white) |
| 7 | PA Control (black)/analog with digital overlay | PA Control (black) | PA Control (black) |
| 8 | PA Control (white)/analog with digital overlay | PA Control (white) | PA Control (white) |
| 9 | Reserved for digital trainline/passenger information | Passenger Info (black) | Music-3 (radio)(black) |
| 10 | Reserved for digital trainline/passenger information | Passenger Info (white) | Music-3 (radio)(white) |
| 11 | Brake Application (not used) | Brake Application (spare-reserved for future use) | Brake Application |
| 12 | Brake Release (not used) | Brake Release (spare-reserved for future use) | Brake Release |
| 13 | Brake Negative (not used) | Brake Negative (spare-reserved for future use) | Brake Negative |
| 14 | Open Doors - Right Hand Side | Open Doors R.H. | Open Doors R.H. |
| 15 | Open Doors - Left Hand Side | Open Doors L.H. | Open Doors L.H. |
| 16 | Close Doors - Right Hand Side | Close Doors R.H. | Close Doors R.H. |
| 17 | Close Doors - Left Hand Side | Close Doors L.H. | Close Doors L.H. |
| 18 | Door Closed Light | Door Closed Light | Door Closed Light |
| 19 | Brake Released Light | Brake Released Light | Brake Released Light |
| 20 | Brake Applied Light | Brake Applied Light | Brake Applied Light |
| 21 | Hot Journal Light (not used) | Hot Journal Light | Hot Journal Light |
| 22 | Conductor's Signal | Conductor's Signal | Conductor's Signal |
| 23 | Door Close Light | Conductor's Door Closed Light | Door Close Lt |
| 24 | Reserved for digital trainline/passenger information | Tape Music #2 (black) (spare) | Tape Music #2 (black) |
| 25 | Reserved for digital trainline/passenger information | Tape Music #2 (white) (spare) | Tape Music #2 (white) |
| 26 | Conductor's Door Light Feed | Conductor's Door Light Feed | Conductor's Door Light Feed |
| 27 | Attendant Call | Attendant Call System (not active) | Attendant Call |
| Shielded pairs | 3&4, 5&6, 7&8, 9&10, 24&25 | 3&4, 5&6, 7&8, 9&10, 24&25 | 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 |

10.4 MU Trainline Control

Locomotive control shall be trainlined by means of 27-point jumpers at each end of each locomotive. Two 27-point receptacles, Pyle National WWRF-27 or approved equal, shall be provided at each end of each locomotive, the location of which are to be approved by the Customer. Jumpers shall terminate at each end in Pyle National WWRF-27, or approved equal receptacles. One Pyle National WWPCJ-2757LN S-505, or approved equal jumper cable shall be supplied with each locomotive.

Locomotive control jumpers shall be of the minimum length necessary to meet the operating geometry requirements of Chapter 1. To distinguish them from the communication HEP and control jumpers, the locomotive control jumper heads and receptacles shall be painted black.

Contractor shall provide two shielded twisted pairs with shields grounded through .47UF capacitor for possible future use in signal multiplexing.

The locomotive shall have the ability to provide load meter reading in cab control car through locomotive Multiple Unit control trainline using pins 18 and 19.

The pin assignments for the locomotive trainline circuits are shown in the table below:

Table 10-2: Multiple Unit (MU) Control Trainline Pin Assignments

| Pin | PRIIA Standard | Amtrak Standard (for information only) | APTA Standard (for information only) |
|------------|----------------------------|---|---|
| 1 | Spare | Spare | Spare (reserved for cruise control) |
| 2 | Alarm Bell | Alarm Bell | Alarm Bell |
| 3 | Engine Speed Solenoid "DV" | D Throttle | D Throttle |
| 4 | Control Negative | Control Negative | Control Negative |
| 5 | Emergency Sand | Emergency Sand | Emergency Sand |
| 6 | Generator Field | Generator Field | Generator Field |
| 7 | Engine Speed Solenoid "CV" | C Throttle | C Throttle |
| 8 | Forward | Forward | Forward |
| 9 | Reverse | Reverse | Reverse |
| 10 | Wheel Slip Indicator | Wheel Slip | Wheel Slip |
| 11 | Spare | Spare | Spare |
| 12 | Engine Speed Solenoid "BV" | B Throttle | B Throttle |
| 13 | Control Positive | Control Positive | Control Positive |
| 14 | Spare | Spare | Spare |
| 15 | Engine Speed Solenoid "AV" | A Throttle | A Throttle |
| 16 | Engine Run | Engine Run | Engine Run |
| 17 | Dynamic Brake Setup | Dynamic Brake Setup | Dynamic Brake Setup |
| 18 | Remote Load Meter Line 1 | Remote Loadmeter | Remote Loadmeter |
| 19 | Remote Load Meter Line 2 | Remote Loadmeter | Remote Loadmeter |
| 20 | Dynamic Brake Warning | Dynamic Brake Warning | Dynamic Brake Warning |
| 21 | Dynamic Brake Start | Dynamic Brake Start | Dynamic Brake Start |
| 22 | Spare | Spare | Spare |
| 23 | Manual Sanding | Manual Sanding | Manual Sanding |
| 24 | Dynamic Brake Excitation | Dynamic Brake Excitation | Dynamic Brake Excitation |
| 25 | Spare | Spare | MU Headlight |
| 26 | Remote Fault Reset | Remote Fault Reset | Remote Fault Reset |
| 27 | Brake Emergency | Brake Emergency | Brake Emergency |

10.5 Door Control Interlock

Provisions shall be made to interlock the car doors closed detection system with the propulsion system of the locomotive. The locomotive shall contain a zero speed detection system. An indication on or adjacent to the Engineer's console shall illuminate when the system is in operation, and when all doors are closed. The doors open condition shall inhibit the propulsion system, thus preventing motion. A manual isolation feature shall be provided. A Brake releases inhibit shall be furnished to prevent brakes on the train from being released when a wheelchair ramp (if installed on the cars) is deployed.

10.6 Data Cable Trainline

This section is intentionally blank pending further development of specification for data cable trainline.

10.7 Labeling, Coding and Stowage

Appropriate warnings and identification of all trainline connections shall be prominently displayed on the outside of both ends of the locomotive. Simplified instructions and directions for connection, disconnection and storage of jumpers shall include safety precautions and the required sequence of operations. Color coding shall be used to assist personnel in the makeup of the trains. The color coding is:

- Trainline Communication - Blue jumper, Blue receptacle
- HEP Power - Red jumper, Red receptacle
- MU Control - Black jumper, Black receptacle

All loose trainline jumpers on the locomotive shall be stored and secured in a suitable location approved by the Customer.

* End of Chapter 10 *

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Chapter 11

Lighting

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11.0 Lighting

11.1 Overview

All lighting shall be supplied from the 64-74 Volts Direct Current (VDC) battery system. Engine room lighting shall be suitable for the operating and maintenance personnel. All lighting shall be Light Emitting Diode (LED) technology where possible with the exception of the headlights and crossing lights, reference AAR Standard M-592

11.2 Exterior Lighting

The exterior lighting of the locomotive shall be equipped with all light fixtures and intensity performance in accordance with FRA and AAR Standards, railroad operating practices and the requirements of this Specification. The following exterior lights will be supplied as a minimum:

11.2.1 Headlights and Crossing Lights

Twin PAR56, 30 – 74VDC 200- 350 W sealed beam shall be supplied at the F-end. Access for bulb replacement shall be from inside the locomotive if possible. LED headlights and crossing lights may be proposed for approval. An OFF – DIM - DIM & CROSSING LIGHTS - BRIGHT & CROSSING control switch shall be installed in the Engineer's console, readily accessible and easy to operate. Other headlight control configurations may be specified by the Customer. If a rear headlight is provided in the design, a headlight control switch shall also be provided for the rear headlight. The rear headlight switch shall have an Off-Dim-Bright function.

Crossing lights shall be installed on the front of the locomotive and controlled through the front headlight switch. The Crossing lights must be capable of flashing at a rate of a minimum of 40 flashers per minute with a maximum flash rate of 180 flashes per minute.

The crossing lights shall be both automatically and manually activated.

11.2.2 Marker Lights

Two red marker lights located at the F-end of the locomotive shall be furnished.

11.2.3 Step, Ladder and Ground Lights

LED lighting shall be furnished for all steps, trucks, exterior platforms and ladders. Location of lights and switches are subject to Customer approval. Lighting at ladders will also illuminate the ground area immediately below the ladders and steps.

11.2.4 Locomotive Number Boards

At the Customer's option, illuminated locomotive number boards shall be located at the F-end of the locomotive. The number boards shall be controlled by a console mounted switch.

11.2.5 Train Number Boards

At the Customer's option, a digital display illuminated, train number board shall be located at the F-end of the locomotive. The train number boards shall be controlled by a console mounted switch.

11.2.6 Strobe and Emergency Indicator Lights

At the Customer's option, strobe or emergency indicator lighting may be required.

11.2.7 Engineer's Cab Lights

Two main ceiling lights, one each on the right and left side of cab or one fluorescent overall cab light shall be provided. Two additional over the console lights with a narrow beam shall be provided to light the Engineer's desk and the left hand side desk area. The lights shall use LED lighting technology where possible. The light intensity at the work surface shall achieve 20 foot-candles.

11.2.8 Engine Room and Toilet Room Lights

The engine room and toilet room shall have sufficient fluorescent or LED lights. The lighting intensity shall be 30 foot-candles at the floor level. The lights shall be fitted with a 30 second off delay following last detected motion of personnel. Switch locations to be approved by the Customer.

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Chapter 12

Locomotive to Train Communication

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12.0 Locomotive to Train Communication

12.1 Overview

The locomotive shall be equipped with a communication system to allow the Engineer to communicate with other train operating personnel.

12.2 Voice Radio

The following features shall be incorporated in the Engineer's cab radio:

- The radio must be a digital and narrow band type consistent with latest regulations.
- A 4 in. low-profile antenna, or approved equal shall be provided.
- A transceiver and handset shall be furnished.
- As an option, the Contractor shall offer radio hookups on the left side of the cab.
- A holder shall be provided to retain the radio hand set when not in use.
- The handset and holder location must be within easy reach of the Engineer.

12.3 Antennae

Radio antennae on the locomotive roof shall be located to maximize reception and minimize clearance vulnerability. Global Positioning System (GPS) and Cellular antennas shall also be accommodated in the design.

The antenna emissions shall be compatible with PTC requirements.

* End of Chapter 12 *

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Chapter 13

Head End Power (HEP) System

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13.0 Head End Power (HEP) System

13.1 Overview

The locomotive shall be equipped with an inverter—type Head End Power (HEP) source which shall produce 480VAC, 3-phase, 60 Hz electric power for heating, lighting and other hotel power needs of connected passenger cars. The HEP power source shall be capable of producing 600kW at 480V, 60 Hz with a 100% duty cycle, with 10% overload capacity for 30 minutes.

13.2 Head End Power (HEP) Control

The output of the HEP power source shall be controlled to within 3% of 480V between no-load and full load, except that 10% voltage variation shall be tolerated for not more than two seconds for an increase of up to 75 kW in the hotel load. Overloads from initial load during start up of an eight car consist shall be automatically controlled by voltage reduction (soft start), to an acceptable level. The following information shall be available to operating and maintenance personnel: voltage and amperage for all three phase legs and frequency. A wayside layover interlock is required to prevent connecting to wayside power while the locomotive is generating HEP or vice versa.

The HEP controls shall be equipped with trainline voltage control and Trainline Complete (TLC) function which shall determine when the HEP generator can energize the 480V trainlines. The TLC function shall prevent having an energized empty HEP receptacle.

13.3 Control and Distribution System

HEP control shall prevent loss of HEP power in the event of traction power loss.

The head-end power distribution system shall be capable of the following modes of operation:

- To distribute onboard—generated 480VAC power through the trainline.
- To distribute 480VAC power from a locomotive or wayside power source from one end of the locomotive to the other end through any or all of the trainlines.
- The logic for the Trainline Complete (TLC) circuit continuity shall be designed to ignore transients above 5 mph.

Three-phase HEP power will be removed from the three-phase bus for any of these conditions: over load, over frequency, under frequency, over voltage and under voltage.

The control system shall be designed to prevent application of power to trainlines if the trainlines are already energized from another source of 3-phase power, such as another locomotive or shore power. The control system shall also prevent application of power if the series-control trainline loop is not electrically complete. The control system shall function to immediately remove power from trainlines upon interruption of the series control trainline loop continuity.

13.4 Control Panel

The locomotive shall be equipped with an interface or display to control the HEP power source. The functions of the interface should include the following:

- Controls as required to start and stop the HEP
- Controls as required to reset tripped safety appliances
- Meters and switches
- An HEP start and stop switch mounted on the Engineer's console shall be provided
- Indicators are as follows:
 - Main breaker closed (green) (one per breaker)
 - 480V external feed (red)
 - Main power breaker (or breakers, as required)

A digital, solid-state HEP control system shall be required.

Shut-down of the HEP power source shall also be controlled remotely from the operating cab panel. An isolating switch, capable of being opened with a remotely located stop push button shall be provided. The stop push button shall function under any condition of plant operation to immediately open breakers, reduce alternator excitation and remove all power from the distribution trainlines. The emergency shut off shall also operate the shut down sequence.

In addition, HEP power source shut-down shall be possible from the control cab of the cab car via trainline control signals.

13.5 Connection for Trainline

Trainline power connections shall be provided which are compatible with Amtrak and other agencies' equipment per Chapter 10.

13.6 Control Interlock Circuits

Interlock circuits shall be as provided as approved by the Customer during design reviews.

* End of Chapter 13 *

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Chapter 14

Battery System

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14.0 Battery System

14.1 Overview

This chapter describes the basic requirements of the locomotive battery system.

14.2 Batteries

Low maintenance batteries shall be installed, as approved by Customer. The battery capacity shall be sufficient to start the main diesel engine at 75% battery capacity.

14.3 Battery Compartment

The battery compartment shall be self draining, and liquid shall not hit underframe equipment and trucks. The battery compartment shall be fitted with ready-access cover or hatch, stainless steel grating at the bottom of the battery box with adequate venting. Battery tray, hold down, and slides shall all be stainless steel. It shall be easily accessed for inspection and maintenance and properly vented to the atmosphere. The construction and size of the battery compartment shall ensure the battery is secured during any unsafe situations. The interior walls of the battery box shall be painted with acid-resistant, electrically insulating paint.

14.4 Battery Charging

A locomotive-type solid-state charger or approved equal shall be provided. A zero-center ammeter shall be provided on the control panel in the Engineer's cab or other location approved by the Customer.

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Chapter 15

Sanding System

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15.0 Sanding System

15.1 Overview

This chapter describes the basic requirements of the locomotive sanding system.

15.2 Locomotive Sanders

Locomotive sanders shall be electrically controlled and trainlined for forward and reverse sanding. Four traps shall be supplied with cutouts provided at each orifice block or other location approved by the Customer. A non-latching push button and cutout shall be provided on the Engineer's console to manually control sanding. A Contractor's standard, individual sanding system to correct wheel slip shall be provided. Any emergency air brake application shall initiate sanding, nominally timed for 10-second cut-off limitation at zero speed.

15.3 Sand Boxes

Four sand boxes of five cubic feet capacity each shall be supplied, two at the front and two at the rear of the locomotive. The sand boxes shall be integral to the body structure or mounted to the carbody. The sand box openings shall be fitted with watertight hatch covers with latching mechanisms. Clean out openings for the sand boxes shall be located at the bottom or side of the boxes.

The sand boxes shall be made of corrosion resistant steel or stainless steel to prevent rust and corrosion build-up.

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Chapter 16

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16.0 Engineer's Cab Controls

16.1 Overview

This chapter describes the Engineer's control station and console which shall be provided on the right side of the cab when viewing forward from the cab. The console layout shall follow the intention of Amtrak and AAR "clean cab" guidelines. Gauge and indicator orientation shall eliminate glare and reflections. The indicator lens scheme shall conform to the following:

- Green: GO status (limited use)
- Amber: WARNING status
- Red: NO-GO status, system malfunction or system disabled
- White: INFORMATION status (limited use)

The Contractor shall submit drawings including perspective renderings, as required, illustrating the console arrangement for approval by the Customer.

All on-board system time clocks of systems connected to event recorders or the central locomotive diagnostic system shall be synchronized and integrated at the Engineers control screen. This will include but will not be limited to:

- Electronic cab display system
- Event recorder
- Electronic air brake system
- All fault monitoring systems
- Provide for installation of both PTC and cab signal systems
- On-board video/DVR systems
- The time standard will be designated by the Customer's specification

16.2 Controls and Switches

The controls and switches located at the Engineer's console are those related either to the use of operating the locomotive, or those which control this locomotive and trainlined locomotives. There shall be no foot operated controls unless approved by the Customer. The controls and switches to be located at the Engineer's control station and console shall include, but are not limited to the following, to be numbered, lettered or colored as shown:

| Control Levers | Type or Label | Location |
|---|--|--|
| Master-Controller | Single-handle controller with eight notches of power, idle, eight notches of dynamic braking | Desk |
| Reverse Lever | Forward/Neutral/Reverse/Off with locking and handle removal in Off | Desk |
| Automatic Brake with independent brake valve | Two Handle Controller | Desk |
| Switches | | |
| Headlight Control | Off- Dim & Crossing Lights- Dim-Bright & Crossing | Console |
| Rear Headlight (if equipped) | Off-Dim-Bright | Console |
| Sanding | Momentary contact, forward/reverse sanding | Console |
| Gauge Light Switch | | Console |
| Gauge Light Dimmer | | Console |
| Cab Light | | Console |
| Overhead Desk Light | | Console |
| Cab Heater/Defroster | | Console |
| Windshield Wipers | | Console |
| Number Lights | | Console |
| HEP Electrical Reset | | At or near electrical cabinet or Console |
| HEP Start | | Cab or monitor |
| HEP Stop | | Cab or monitor |
| Electric Defrosters (Heated windshields) | | Console |
| Push Buttons | | |
| Attendant's Call | | Console |
| Alertness Reset | | Console |
| Communications Control | | |
| Air Horn | Push Button | Desk |
| Air Horn (Grade Crossing Sequence, if equipped) | | Floor |
| Radio | | Desk |
| Control/Fuel Pump | | Desk |
| Generator Field | | Console |

16.3 Gauge Functions and Indicators - Engineer's Station

The control console with fully integrated electronic displays shall include essential train operation controls, gauge functions and indicators. Design of control devices, indicator panels, auxiliary control panels and other items within the Engineers cab shall follow accepted principles of human/machine interface engineering and shall be demonstrated by mock-up and approved by the Customer.

All gauge functions and indicators shall be grouped logically. Critical indicators including locomotive air brake pressure data, tractive effort and locomotive speed, as well as various status indicators, shall be directly forward of the console (mounted approximately vertically) or on the Engineer's display.

Provision for a cab signal display on a location in line of sight of the Engineer but without obscuring outside visibility shall be made.

16.3.1 Gauge Functions and Indicators - Left Side Console (Customer's option)

At the Customer's option, a left side of the cab console with gauges and indicators shall be incorporated in the design of the cab. The left side console shall contain a speed indicator, a horn control and a bell control, all in a similar position to that on the Engineer's or right side together with an emergency brake valve, a timetable light switch, and windshield wiper defroster controls for the left windshield.

16.4 Alarms

The Contractor shall furnish and install the following alarms within operating cab environment which shall function in accordance with the schedule in the table below:

| Audible Indicators | Functions |
|--------------------|---|
| Main Alarm Bell | Ground Faults, Attendant's Call, HEP No Power |
| Buzzer | Conductor's Signal |
| Sonalert | Cab Signal Penalty Brake Application Warning |
| Klaxon (yelp) | Alertness Control |

As an alternate, a time coded or multiple tone single sound source arrangement may be used to simplify the alarm system.

The alarms shall function as shown in the table below.

| Event | Audible | Trainlined | Visual | Trainlined | Effect |
|------------------------|----------------|-------------------|---------------|-------------------|-------------------------------------|
| Ground, Propulsion | Bell | Yes | yes | No | Propulsion power off |
| Ground, HEP | Bell | Yes | Yes | No | Indication only |
| Wheel Slip/Slide | - | - | Yes | Yes | Reduced propulsion |
| Dynamic Brake Overload | Bell | Yes | Yes | No | Removes power from affected circuit |
| Motor Circuit Overload | Bell | Yes | Yes | No | Removes power from affected circuit |
| Alertness Control | Klaxon | No | Yes | No | Impending penalty brake |
| PTC/Cab Signal/ATC | Sonalert | No | - | - | Impending penalty brake |
| No Battery Charge | - | - | Yes | No | Indication only |
| Power Off (PCS) | - | - | Yes | No | Propulsion power off |
| Locomotive Over speed | - | - | Yes | No | Impending penalty brake |
| No Speed | - | - | Yes | No | Indication only |

16.5 Head End Power (HEP) Plant Control Panel

The Head End Power (HEP) Control Panel shall be mounted on the high voltage cabinet or in the cab area and shall contain the following indicators and switches (electrical systems, when tripped, shall be resettable from the cab):

- HEP T.L. Comp
- HEP Cutout (Right)
- HEP ON
- Thermal Overload
- Inst. O.L. Trip
- 480V External Feed (red)
- Volt Trip
- HEP System Ground
- Freq. Trip
- HEP Source Switch
- HEP Trainline Set-up Switch
- HEP ON Switch
- HEP OFF Switch
- HEP Cutout Switch
- Main Breaker Closed (green)
- Generator Hi/Low Voltage
- Generator Hi/Low Frequency

* End of Chapter 16 *

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Chapter 17

Fuel System

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17.0 Fuel System

17.1 Overview

This chapter describes the basic requirements for the locomotive fuel system.

17.2 Fuel Tank

A fuel tank with a minimum usable capacity of 1,800 gal shall be hung from the carbody, or made integral to the locomotive carbody design subject to the Customer's approval. The tank design and location shall provide for constant weight distribution regardless of fuel level. Other tank volumes may be required by each Customer.

Tank shall be designed for fueling at a minimum fill rate of 300 gallons per minute (gpm) and shall be fitted with suitable washout plugs and drain valves.

The tank shall be designed in accordance with AAR S-580 (2008) which references AAR S-5506.

17.3 Fill Pipe

One 2.5 in. I.D. fill pipe shall be provided, one located on each side, at or about tank center. Pipes shall be fitted with Snyder II fuel fitting or approved equal. Each fill pipe shall have the word FUEL stenciled above the filler at the side sill location.

17.4 Fuel Gauges

Fuel level gauges, one at each side near the fill pipes shall be provided. A Nathan 8 in. Glo-Rod sight glass, or approved equal shall be provided at an approved location on the tank. At Customer's option electronic fuel level gauges may also be required.

17.5 Emergency Cutoff

Emergency cutoff shall be electrically operated, remote control, arranged for remote reset.

There shall be at least four cutoff stations:

- Right and left locomotive sides, below platform level, and near fill pipes, easily accessible from ground level, completely waterproof
- In Engineer's cab
- Near the engine room start station

17.6 Spare Knuckle Holder

Single spare knuckle holder shall be provided in a location subject to Customer approval; holder shall be secured against movement.

* End of Chapter 17 *

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Chapter 18

Materials and Workmanship

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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 locomotives. 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 locomotives, 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 locomotives shall be marked or stored so as to be readily identifiable, and shall be adequately protected during handling and storage.

All stored material vulnerable 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 locomotive 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 to the 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 locomotive:

- Polyvinyl Chloride (PVC), except in limited applications exterior to the cab and engine compartments.
- 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 locomotives, 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 locomotive. 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.

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 locomotive shall be inch standard fasteners, except as provided otherwise. All fasteners used on the locomotive 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 shall not be used without written Customer approval.

Structural adhesives hook & loop materials (Velcro) or interlocking plastic tapes, such as 3M Dual-Lock, shall be allowed on a case-by-case basis after review with the Customer. Adhesives shall only be allowed once accelerated aging and temperature range tests prove the material has an acceptable service life.

18.4.1 Threaded Fasteners

All inch-standard threaded fasteners shall conform to ANSI/ASME Standard B1.1 or Industrial Fasteners Institute 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 ASME 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 Customer 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 locomotive 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 Customer 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 carbodies. 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.

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/ASME 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-23469/2B. 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 for approval if they differ from ASTM Standard A666 requirements and submitted with the locomotive 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 crewmembers 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 locomotive.

- 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 locomotives shall be retained on file by the

Contractor shall be available for inspection by the Customer upon request and submitted with the locomotive 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 E446-98(2004)e1 or E168-06, as may be applicable. The radiographic sensitivity shall be at least 2% (2-2T). 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 E802-95 to acceptance level IV. All weld repairs shall meet the requirements of ASTM Standard A488/A488M-07. When castings are found to be unacceptable, they shall be repaired in the original factory of manufacture prior to shipment or by another repair process approved by the 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 carbody structural elements shall be 50%

of the material's yield strength, for the carbody 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 AAR Standard M-101, latest revision, Grade F, Double Normalized and Tempered.

18.7.5 Wheels

The wheels shall be heat treated, multiple-wear type, 40 - 44-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.

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/B26M, B85/B85M or B108/B108M for, respectively, sand, die or permanent mold castings. Aluminum alloy forgings shall conform to ASTM Standard B247-09. 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 locomotive 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 carbody, 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 vehicle 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 elastomers parts are lot controlled at the time of supplier manufacture and at the time of receipt of the material by car builder, and the car manufacturing facility is to use a first-in-first-out inventory process. Products such as air hoses shall be labeled per AAR requirements.

18.9.1 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 D573-04, 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 D573-04 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:

| Gas | Critical Concentration (*ppm) (max.) |
|----------------------------|--------------------------------------|
| CO | 3,500 |
| CO ₂ | 90,000 |
| NO + NO ₂ (Nox) | 100 |
| SO ₂ | 100 |
| HC1 | 500 |
| HF | 100 |
| HBr | 100 |
| HCN | 100 |

* parts per million (ppm)

The test specimens shall be cutout 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 D1149-07 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 crewmembers from being seen from outside the vehicle or limit their vision when looking out the bodyside windows. Any tint on locomotive cab windows shall be suitable for this application and shall not distort colors or otherwise impede the crew's view of wayside signals, signage or other safety critical colors/displays outside the locomotive, as outlined in the following sections.

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 requirements 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 tint. The glazing shall be 0.375 inch thick. The glazing's maximum solar energy transmittance shall not exceed 90%.
- 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 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 $\pm 4\%$ 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 0.3 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 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 locomotive. 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 F1344-10. 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 testing requirements. 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 locomotive 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:

| Test Conditions | Minimum Metal to Wood Average Shear Value (or 80% Wood Failure) |
|--|--|
| Dry shear | 250 lbf/in. ² (1.7 MPa*) |
| Boil shear, 3 hour boil, tested wet at room temperature | 150 lbf/in. ² (1 MPa) |
| Soak shear, 48 hour soak wet at room temperature | 150 lbf/in. ² (1 MPa) |
| Creep or cold flow, under static load for 48 hour, at room temperature | 250 lbf/in. ² (1.7 MPa) |

* *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-8053C, paragraph 3.4, prior to installation in the locomotive.

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 lb/in. (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 lb/in (13.6 kg/2.5 cm) climbing drum strength when tested in accordance with SAE-AMS-STD-401. Stainless steel honeycomb panels shall be tested in accordance with SAE-AMS-STD-401 to demonstrate the following requirements. 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)
- 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 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.

18.12.6 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.

- 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 mm²) 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 locomotive using production bonding and fastening techniques. A uniformly distributed load in accordance with the crush loading requirements 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/ft² (976 kg/m²) shall be applied to both sides of the joint (butt or shiplap).
- Small Area Static Load Test – Using the identical floor panel mounting configuration as described above, a 300 lb (136 kg) load shall be applied to a 1.0 in. (25.4 mm) by 3.0 in (76 mm) contact area directly over the midspan, 6 in. (152 mm) from the outer carbody sidewall edge. The footprint shall be machined flat within 0.010 in. (0.24 mm) and the edges shall have a radius of not more than 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 Welding and Brazing

18.13.1 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 steel welding practices shall be according to requirements of AWS Standard D1.1/D1.1M, *Structural Welding Code – Steel*; AWS Standard D1.2/D1.2M, *Structural Welding Code – Aluminum*; AWS Standard D1.3/D1.3M, *Structural Welding Code – Sheet Steel*, AWS Standard D1.6/D1.6M, *Structural Welding Code – Stainless Steel*, and the AWS Handbook. AWS Standard D1.1/D1.1M shall apply to steel of 0.125 in. and greater thickness, and AWS Standard D1.3/D1.3M shall apply to steel less than 0.125 in. thickness. Requirements for dynamically loaded structures shall be applied. Cast steel welding shall be according to ASTM Standard A 488/488M, *Steel Castings, Welding, Qualification of Procedures and Personnel*. Resistance welding shall be in accordance with AWS Standard D17.2/17.2M, *Specification for Resistance Welding in Aerospace Applications*. Laser welding, if used, shall comply with AWS Standard C7.2, *Recommended Practices for Laser Beam Welding, Cutting, and Drilling*.

Aluminum welding as covered by this section shall conform to Aluminum Company of America's Technical Report Number 524 *Specification Covering Use of Aluminum in Passenger Carrying Railway Vehicles* and AWS Standard D1.2/D1.2M *Structural Welding Code, Aluminum*. Requirements for dynamically loaded structures shall apply.

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/B2.1M shall not be permitted in their original form. WPS and PQR originally qualified per AWS Standard B2.1/B2.1M 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 *Boiler and Pressure Vessel Code* Section IX, ASTM A 488/488M, or other approved qualifying procedures. Records of welder qualification tests shall be made available for review.

18.13.2 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 *Boiler and Pressure Vessel Code* 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/D1.1M, 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

18.13.3 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-132A, *Protective Finishes*. Finished welds shall present a clean appearance.

18.13.4 Support

All parts which shall be joined by welding shall be adequately supported during welding by tables, jigs or fixtures.

18.13.5 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.

18.13.6 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.

18.13.7 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.

18.13.8 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.

18.13.9 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.

18.13.10 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.

18.13.11 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 carbody 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.

18.13.12 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:

- AWS Standard D17.3/D17.3M, *Specification for Friction Stir Welding of Aluminum Alloys for Aerospace Applications*.
- ANSI/AWS Standard C7.2, *Recommended Practices for Laser Beam Welding, Cutting, and Drilling*.
- ANSI/AWS Standard C7.4/C7.4M, *Process Specification and Operator for Laser Beam Welding*.
- ISO/DIS Standard 15609-4, *Specification and Qualification of Welding Procedures for Metallic Materials - Welding Procedure Specification - Part 4: Laser Beam Welding*.

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.

18.13.13 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.

18.13.14 Torch Brazing

All brazing, characterized by heating above 840°F, shall follow the recommendations contained in the *AWS Welding Handbook*, Volume 2. Procedures and personnel who do brazing work shall be qualified in accordance with AWS Standard B2.2/B2.2M, *Standard for Brazing Procedure and Performance Qualification*.

18.13.15 Torch Soldering

All structural (not electrical) soldering, characterized by heating below 840°F, shall follow the recommendations contained in the *AWS Welding Handbook*, Volume 2. Procedures and personnel who do torch soldering shall be qualified in accordance with AWS Standard B2.3/B2.3M, *Specification for Soldering Procedure and Performance Qualification*.

18.14 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.

18.14.1 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.

18.15 Paints and Coatings

18.15.1 Materials and General Requirements

Painting of the locomotive 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 locomotive 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.

18.15.2 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 locomotive 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.

18.15.3 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
- Wheels
- 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.

18.16 Insulation

18.16.1 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.

18.16.2 Thermal Insulation

The roof, sides, underfloor, 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.

18.16.2.1 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.

18.16.2.2 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.

18.16.2.3 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

18.16.2.4 Insulation Performance

Insulation materials shall be certified to conform to the following requirements:

| Property | ASTM Test Method | Requirement |
|-------------------------|----------------------|---|
| Flame Resistance | | |
| Glass Fiber Board | E162-09 E662-09 | Flame spread 25 max Ds(4.0) – 100 max |
| Non-rigid Insulation | E162-09 E662-09 | Flame spread 25 max Ds(4.0) – 100 max |
| Spray-on Insulation | E162-09 E662-09 | Flame spread 25 max Ds(4.0) – 100 max |
| Vapor Barrier | | |
| Rating | C353 Water Method | 2.5 perm at 90°F [32°C] and 50% relative humidity |

Note: A vapor transmission rate of one grain of water vapor per square foot per hour at a pressure difference of one inch of mercury is defined as one perm.

The thermal conductivity of insulation materials shall be certified when tested in accordance with ASTM C177-10 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.

18.17 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 date 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.

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.

18.17.1 Electrical Fire Safety

Electrical equipment shall conform to NFPA Standard 130, Section 4-3, except where more restrictive requirements are imposed by this Specification.

18.17.2 Combustible Content

The design of the vehicle shall minimize the total combustible material content of the vehicle.

18.17.3 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.

| | |
|-------------------------------------|----------|
| Carbon Monoxide (CO) | 3500 ppm |
| Hydrogen Fluoride (HF) | 200 ppm |
| Nitrogen Dioxide (NO ₂) | 100 ppm |
| Hydrogen Chloride (HCL) | 500 ppm |
| Hydrogen Cyanide (HCN) | 150 ppm |
| Sulfur Dioxide (SO ₂) | 100 ppm |

The tests shall be run in the flaming mode after 240 seconds using the NBS Smoke Density Chamber for sample combustion. The gas sampling may be conducted during the smoke density test. The test report shall indicate the maximum concentration (ppm) for each of the above gases at the specified sampling time.

18.18 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.

18.18.1 Air Brake Piping and Fittings

Air brake tubing and piping shall be of good commercial quality, free of burrs and scale.

Carbody air lines ½ inch nominal and smaller, and in protected locations, shall be of seamless copper tubing, in accordance with GSA Federal Standard WW-T-799F, Type "K", with wrought copper or cast brass sweat type fittings in accordance with ANSI/ASME Standards B16.22 and B16.18, or stainless steel with stainless steel flare fittings.

All air piping on trucks and carbody 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 ell or close nipples shall not be used, except at brake valve exhaust ports.

Hoses shall be allowed only to allow for coupler motion, gladhand connections and connections to brake cylinders from truck body piping. Truck piping shall employ a minimum number of fittings and hoses.

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 45° or 90° 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.

18.18.2 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 carbody structure, electrical cables and other undercar equipment.

18.18.3 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 GSA Federal Standard QQ-B-654A, BCuP-5, or BAg-5. Condensate drain tubing and carbody 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.

18.18.4 Water Piping and Fittings

All water and waste system piping shall be seamless stainless steel tubing approved for water service applications. ASTM A269 or A312 austenitic stainless steel tube or other Engineer-approved materials shall be used, along with matching fittings. The use of copper waste system piping is expressly prohibited, due to extensive corrosion experienced in Amtrak service. All water systems being supplied shall comply with the design requirements of PRIIA Specification 305-902. All piping shall be clamped with necessary sound insulation to prevent rattle, and must be sloped to allow drainage.

If use of copper piping is approved by the Engineer for water supply applications, it shall be Type K drawn (H temper) seamless copper tube per ASTM B88. All joints for copper tubing shall utilize fittings of wrought copper in accordance with ANSI Standards B16.22 and B16.88, and shall be joined using silver solder.

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. 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 vehicle. 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 carbody 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.

18.18.5 Sewage Piping and Fittings

18.18.5.1 Non-metallic Sewage Pipes and Fittings

A non-metallic 2 in. diameter waste line for the locomotive toilet shall be provided, conforming to Amtrak Specification 759. PVC piping may be used in this area.

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 carbody series design. The piping system must be capable of holding a 15 in. vacuum at all times, since some vehicles 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.

18.19 Air Filters

18.19.1 HVAC and Equipment Ventilation Filters

HVAC system air filters shall conform to MERV 8 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.

18.19.2 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 150°F. 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.

18.20 Wire and Cable

All wire and cable used shall exhibit the physical and electrical properties for 110°C rated wire and cable specified in PRIIA Specification 305-915. 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 on connector - No. 16
- All other wire - No. 12 unless approved by the Customer

18.20.1 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.

18.20.2 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 43.13-1B:

| Wire Size | Maximum Number of Nicked Strands* |
|---------------------------|-----------------------------------|
| Wires smaller than No. 10 | None |
| No. 10 through 1/0 | 7.4% |
| Above 1/0 through 1600/24 | 4.4% |
| Above 1600/24 | graduated scale |

**Definitions:
A cutoff strand shall count as two nicked strands.
A nick is defined as 25% or more of the strand area damaged, or cut more than 1/3 of its diameter.*

18.20.3 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.

18.20.4 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 vehicle to vehicle 27-point communications trainline jumper

Conductors which shall operate at potentials differing by 50V 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.

18.20.5 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. Wires in conduits and wire ducts shall not utilize more than 40% of the interior cross-sectional area.

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.

18.20.6 Underframe

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 underframe 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. in length, completing the run.

Flexible conduit shall not be used for any application on the exterior or underside of the carbody 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.

18.20.7 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.

18.20.8 Underfloor

Wiring run under the floor shall be either in conduit or wire duct. Care shall be taken to ensure water does not enter the conduit/wire duct from above, such as from vehicle cleaning.

18.20.9 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 vehicle floor and within the sides, ends or roof of the vehicle 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.

18.20.10 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 vehicle movement, touch each other or any other part of the vehicle, except the cleat cushioning material.

18.20.11 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:

| | |
|------------------------|-----------------------|
| No. 10 AWG and smaller | Three re-terminations |
| No. 8 AWG and large | Two re-terminations |

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.

18.20.12 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.

18.20.13 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
- Vehicle electrical panels, etc.
- Device names: circuit breakers, indicators lights, switches, relays, contactors, pressure switches, etc.
- Vehicle 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:
 - Relay names
 - Contactor/motor starter names
 - 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 carbody 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 vehicle wiring to a panel without requiring a drawing

18.20.14 Pulling Compound

Pulling compound shall be non-conductive, non-hygroscopic, non-odorous, and shall not attract vermin.

18.20.15 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.

18.20.16 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.

18.21 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.

18.21.1 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 35 mm wide DIN-rail in 7.5 mm, 15 mm and 58 mm heights. The DIN-rail shall meet RoHS (Restriction of Hazardous Substances Directive) standards and shall be available perforated or unperforated. Materials will include chromated-steel, copper, and aluminum. The modules shall be color coded for the ability to tell the signal type at a glance. The terminal blocks shall be available in the following colors/color combinations of gray, blue, red, yellow/green, black, yellow, orange and brown. The metal 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 carbody 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 2.5 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.

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.

18.21.2 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.

18.21.3 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.

18.21.4 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.

18.21.5 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.

18.21.6 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 carbody shall be grounded to each truck frame by means of a separate cable which shall be sized to safely ground the vehicle under normal conditions.

The 120VAC, 60 Hz, single-phase service shall be separately and firmly grounded to the carbody structure and have a green indicating color band applied to the terminations.

All apparatus operating at 480VAC and not directly grounded to the carbody through its mounting shall have grounding straps. This particularly applies to resiliently mounted equipment.

18.21.7 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 SAE-AS7928, 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.

18.22 Conduit

18.22.1 Types

Thin-wall EMT type conduit shall conform to GSA Federal Standard WW-C-563A. Flexible metal conduit shall conform to GSA Federal Standard WW-C-566C or SAE-AMS-T-81914.

18.22.2 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.

18.22.3 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.

18.22.4 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.

18.22.4.1 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 120V 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.

18.22.4.2 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.

18.22.4.3 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.

18.22.4.4 Wireways

Wireways will be permitted in approved ceiling locations only. They will not be permitted in the carbody sidewall area. Only conduit will be permitted in the carbody.

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.

18.23 Electrical and Electronic Designs

18.23.1 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.

18.23.2 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 Contractor 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.

18.23.3 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.

18.23.4 Wiring

Wire selection, routing and securement shall be accomplished with the goal of having the wire and cable last the life of the carbody. 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.

18.23.5 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-vehicle repair of an optical fiber require sophisticated or complex polishing and alignment. The connections between optical fibers and vehicle-replaceable units shall be via approved "quick disconnects".

18.24 Electrical Devices and Hardware

All electrical devices shall be service-proven. Electrical connections shall use either captive screws or captive nuts, with crimp terminals.

18.24.1 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.

18.24.2 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-DTL-3950G. Toggle and push button switches shall be per MIL-DTL-3950G, MIL-PRF-8805D, MIL-DTL-83731B 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 Engineer's control console, shall be environmentally sealed.

18.24.3 Circuit Breakers

All circuit breakers provided shall be extremely rugged and fully suitable for the service intended. They shall meet the requirements of PRIIA Specification 305-917. 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 IEEE C37.16 for the load and type of service specified. All thermal-magnetic trip circuit breakers shall conform to the requirements of IEEE Standards C37.13 and 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.

18.24.4 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.

18.24.5 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 200 psi. 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.

18.24.6 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.

18.24.7 Transformers and Inductors

Transformers and inductors shall be rated at 20% over the maximum specified current level.

18.24.8 Switch, Circuit Breaker and Fuse Panels

All switch, circuit breaker and fuse panels shall conform to PRIIA Specification 305-917, 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.

18.24.9 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.

18.25 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.

18.25.1 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.

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 $+85^{\circ}\text{C}$.

All semiconductors shall be rated "industrial or automotive grade" for reliable operation over the temperature range of -40°C to $+85^{\circ}\text{C}$, except for discrete power semiconductors (≥ 1 Watt) which shall be rated for temperature range of -55°C to $+125^{\circ}\text{C}$. 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.

18.25.2 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.

18.25.3 Burn-in

Either all integrated circuits shall be burned-in and screened for defects to MIL-STD-883H, 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.

18.26 Printed Circuit Board Standards

Printed circuit boards shall be designed, constructed and inspected to IPC-2221, 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 IPC-2221.

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.

18.26.1 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.

18.26.2 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.

18.26.3 IC and Device Sockets

IC and device sockets shall comply with MIL-S-83502 and MIL-S-83734, as is applicable for the device.

18.26.4 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.

18.26.5 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.

18.26.6 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-DTL-55302F, 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.

18.26.7 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.

18.26.8 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 1.5 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.

18.26.9 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.

18.27 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.

18.27.1 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; and
- Permit thorough interrogation of all input, output and internal conditions by external diagnostic equipment.

18.27.2 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

18.27.3 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 IEEE Standard 1016-2009. The final Software Design Description shall include details are summarized below only for information:

| | |
|---------|--|
| Level 1 | Computer description and operation |
| Level 2 | Software architecture, basic program and functions |
| Level 3 | Detailed flow information |
| Level 4 | Annotated compiler/assembly listing |
| Level 5 | Detailed memory map and listing |
| Level 6 | Input/output port map |

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.

18.28 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.

18.29 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 *

Standardized Technical Specification

PRIIA 305 Next-Generation Equipment Committee
Diesel-Electric Passenger Locomotives

Chapter 19

Tests

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19.0 Tests

19.1 Overview

The Contractor shall conduct all tests required by this Specification, except where the test is required to be performed by an independent party. All tests shall be arranged by the Contractor, who shall be responsible for all testing costs, unless otherwise approved. Test procedures shall be submitted to the Customer for approval at least 30 days before the first test date.

19.2 General Guidelines

The test program is to include the following:

- **Component Testing:** An extensive test performed on an individual component, group or locomotive system to demonstrate compliance with regulations, specification performance requirements, durability or additionally as may be required by the Contractor or Customer.
- **Production Tests:** Tests performed on individual components, groups or locomotive systems during manufacturing to check functionality. These tests are frequently a subset of what is tested during the type test
- **Acceptance Tests:** Upon delivery to the Customer's property, the completed locomotive undergoes a limited series of tests as agreed to between the Contractor and Customer to ensure that the locomotive performs satisfactorily. It frequently requires simulated revenue service of about 500 miles of with trailing cars supplied by the Customer. Upon completion of the simulation with no failures, the locomotive is accepted for revenue service.

19.3 Test Matrix

The following tests shall be performed on the locomotive(s) and individual components by the Contractor as indicated in the table. The Test Matrix outlines which systems of the locomotive are to be tested, the type of test(s) and the number of locomotives or components requiring testing. The testing of the individual components shall require certification or testing results verifying the component and or systems meets its proof of design and reliability standards.

Within 30 days after Notice to Proceed (NTP), the Contractor shall provide the Customer with its proposed matrix of tests that take into account components and systems from specific manufacturers that have been service-proven, and thus may not require as extensive testing as otherwise might be required. **CDRL**

The sections that follow the matrix provided below with additional detail and guidance of specific test requirements to some, but not all of the tests. This anticipates that the Contractor and Customer will, during an early design review, agree upon the details of tests to be performed. Regardless of whether detailed in this section, the Contractor is solely responsible for developing tests that adequately test the locomotive and components so that it meets its proof of design and the operational and reliability requirements of this technical specification, as well as all regulatory requirements in effect at NTP.

Table 19-1: Test Matrix

| Tests | Type | Locomotive Tested |
|---|-----------------------|-----------------------------------|
| Locomotive Carbody Compression Test | Production | One locomotive |
| Collision Post Test | Production | One locomotive |
| Corner Post Test | Production | One Locomotive |
| Vertical Dynamic Test | Acceptance | One Locomotive |
| Smoke and Flame Components per 49CFR 238.103 | Component | One locomotive |
| Window Glazing per 49CFR 223 | Component | One locomotive |
| Traction Motor per IEC-60349-2 | Component | One motor |
| Inverters per IEC-61287-1 | Component | One traction and one HEP inverter |
| Traction Alternator per IEC-60349-1 | Component | One alternator |
| HVAC Performance | Production/Acceptance | One locomotive |
| Clearance Test | Production | One locomotive |
| Truck, Coupler and Cable Curving Test | Production | One locomotive |
| Fuel Fill Test | Production | One locomotive |
| Static Roll Stability 49CFR 213.329 | Production/Acceptance | One locomotive |
| Noise Test | Production | One locomotive |
| Engine Cooling System | Production | One locomotive |
| Equipment Air Cooling System | Production | One locomotive |
| Emissions | Production | One locomotive |
| EMI/EMC | Production | One locomotive |
| Locomotive Track Test | Acceptance | One locomotive |
| Acceleration | Acceptance | One locomotive |
| Road Brake Test | Acceptance | One locomotive |
| Wheel Slip/Slide Test | Acceptance | One locomotive |
| Locomotive Electrical Test | Production/Acceptance | All locomotives |
| Propulsion Test | Production/Acceptance | All Locomotives |
| Locomotive Sequence Test | Production/Acceptance | All locomotives |
| Air Brake Test | Production/Acceptance | All locomotives |
| Blended Brake Test | Production/Acceptance | All locomotives |
| Parking Brake Test | Production/Acceptance | All locomotives |
| HEP Test per APTA RP-E-011-98 | Production/Acceptance | All locomotives |
| Air Conditioning Functional Test | Component/Production | All locomotives |
| Cab Heating Functional Test | Component/Production | All locomotives |
| Event Recorder | Component/Production | All locomotives |
| Alerter | Component/Production | All locomotives |
| Positive Train Control (PTC) and/or Automatic Train Control (ATC) if equipped | Acceptance | All locomotives |
| Cab Car Compatibility with the Locomotive | Production/Acceptance | All locomotives |
| Radio/PA | Component/Production | All locomotives |
| Headlights, Misc. Light Adjustment | Production | All locomotives |
| Horn Test per 49CFR 229.129 | Production | All locomotives |
| Locomotive Water-tightness Test | Production | All locomotives |

19.3.1 Reports

Written or computer generated reports of all tests performed on the locomotives and their components shall be submitted to the Customer. Tests required by this Specification which are performed on all locomotives or all components shall be included in the locomotive history books.

19.3.2 General Test Requirements

All tests shall be performed at plants of the Contractor or of the subcontractors unless otherwise specified. Use of track testing on the railroad other than that described specifically herein is to be held to a minimum. All tests and test facilities shall be approved by the Customer. Where the Contractor already has standard tests/procedures that meet the intent of any of the following sections, these may be submitted as alternate test proposals for approval by the Customer. The test plan developed by the Contractor shall be sufficient to demonstrate the sustained operating capabilities of the locomotive as characterized by duty cycle, speed and mileage profile, or other operating parameters defined by the Customer.

The Contractor and the Customer jointly shall select suitable track of proper length and alignment to permit implementation of the qualification track tests required. These tests shall be conducted by and at the expense of the Contractor. All working and moving parts, and all operating devices; and controls of each locomotive and its apparatus, shall be tested and put in proper operating condition. Should the locomotive be disassembled in any way for shipment, it shall be given an operational test upon reassembling at the delivery point on a track provided by the applicable Railroad, at the expense of the Contractor.

After receipt of the locomotive at the designated delivery point and before passing into regular operation, each locomotive will be carefully inspected, and any part, device or apparatus requiring adjustment, repair or replacement will be called to the attention of the Contractor, in writing, who shall make adjustment, repair or replacement at his own expense.

The Customer reserves the right to make, at its own expense, additional operating tests of locomotives as required to demonstrate sustained operating capabilities.

The Customer shall have the right to approve the Contractor's representative/test manager prior to the conduct of any of the specified tests. Any defects disclosed by such tests, in apparatus, material or workmanship shall be corrected at the Contractor's expense. All expense and costs incurred in the removal of locomotives from the designated delivery point for correction of defects shall be borne by the Contractor.

Official final acceptance of the locomotive by the Customer shall be performed after all tests are successfully completed in accordance with the requirements stated herein. All costs and expenses incurred in performing these tests, including transportation to and from the test tracks, shall be borne solely by the Contractor.

19.3.3 Locomotive Carbody Compression or Squeeze Test

Body compression tests will not be required if the following conditions are met:

- An existing design is used without significant structural change.

AND

- The existing design has been embodied in a locomotive which passed a satisfactory compression test for which adequate records exist.

AND

- It can be agreed between the Customer and the Contractor that the total weight of this locomotive does not exceed that of the tested locomotive by more than 5%.

If the body compression test is found necessary, it shall be made on the first locomotive as a bare structure, by the Contractor, to prove compliance of the structure with this Specification and applicable FRA regulations. The test shall be made at the Contractor's plant or other acceptable, consistent with APTA Standard SS-C&S-034-99 (latest revision), facility approved by the Customer.

- The body, as delivered to the test facilities by the Contractor, shall be structurally complete. The body shall consist of a structure shell only, excluding such items as exterior and interior trim, windows, doors, seats, lights, insulation, interior lining, etc. Underfloor apparatus, however, may be substantially complete. Sub-floor panels and floor insulation may also be installed. Other apparatus may be installed with prior approval by the Customer.
- During the test, the body shall be supported in such a way as to allow longitudinal movement. The body shell shall be loaded with sufficient dead weight to bring the total body weight up to the normal ready-to-run weight. This loading shall be distributed according to the distribution of weight in the finished locomotive.
- The pressure of the testing machine shall be applied by hydraulic power and the force measured by a means independent of those producing the force, to eliminate errors due to friction. Sufficiently recent calibration of load cells shall be available to assure accuracy within $\pm 1\%$.
- The test load of 800,000 lbs shall be applied to the rear draft stops, by means of ram and on the centerline of draft. No allowance shall be made for the camber of the body. The ram shall be supported but shall remain free to move longitudinally with respect to the locomotive end. Cushioning means, such as lead sheets, shall be provided to assure uniform bearing at the draft stops.
- Strain gauges shall be applied at points agreed upon in advance with the Customer. These strain gauges shall have a means of calibrating them to suit the material used and to adjust for other factors which might affect the accuracy of the reading. Strain lacquer shall be incorporated as requested by the Customer for investigation of stress concentrations. SR-4 electric strain gauges, or other gauges specifically suited for the application, shall be used as required. A minimum of 60 strain gauges shall be used.
- Vertical deflection shall be measured in the region of the side sill by means of a wire stretched between corner posts or via optical measuring instrumentation. This wire, if used, shall be fastened at one end and kept tight at the other end by means of a weight with the wire passing over a pulley. Deflections shall be measured using scales with mirrors located at the body corner posts, at bolster posts, and at the center of the locomotive. Deflections shall be measured to the nearest 0.01 in., and the deflections shall be considered as the average of the readings taken on both sides. The deflection measured at any preliminary load application may be disregarded to eliminate the influence of whatever friction may be present. Deflection between bolsters and center of locomotive shall be determined by plotting the data determined above.
- For the purpose of this Specification, a member shall be considered as having developed permanent deformation if the yield point or yield strength in the appropriate direction - tension or compression - as published or otherwise issued by the material Contractor is reached or exceeded (with the exception of localized yielding in the vicinity of weld heat affected zones). For materials for which the Contractor publishes a yield point, strain gauge readings taken as directly proportional to the claimed yield point stress shall be used to determine whether or not the point has been reached. For materials for which the Contractor publishes yield strength, strain gauge readings corresponding to a directly proportional reading for the yield strength plus 0.002 inches per inch shall be used to determine whether yield has occurred. For calculation of strain at the

published yield point or yield strength values, the modulus of elasticity shall be taken as the Contractor's published value.

- If a reading indicating attainment of the yield point or yield strength is found on any strain gauge, the Contractor may request a retest prior to the redesign; and the Customer may grant this request with the provision that up to four additional strain gauges in the same general area will be required to determine the effects of surrounding material of the plastic deformation that has presumably occurred, and to determine whether stress values as great as the published yield point or yield strength are reached in the retest. If the high reading has been accompanied by visible evidence of distress in the member, a design correction will be required regardless of strain gauge values indicated in any retest.

19.3.4 Collision Post Test

Consistent with APTA Standard SS-C&S-034-99 (latest revision), the Contractor shall submit a plan for making this test to the Customer for approval. This test is to be conducted on the same carbody used for the compression test. Where the design load limit is specified as ultimate, the collision post will only be loaded to the ratio of S_y/S_u times the design load.

If an existing design is used without significant structural changes and that design has previously passed a satisfactory collision post test for which adequate records exist, a further test may not be required at the Customer sole discretion.

19.3.5 Corner Post Test

Consistent with APTA Standard SS-C&S-034-99 (latest revision), the Contractor shall submit a plan for making this test to the Customer for approval. This test is to be conducted on the same carbody used for the compression test. Where the design load limit is specified as ultimate, the Corner post will only be loaded to the ratio of S_y/S_u times the design load.

If an existing design is used without significant structural changes and that design has previously passed a satisfactory corner post test for which adequate records exist, a further test may not be required at the Customer sole discretion.

19.3.6 Clearance Test

The Contractor shall make tests of a locomotive to determine the tilt angle of the one when standing on track with a super-elevation of 6 in. Worst case conditions shall be shown for fully worn wheels and broken springs.

Drawings and written reports of these tests shall be submitted for approval. Preliminary clearance drawings shall be furnished to the Customer within 90 days following contract award.

Truck clearances, lengths and location of brake air hoses and electrical jumpers, and coupler and drawbar clearances and operation shall be checked by moving a locomotive over a curve and crossover as listed in Chapter 1.

19.3.7 Sound Level Test

Sound level measurements shall be made during the qualification tests on one locomotive, as well as statically with all auxiliary equipment operating using a standard sound level meter. The locomotive sound test shall comply with 49CFR Section 229.121.

19.3.8 Locomotive Track Test

The Contractor shall provide the Customer with a proposal to test a locomotive that must demonstrate that the locomotive is suitable for sustained operation at a top speed of 125 mph. Testing with instrumented wheel sets will be required.

The first completed locomotive with four PIIA compliant cars or approved equal cars shall be track tested. This test shall demonstrate the satisfactory operation of all control systems, auxiliary systems, propulsion systems, braking system alarm circuits, and shall be conducted at a site suitable to the Customer. The test shall also demonstrate the performance and ride quality characteristics of the locomotive.

The Customer may specify a program of consist testing (locomotives plus cars) on its candidate corridor(s), in which approximately 500 miles of non revenue operation shall be accumulated, as well as the location for the corridor consist track testing. Test duration may also be extended beyond the mileage limits cited in this section, at the mutual agreement of the Customer and the Contractor. This test shall be conducted by and at the expense of the Contractor. The test shall demonstrate the operational performance of the locomotive regarding acceleration, maximum running speed and braking. This shall be considered successful when the last 300 miles have been completed without experiencing any malfunction in a component or system. The test may be terminated, at the Customer discretion, when at least 500 miles have been completed without experiencing any malfunction in a component or system.

The data recorded during the tests shall include, but is not limited to the following:

- Acceleration deceleration
- Traction motor current
- Traction motor voltage
- Brake pipe pressure
- Locomotive B.C.P.
- Dynamic brake current
- Speed
- Distance intervals
- Time intervals
- Ride quality indices
- Wheel slip and slide performance

The Contractor shall provide, at his expense, the test personnel and instrumentation (locomotive mounted and wayside) necessary to demonstrate the safety margin of the locomotive and trucks against derailment and track deformation. The data shall include measurement of VTI criteria specified in this Specification.

The test program for the new locomotives and cars to be used in the High-Speed Rail (HSR) service shall include consist track testing. For the purposes of this testing, a “consist” shall be defined to be the first completed new locomotive and the first complete consist of new rolling stock in the Customer’s order. The Customer is responsible for working with its rolling stock Contractor(s) to integrate the provision of a new locomotive and a new consist to meet the test program requirements as specified in this section.

Alternatively, the Customer may provide a set of existing rolling stock for the consist testing, so long as it can be demonstrated that the existing rolling stock is the functional equivalent of the new rolling stock, in terms of sustained speed capabilities, capacity, trailing load, etc. The FRA, the Customer and the Contractor must reach mutual agreement on any testing involving existing rolling stock.

For new designs of locomotives (those designs which have not previously been tested and accepted in a rigorous test program conducted at the Transportation Test Center [TTCI]), shall include a program of testing at the TTCI, as well as track testing on the proposed corridor(s) on which the new HSR consists are to be used. Testing at the TTCI shall be sufficient (as mutually determined by the FRA, the Customer and the Contractor) to demonstrate the suitability of the consist to operate at a sustained speed of 125 mph.

The on-corridor testing program for the train consist shall be as mutually agreed to by the service provider, the host railroad(s), the Customer and the Contractor to demonstrate the suitability of the consist to operate in the proposed service, including operation according to the most demanding schedule to be implemented at the start-up of HSR service. This schedule shall be defined in the Customer's approved Service Development Plan (SDP) for HSR service.

TTCI consist testing may be waived for those locomotive which have already been tested at the TTCI, so long as the test program established that the new equipment was suitable for operation at a sustained speed of 125 mph. In this instance, the locomotive must meet the requirement for the on-corridor train consist testing, as described above.

19.3.9 Brake Test

The following brake tests shall be performed by the Contractor.

19.3.9.1 Road brake test

A road brake test shall be performed with a trainset consisting of a locomotive and the maximum expected consist to be operated by the Customer with the locomotive. The Contractor shall provide instrumentation (to include, as a minimum, wheel temperature, B.C.P., time, distance, speed and acceleration), and test personnel to adequately evaluate the brake equipment and demonstrate stop distances and times and verify braking characterization. Contractor shall also conduct concurrently wheel slip/slide tests. Reports of all tests shall be submitted for approval prior to final locomotive acceptance. The road brake test is to be performed in conjunction with the locomotive track test. A single locomotive shall also be tested to determine stop distance and wheel temperatures up to maximum authorized speed at 10 mph increments.

19.3.9.2 Blended brake test

On each locomotive, the blended air/dynamic brakes shall be functionally tested according to Contractor's standards so that the current settings control calibration, etc., meet the performance requirements.

19.3.10 Wheel Slip/Slide System Test

In order to provide a test of the operation of the wheel slide protection system under actual operating conditions, facilities shall be provided for a test of this system during the road brake tests. Instrumentation shall be maintained on this train at all times ready to record the following quantities simultaneously:

- Individual axle speeds
- B.C.P.
- Time intervals
- Traction motor current

Recording shall be by means of multiple-channel recording digital chart recorders. Personnel assigned to observe the test shall be prepared to run this instrumentation at any time that adverse adhesion conditions may occur. This test shall be continued until recordings have been obtained showing three stops and starts during which slides and slips were successfully

corrected. In the event that sufficiently adverse rail conditions to obtain such recordings do not occur during the test, the Contractor shall induce slips and slides with artificial rail wetting equipment to demonstrate the performance of this system. The slip/slide test can be run in conjunction with the locomotive track test.

19.3.11 Locomotive Electrical Tests

The following electrical tests shall be performed by the Contractor on each locomotive:

- Test all wiring circuits to insure continuity and polarity after assembly and installation of all equipment.
- Make a direct current ground insulation test on each locomotive as follows: (a) disconnect all ground wires; (b) disconnect the storage battery at its terminals; (c) each nominal voltage circuit shall be megger tested using a 500V megger and the insulation resistance shall not be less than two ohms. During this test, ground all other circuits. If this test shows freedom from ground connection, the high potential test specified below shall be applied.
- A high potential ground insulation test shall be made on all circuits and apparatus on each locomotive in accordance with current standard Contractor's procedure. All wires, cables and/or equipment that fail to meet this test shall be removed and replaced. After replacement of any such defective parts, materials or equipment, the locomotive shall be subject to re-testing.
- Reconnect ground connection and storage battery and then test all circuits on each locomotive for proper functioning.
- Components furnished by the Contractor that are assembled, housed and wired into package units at the point of manufacture shall be tested at the point of manufacture, and a certified test report concerning actual tests made on components being furnished for this Contract shall be attached. Requirements for these certified tests shall be mutually agreed upon between the Contractor and the Customer.

19.3.12 Locomotive Propulsion Tests

The following components of the locomotive's propulsion system shall be tested and validated:

- Engine performance
- Electric systems performance
- Dynamic brake
- Control
- Diagnostics

19.3.13 Locomotive Auxiliary Tests

The following auxiliary systems shall be tested and validated:

- Radiator fans
- Traction motor blowers
- Inverter cooling (blowers)

19.3.14 Locomotive Sequence Tests

A complete sequence test shall be made on each locomotive, including front-rear sequence changes, relays and switches, sanding, auxiliary motor starting circuits, wheel slip control, main propulsion and braking, main circuit breaker, calibration of safety relays, meter calibration, excitation, and any other testing required to insure that all circuits are performing properly.

19.3.15 Locomotive Brake Tests

The following brake tests shall be performed by the Contractor.

19.3.15.1 Air brake tests

Air brakes shall be tested and adjusted for performance complying with FRA regulations. Also, tests recommended by AAR and the brake Contractor shall be performed when not in conflict with FRA regulations.

19.3.15.2 Blended brake test

On each locomotive, the blended air/dynamic brakes shall be functionally tested according to Contractor's standards so that the current settings control calibration, etc., meet the performance requirements.

19.3.15.3 Parking brake tests

The parking brake on each locomotive shall be tested. On the first locomotive, a test shall be performed using first new and then fully worn brake shoes to prove compliance with this Specification. On the other locomotives, a functional test shall be performed using new shoes.

19.3.16 Head End Power (HEP) Test

The HEP source shall be tested by the Contractor. Data taken shall include, but is not limited to:

- Voltage
- Current
- Frequency
- Kilowatts (kW)

The load shall be varied over the full range up to 110% of full load.

19.3.17 Air Conditioning Functional Test

In all locomotives, the air conditioning system shall be functionally tested. The operation of the thermostatic control system shall be demonstrated by test and shall be in accordance with specified settings. Controls shall be checked and adjusted for temperature distribution and proper volume of air conditioning.

19.3.18 Heating Functional Test

In all locomotives, the heating system shall be functionally tested. The operation of the thermostatic control system shall be demonstrated by tests and shall be in accordance with specified settings. Controls shall be checked and adjusted for temperature distribution and proper volume of heat.

19.3.19 Miscellaneous Tests and Adjustments

The following tests and adjustments shall be made by the Contractor.

19.3.19.1 Locomotive headlight

The headlight on each locomotive shall be aimed and adjusted to meet the required 49CFR Section 229.125.

19.3.19.2 Horn Test

Each locomotive will have its horn tested consistent with the requirements of 49CFR Section 229.129.

19.3.20 Train Speed Control Test

The Contractor shall test the train speed control system of each locomotive using the necessary test equipment as recommended by the original manufacturer.

19.3.21 Locomotive Water-tightness Test

Each locomotive shall be subjected by the Contractor to a complete test for water-tightness, as described below.

All areas of the sides, ends and roof, including doors and windows, of the locomotives shall be given a complete test for water-tightness. The test shall be made on a completed locomotive. Water shall be sprayed from nozzles which are spaced no more than 3 ft from and aimed directly at the surface being tested. Not less than 0.625 gpm shall be delivered to each square foot of surface being tested. The nozzle velocity of the water shall be not less than 150 ft per second.

It is not required that the water-tightness test be deferred until the carbody is completely assembled. Individual tests may be used to demonstrate the water-tightness of large components such as sides, roof and ends, with testing of the assembled carbody restricted to connections between tested components and areas not previously tested. All spray applications shall run for a period long enough to enable inspection to be made and to insure leak proof structure. It is the intent of this test to establish the total water-tightness integrity of the locomotive interior (where required), cab and enclosures. Locomotives shall have leaks corrected and retested until a satisfactory water test is obtained with no water ingress detected on each completed locomotive. Drops due to condensation will be allowed.

19.4 Test Plans and Data

All test data shall be subject to the Customer review and approval, and shall become the property of the Customer upon satisfactory completion of tests. If the locomotive or any related equipment or subsystems fail to satisfy the test requirements, or demonstrate noncompliance with proposal performance, necessary corrective adjustment shall be made, and this locomotive shall be retested as directed by the Customer.

The Contractor shall, within 120 days following award of the contract, submit to the Customer for review and approval a detailed Test Plan which shall satisfy the requirements of this section.

If the Test Plan requires the locomotive to be sent to the TTCI facility for proof of design and speed validation testing, a Test Plan must be submitted to the FRA.

19.5 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 coupler crush zone on the end of the car. The assembled model may be used to perform a full 3D explicit analysis of the coupler assembly to prove compliance with this Technical 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. .

19.5.1 CEM Test Plan

CEM system design validation shall be provided according to separate CEM System Test Plan that shall be integrated into the locomotive 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 Customer. The CEM System Test Plan shall include, as a minimum, the tests included the CEM System Test Matrix.

Table 19-2: CEM System Test Matrix

| Test | Spec | Type | Car End | Level | Input Parameter | Criterion |
|--------------------------|------|-------------------------|---------|-----------|-------------------|--------------------------------|
| Coupler Energy Absorbed | 6.9 | Dynamic | All | Component | Energy Absorption | Exceeds Minimum Required Value |
| Coupler Initiation Load* | 6.9 | Dynamic or Quasi-Static | All | Component | Initiation Load | Exceeds Minimum Required Value |

* 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.

19.5.2 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.

19.5.3 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.

19.5.4 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.

19.5.5 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, $\pm P\%$;
- Average force, $\pm A\%$;
- Force and displacement vs. time, $\pm T\%$ 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 Customer. 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 Technical 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 coupler assembly performance re-verified.

19.6 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 stainless steel and carbon steel used in production of the locomotive carbody 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 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.

19.7 Reliability and Post-Delivery Tests

The complete operational locomotive fleet shall be monitored by the Contractor to demonstrate conformance with the reliability requirements. This test shall begin when three locomotives are in service and shall continue until the last full month during which two operating locomotives or more remain under warranty. All locomotives 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 locomotive 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 locomotive 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 six 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 a 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 *

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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 computer software), etc. that will be necessary to operate, maintain, inspect, test, troubleshoot and repair all configurations of the locomotive 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. **CDRL**

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. **DR**

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. **DR**

This list should include items such as:

- Brake pads/shoes
- Filters - Heating, Ventilation and Air Conditioning (HVAC), air, water, fuel, oil, etc.
- 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
- 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 locomotives for shipment to the Contractor's field site where the locomotive acceptance process will take place.

All locomotives must receive approval for shipment from the Customer before they can be released from the Contractor facility and shipped to the field site.

The Contractor is responsible for all costs and arrangements associated with the shipment of the completed locomotives to the Contractor's field site.

The locomotives shall be delivered ready for service with all acceptance test equipment and test gear removed. Cleaning shall be handled as necessary by the Contractor.

21.2 Requirements for Shipping Locomotives

Prior to shipment, the Contractor shall weigh all locomotives at shipment and furnish a weight ticket to the Customer. Each truck of each locomotive shall be weighed individually to check for weight distribution. Locomotives shall be weighed with full supplies, as well as weighed light with no supplies. Supplies shall include fuel, water and sand.

All completed locomotives shall be prepared for shipping as follows:

- All hoses shall be connected between the locomotives, if more than one locomotive is shipped at a time.
- The locomotive's automatic brake valve shall be in the cutout position.
- Locked axle protection must be available with an alarm capability in the cab of the lead locomotive of the delivering train.
- Automatic Equipment Identification (AEI) tags shall be properly programmed and installed. The Contractor is responsible for ensuring that the locomotive's technical data is entered into the Umler/EMIS (Equipment Maintenance Information System) system prior to the release of the locomotive.
- All required inspections must be complete, including inspections and approvals from the FRA, the FDA and Amtrak. The Amtrak MAP 816/FRA F6180-49A, *Locomotive Inspection and Repair Record ("Blue Card")* must be completed and signed, and be installed in the document holders in the cab of the locomotive.
- All cab doors and engine room doors locked (if applicable).
- All windows shall be closed.
- All equipment and engine room doors shall be closed.
- The Contractor shall perform any 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 locomotives:

- Engine oil full
- Cooling water drained
- Minimum of 500 gal in the fuel tank
- Battery switch open
- All circuit breakers shall be off

* End of Chapter 21 *

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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 locomotives.

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 locomotives 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 locomotive 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 locomotive 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 locomotives. These include drawings and manuals to safely and properly conduct:

- Operation
- Service and inspection
- Troubleshooting
- Running maintenance
- Heavy repair/overhaul of the locomotive
- Part identification (to the lowest repairable level)
- Wreck repairs
- Modification of the locomotive (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 installed on the locomotive. 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 all 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 inch-standard 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 inch-standard 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 locomotive. **CDRL**

A complete set of as-built drawings shall be delivered within 30 days after the delivery of the first locomotive. **CDRL**

A complete bill of material for the locomotive, 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 locomotive. **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 the first locomotive 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 locomotive in the base order of locomotives, 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 Photographs of Completed Locomotives

The Contractor shall furnish, within 30 days of the delivery of the first locomotive five CDs with high-resolution images, suitable for printing by the Customer as big as 8 in. by 10 in., in size, of the first completed and painted locomotive of each type of equipment, showing at least four different views of each locomotive of equipment, including full front, 3/4 side, top and rear views. **CDRL**

22.3.5 Digital Format

All photographs shall be taken in digital format (jpeg), at high resolution (2400 x 3000 pixels minimum). All photographic prints and files will be submitted to the Customer within 30 days following completion and acceptance of the first locomotive of each base type.

22.4 Conformed Specification

Within 30 days after completion of the last locomotive, 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. **CDRL**

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 locomotive 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
- Locomotive 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. **CDRL**

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 locomotive. 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 locomotive shall not be released from the Contractor's facility until the Customer has accepted the draft of the manuals for use in maintenance of the locomotives. The Contractor shall provide 10 full sets of manuals to the Customer prior to Customer acceptance of the first locomotive. **CDRL**

22.5.2 Manual Updates

After delivery of the first locomotive, and continuing through the end of the warranty period, should any changes to the locomotive, 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 locomotives at the time of warranty expiration. **CDRL**

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 and the mechanical personnel. Operator's manuals shall contain all information needed for the operation of the locomotive, including definitions giving nomenclature, function, location and operation of all indicators, controls, components and subsystems utilized in the operation of the locomotive. This shall include preparing the locomotive for operation, securing the locomotive from operation and operation of the locomotive individually and as a train.

The manual shall give troubleshooting and diagnostic procedures sufficient to isolate faults and problems which are capable of repair by the Engineer and the mechanical personnel, arranged in a format to allow ease of use. 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 Engineer and train crew to correctly, efficiently and safely carry out their duties on the locomotive 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 locomotive.

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 Engineer to identify operational problems and, where possible, isolate faults from the train consist to locomotive, locomotive 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 locomotives as required by the Contractor, subcontractors, Amtrak and the FRA for all periodic inspections including those occurring daily and at 15 days, 92 days, 184 days, 368 days, 736 days, 1104 days and at 1472 days. Additional or differing intervals shall be included if required 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 also 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 every four years. A summary table shall be provided for quick reference that lists the item or system, frequency, source and reference for all required inspections.

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:

- Trucks
- Coupler and Draft Gear
- Truck Brakes
- Air Brake System
- HVAC
- Electrical System, including on board computer diagnostics
- Cab and Controls

This manual shall provide procedures for the identification, diagnosis and proper correction of locomotive failures and malfunctions. Procedures shall be organized so that maintenance personnel can isolate faults down from train consist to locomotive, from locomotive 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 locomotives and shall be revised as necessary.

22.5.7 Running Maintenance Manual

The running maintenance manual shall contain an overview of the locomotive operation and a detailed description and analysis of the locomotive and its assemblies/subassemblies. The manual shall also contain, in a convenient form, all information required for on board locomotive 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 locomotive 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 locomotive and shall be comparable to the tests performed by the Engineer. It is not intended that the operational test of the locomotive 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 locomotive is taken out of service. Heavy maintenance tasks will generally require more than one 8 hour shift to complete. The heavy maintenance manual shall contain a detailed description and analysis of all mechanical, electrical and electronic assemblies/subassemblies so that the Customer's overhaul facilities can effectively and safely service, inspect, adjust, troubleshoot, repair, overhaul and test these assemblies. Contractor and sub-suppliers shall provide all information needed for comprehensive repair and overhaul work at least as comprehensive as that used by the suppliers' own service and repair shops, whether the locomotive 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.

The Heavy maintenance manual shall describe the 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 locomotive system. Each shall include:

- Block diagrams
- Signal flow diagrams
- 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 locomotive 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 the 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 diesel engine, the invertors, alternators, truck, (HVAC) unit, 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 lubrication system and air piping, system schematic diagrams as used on each locomotive, 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
- HVAC system (electrical, refrigerant and air flow schematics)
- Locomotive cooling system
- Locomotive engine lubrication system

- Brake system (electrical, mechanical and pneumatic)
- Main reservoir air distribution system
- 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 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 locomotives, 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 locomotive, 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 maintenance manual, the reference index in both manuals must identify the same parts.

22.5.11 Manual Quantities to be Provided

| Name | Quantity |
|---------------------------------|----------|
| Operator’s Manual | 200 |
| Service and Inspection Manual | 30 |
| Running Maintenance Manual | 10 sets |
| Troubleshooting Manual | 10 sets |
| Heavy Maintenance Manual | 10 sets |
| Illustrated Parts Catalog (IPC) | 10 sets |
| Integrated Schematic Manual | 10 sets |

Manual quantities are subject to change.

22.6 Locomotive History Books

The Contractor shall produce a locomotive history book for each completed locomotive. The locomotive history books shall be a specific record of production, testing, inspection and relevant documentation for each individual locomotive.

The locomotive history book shall contain original documents unless specified otherwise.

All documents shall be marked with the locomotives frame serial number, the production sequence number or the road number for the completed locomotive.

The Contractor shall provide one electronic and three paper sets of the locomotive history book for each locomotive; one that contains the original documents, and two copies. The volume with the original documents shall be appropriately labeled. Locomotive history books shall be provided in three-ring binders. Documents shall be copied double-sided where practical.

At a minimum, each locomotive history book shall contain the following:

- Table of Contents
- Production Release Form
- FRA Form F6180-49A (Blue Cab Card) – two copies
- Locomotive Serial number records for all serialized components installed on the locomotive
- Locomotive Wheel Press Record
- Engine Fuel Injector Serial numbers
- Main Reservoir(s) test certification records
- Locomotive weight record
- Locomotive test procedures with sign off sheets
- Locomotive dimensional clearance record
- List of all field modifications
- A list of all production discrepancies and Customer approvals
- Truck records (separate set of records for each truck)
 - Inspection records
 - Truck assembly sequence
 - Truck assembly weight certificate
 - Wheel/axle pressing graphs
 - Truck to locomotive attachment record

The locomotive 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 locomotive history book shall be presented to the Customer prior to the locomotive being released from the Contractor's facility. **CDRL**

22.7 Training

The Contractor shall organize and present formal instruction programs for personnel who will operate, maintain, repair and troubleshoot the rail locomotives. 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 locomotives 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. **CDRL**

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 locomotives. The program shall include up to 600 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 locomotives or mockups to provide hands-on instruction in the maintenance and operation of the rail locomotives.

Before delivery of the first locomotive, 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. **CDRL**

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 locomotives. The Contractor and/or suppliers shall provide appropriate training aid in the classes as required.

Class audience will be:

- Operating personnel
- Maintenance 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.

22.7.3 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. **CDRL**

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 *

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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 locomotives using this Specification, the features, components, systems and testing requirements described in this chapter shall be designated by each Customer for application to the locomotives 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 SPACED RESERVED FOR SUPPLEMENTAL SPECIFICATION DOCUMENTS THAT MAY BE USED BY THE CUSTOMER FOR SPECIFIC VARIABLES.]

23.2.2 Drawings

[THIS SPACED RESERVED FOR SUPPLEMENTAL DRAWINGS 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, de-lamination, 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 Locomotive Numbers, Reporting Marks and Names

The Customer shall provide the reporting marks, road numbers and other locomotive-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 locomotives shall be designed and installed in accordance with PRIIA Specification 305-909.

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

Locomotive seats shall be supplied that conform to the requirements of **[CUSTOMER SPECIFICATION]**.

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Chapter 24

Safety Accessories

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24.0 Safety Accessories

24.1 Overview

This chapter describes the safety accessories required for the locomotive.

24.2 Event Recorder and Speed Indicators

A FRA compliant event recorder and speed indicator system subject to the Customer approval shall be provided. The event recording system shall meet the requirements of 49CFR Section 229.135. The system displays shall be integrated with state-of-the-art cab electronics. All on-board system time clocks shall be synchronized and integrated at the Engineers control screen, or by other method approved by the Customer.

24.3 Positive Train Control (PTC)

Customer shall require other locomotive-borne signal system equipment installations, including Positive Train Control (PTC), Electronic Train Management System (ETMS), Cab Signal and/or Automatic Train Control (ATC) systems consistent with 49CFR Part 236, Subpart I – *Positive Train Control Systems*.

Provisions shall be made in the design of the locomotive to allow adequate space for the PTC equipment. Provisions shall be made for conduits, switches, antenna and other required items needed for the installation.

24.4 Alertness Control (vigilance system)

An electronic alertness monitoring system shall be provided with the following resets:

- Throttle
- Use of bell or horn
- Brake application (blended or pneumatic alone)
- Console reset button
- Metal "touch-off"

A B.C.P. of 20 psi or more shall suppress alertness control. Control shall be completely inactive (no audible alarm) in TRAIL position. Provision for standing test of system shall be provided. The alertness control (vigilance system) may be integrated with the cab electronics system.

24.5 Crossing Bell

An electronic crossing bell shall be provided. It shall be located below the deck for maximum sound dispersal fore, aft and sides of unit.

24.6 Horn

A FRA compliant Nathan K5LA air operated horn, or electronic equivalent, conforming to 49CFR Section 229.129(a) shall be provided. The horn shall face in the forward direction. The horn shall be protected or located to avoid plugging with airborne snow or debris in the slip stream over front nose of unit; recessed in carbody and easily accessible for maintenance and

replacement. Horn shall be located as far from cab as possible at a location approved by the Customer.

24.7 Fire Extinguishers

Three dry chemical type 3A-80 B C fire extinguishers or equal shall be supplied; one in cab and two in engine room. Quick-release clamps shall be used to secure the fire extinguisher in the equipment room and cab area. Other fire extinguishing systems may be required by the Customer.

24.8 Video and DVR Systems

A video/DVR system with forward facing camera(s) shall be furnished. Additional camera views may be required, e.g., rear-facing to observe passenger platform operations, along with in-cab video screens. The configuration of cameras, storage media and associated equipment shall be determined during design review and approved by the Customer.

24.9 First Aid Kit

A first aid kit shall be furnished, as approved by the Customer.

* End of Chapter 24 *

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Chapter 25

Environmental Characteristics

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25.0 Environmental Characteristics

25.1 Overview

The locomotive shall be designed to be environmentally friendly. The locomotive shall comply with the latest EPA/FRA emission and noise level requirements contained in Chapter 1.

25.2 Noise Emissions

25.2.1 External Noise (measured at 100 ft) and Inside Cab Limits

The locomotive shall conform to the requirements of 40CFR Part 201, 49CFR Part 210 and 49CFR Section 229.121.

25.3 Diesel Engine Exhaust Emissions, Fuels, Fuel Consumption and Life-Cycle Costs

The engine shall be equipped with an AESS system to save fuel and reduce engine exhaust emissions. The diesel engine shall be compatible with ULSD. Fuel consumption shall be optimized to allow for the lowest possible life-cycle costs. The locomotive shall conform to the Tier 4 emissions requirements of 40CFR Part 1033 for Line-Haul locomotives.

25.4 Liquids Waste Retention Tank

A holding or retention tank shall be incorporated into the design of the locomotive to prevent any oil or other fluids from dripping onto the ground. The tank shall be capable of being drained during locomotive servicing. The size of the tank will be proposed by the Contractor and approved by the Customer.

* End of Chapter 25 *

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