TECHNICAL SPECIFICATION ADDENDUM 1 CHANGES

Item	Section Title	Page(s)
Attachment A Section 3 Carbody		
	Attachment A Section 3.4.2 Stress Analyses and Tests Plan	3-31, 3-32
	Attachment A Section 3.4.4.7 CEM Analyses	3-37
	Attachment A Section 3.8 Diaphragms	3-43
	Attachment A Section 3.10.2 Evaluation Scenario	3-44
	Attachment A Section 3.10.3 Approach	3-45
	Attachment A Section 3.10.5 Coupling Functions	3-47
	Attachment A Section 3.10.6 Load Transfer Function	3-48
Attachment A Section 4 Interior Arrangement, Features and Appointments		
	Attachment A Section 4.2.2 Performance Requirements	4-4
	Attachment A Section 4.8.6 Cab Car Windshield	4-14
	Attachment A Section 4.9.3 Cab Door	4-16
	Attachment A Section 4.12.1 Toilet Room	4-18
	Attachment A Section 4.12.8 Waste System	4-21, 4-22
Attachment A Section 5 Coupler, Draft Gear, and Trainline Connections		
	Attachment A Section 5.3.1 CEM Features	5-3
Attachment A Section 7 Cab and Cab Controls		
	Attachment A Section 7.2.1 General Arrangement	7-2
Attachment A Section 17 Testing and Analysis		
	Attachment A Section 17.5.1.14 (b) CEM Test Plan	17-35

IFB NO. EP142-06 METROLINK COMMUTER RAIL CARS

TECHNICAL SPECIFICATION

MASTER TABLE OF CONTENTS

TABLE OF CONTENTS

SECTION 14 MONITORING SYSTEM

SECTION 15 MATERIALS AND WORKMANSHIP

SECTION 1

SCOPE

SECTION 1

SCOPE

TABLE OF CONTENTS

SECTION 1

SCOPE

1.1 PURPOSE AND PROJECT OVERVIEW

The Contract requires the Contractor to furnish all management, labor, materials, tools, equipment, data, design, services and incidentals necessary to manufacture and deliver multi-level commuter rail passenger cars in conformance with the Technical Specification. The Contract is subject to the provisions of the Master Agreement between the U. S. Department of Transportation's Federal Transportation Administration (FTA) and Southern California Regional Rail Authority (SCRRA), and the Contractor shall adhere to all FTA requirements. The Contractor shall not perform any act, fail to perform any act, or refuse to comply with any SCRRA requests that are related to the terms and conditions of the FTA agreement or perform any act which would cause SCRRA to be in violation of the FTA Agreement

The project Work consists of engineering and design documentation, testing, manuals, mock-ups, training program, software, licenses, special tools, test equipment, and other deliverables and services described in the Contract. The Contractor shall be responsible to ensure proper interrelation, functioning and systems integration of all aspects of the Work related to the vehicle systems and their relationship with other equipment and systems of the vehicle.

The vehicles shall be designed and built to comply in all respects with applicable laws, regulations, standards and recommended practices of the following agencies and organizations:

- US Department of Transportation
- Federal Railroad Administration
- Federal Transportation Administration
- US Public Health Food and Drug Administration
- State of California
- American Public Transportation Association
- Association of American Railroads

Should conflicts exist or an item or feature is deemed by the Contractor not to be adequately described or explained in the Technical Specification, the Contractor shall apply to the Engineer for further written explanation, as may be necessary, and shall conform to the written explanation provided by the Engineer. The Contractor shall be responsible to ensure the suitability of the systems, devices, apparatus, components and parts for the service intended.

This Technical Specification provides a description of locomotive hauled multi-level commuter rail passenger cars. The cars are intended for operation in trains of up to ten (10) cars. The cars shall be suitable in all respects for safe comfortable operation at all speeds up to 110 mph, and shall be compatible with existing locomotives and cars operated by SCRRA. The Technical Specification provides the requirements for two (2) configurations of cars described as cab car with a toilet room and trailer car with a toilet room. The cars shall be numbered as follows:

Car Configuration	**SCRRA Road No.**
Cab Cars with toilet room	Numbering starting with 638
Trailer Cars with toilet room	Numbering starting with 211

The cab car configuration shall permit control of the train from the Operator's control station of either the locomotive or the cab car. The Operator's control station shall be located at the F-end of the cab car. Although the cab car will normally be positioned at the opposite end of the train from the locomotive, cab cars may also be located in any position within the train, in which case, the cab cars shall function as a trailer car. The cab cars shall have a full set of CEM features. The trailer cars shall not be equipped with an Operator's control station. Cab cars and trailer cars shall be designed for use in any orientation between end-of-train cab car and locomotive. The trailer cars shall have minimal implementation of CEM features limited to push-back, energy absorbing couplers.

In accordance with the requirements of 49 CFR 37 and 38, all cars shall have provisions for seating passengers with disabilities including wheelchair confined persons. The B-end, lower level of all car configurations shall be designed to permit access of passengers using mobility devices. Cab cars shall have a minimum of four (4) wheelchair accessible seating locations and trailer cars shall have a minimum of two (2) wheelchair accessible seating locations on the lower level. Wheelchair accessible seating locations shall have companion seating. All cars shall be equipped with an accessible toilet room located on the B-end lower level.

The different sections of this Technical Specification provide the requirements for the design, application and implementation of the Work. All car systems and the complete car shall meet or exceed applicable safety standards, minimize maintenance requirements, maximize reliability, promote energy conservation, and minimize noise emissions.

The cars shall be tested successfully to determine full compliance, in accordance with the static and dynamic requirements, as described in Section 17 of the Technical Specification prior to using the cars in revenue service operation.

1.2 BACKGROUND

1.2.1 Description of Existing Service

The Southern California Regional Rail Authority (SCRRA) is a joint powers authority (JPA) organized under §6500 et. Seq. of the California Government Code and §130255 of the California Public Utilities Code created to develop and operate a five county commuter rail system known as Metrolink. The County Agencies consist of Los Angeles County Metropolitan Transportation Authority (LACMTA), Orange County Transportation Authority (OCTA), Riverside County Transportation Commission (RCTC), San Bernardino Associated Governments (SANBAG), and Ventura County Transportation Commission (VCTC). Metrolink provides passenger service on jointly used railroad lines that support Amtrak passenger operation and Union Pacific and Burlington Northern Santa Fe freight operations.

Metrolink operates more than one hundred thirty-six (136) trains that transport over 34,000 passengers each weekday. The success that the Metrolink service continues to experience requires SCRRA to acquire additional rolling stock to support the increased service demands.

1.2.2 Description of Existing Fleet

SCRRA operates and maintains a commuter rail car fleet of forty-one (41) locomotives, consisting of twenty three (23)-F59PH, fourteen (14)-F59PHI and four (4)-F40PH; and one hundred forty-three (143) multi-level commuter rail cars, consisting of thirty five (35) cab cars and one hundred eight (108) trailer cars. Three (3) separate procurements, between 1991 and 1999, were used to acquire the multi-level commuter rail passenger cars operated by SCRRA. The intent of the Work described in the Technical Specification is to ensure the cars provided under this Contract are suitable for daily passenger service operation and can be utilized in the same manner as, and in conjunction with, the multi-level commuter rail cars in SCRRA fleet.

1.2.3 Description of Existing Facilities

SCRRA's Central Maintenance Facility (CMF) is located at 1555 San Fernando Road in Los Angeles, CA. The CMF is arranged to support maintenance and inspection activities necessary to comply with FRA and California Public Utilities Commission (CPUC) Regulations, APTA Standards and Recommended Practices, Association of American Railroad (AAR) Standards, industry accepted standards and practices and SCRRA's requirements. The CMF is equipped to service the trains prior to their release for revenue operation and perform necessary running repairs. The facility includes a drop table to permit the removal and reinstallation of complete truck assemblies; a wheel-truing machine; shops equipped to perform running repairs and to change major components.

In addition, SCRRA maintains equipment storage facilities at Lancaster, Montalvo, Moorpark, San Bernardino, and Riverside. These facilities are equipped to service the trains prior to their release for revenue operation and provide stand-by power and compressed air. The service work performed at these locations includes:

- Perform daily pre-service inspections,
- Test and inspect the air brake system,
- Perform electrical and mechanical inspections,
- Clean interior cab and passenger areas, and
- Toilet servicing, some locations.

If further clarification(s) or information is required by the Contractor related to the facilities and equipment, SCRRA will, upon review of written request, arrange for the Contractor to visit the requested facilities.

1.3 DEFINITIONS AND ABBREVIATIONS

1.3.1 Definitions

The definitions provided in this Section are meant to supplement and complement those included in the Terms and Conditions. Wherever the following terms are used in the Technical Specification, the intent and meaning shall be interpreted as follows:

A-end - The end of the car opposite the B-end of the car, also designated as the F-end of the cab car.

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

Analysis - Written report of the systematic examination of parts, components, and systems against Contract and Technical Specification requirements.

Approved or Approved Type - Design, type of material, procedure, or method given approval by SCRRA.

Approved Equal - Whenever the words "equal" or "approved equal" are used in connection with a specific manufacturer or item of equipment in this Specification, they mean that in order to substitute any other component for use in lieu of the specified component, the proposed substitute brand or make of material, device, or equipment must be proven to the satisfaction of SCRRA to be the equal of that specified, considering the following:

- Performance,
- Safety,
- Quality,
- Workmanship,
- Economy of Operation,
- Life Cycle Cost,
- Reliability,
- Maintainability,
- Interchangeability, and
- Suitability for the purpose intended.

SCRRA shall determine if any material or equipment proposed by the Contractor is equal to that specified.

Availability - The percentage of the car fleet useable for revenue service at the beginning of each day’s schedule. Also on per car basis, the percentage of time a car is useable for service - (MTBF)/(MTBF + MTTR).

B-end - The end of the car at which the hand brake is located; the end opposite the A-end or F-end.

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

Burn-In - A 1,000-mile, trouble-free, operational test conducted by SCRRA after all other tests are successfully completed; the operation of an item under stress for a specified length of time to stabilize its characteristics.

Calculations - Numerical computations performed to demonstrate compliance with the Specification.

Car History Book - A document specific to an individual car containing records of technical and parts data pertinent to that car.

Central Maintenance Facility (CMF) - The facility used to support daily inspection and service, periodic and unscheduled maintenance and repair of SCRRA rail vehicle fleet. Located at 1555 San Fernando Road, Los Angeles, CA.

Coast - The mode of operation of a car or train in which propulsion (positive traction) and brake (negative traction) are inactive and any acceleration or deceleration results only from the rolling resistance of the train, aerodynamic drag and the physical characteristics of the track.

Commissioning – The conduct of pre-acceptance Contractor activities involved in delivering, adjusting, and testing the cars to demonstrate compliance with Specification requirements.

Comment - Written critiques of the Contractor’s submittals to SCRRA.

Contract Drawings - Drawings provided by SCRRA as part of the Contract Documents.

Crash Energy Management (CEM) – A strategy for improved occupant survivability during a collision. Designs using this strategy include sacrificial crush zones at the ends of the cars and other unoccupied space.

Contractor’s Drawings - Items such as general arrangement drawings, detail drawings, as-built drawings, graphs, diagrams, and sketches that are prepared by the Contractor to detail its Work.

Delivery, Delivered - The transfer of the completed vehicle (with all in-plant testing completed and results accepted by SCRRA) to SCRRA property, ready for commissioning and acceptance testing.

De-rating - Deliberate use of an item in such a way that applied stresses are below rated values.

Design Speed - The anticipated maximum possible operating speed of the car. The design speed for this program is 110 mph. The car and its components shall be suitable for safe operation at this speed.

Downtime - The elapsed time during which equipment is not capable of use in revenue service use due to maladjustment, malfunction of systems, or maintenance in progress.

F-end - The end of the car opposite the B-end of the cab car. Also designated as the A-end in the cab car.

Fail-Safe - A characteristic of a system that insures that any malfunction affecting safety will not cause the system to achieve an unsafe state.

Failure - The inability of a component, system, or subsystem to function or perform in accordance with the Specification and requiring a corrective action to restore the specified function or performance.

Failure, Dependent - The failure of a system, subsystem, or component induced by the failure of another system, subsystem, or component.

Failure, Independent - The failure of a system, subsystem, or component not induced by or the result of the failure of another system, subsystem, or component either directly or indirectly.

Failure Rate - The frequency of failure, expressed as failures per hour or failures per mile, or the number of failures, usually presented as a percentage of the total amount of same items used. Failure rate is the mathematical reciprocal of MTBF or MDBF.

First Article - The first unit of any production component of the car that is produced in accordance with approved drawings. The Contract provides that nothing be manufactured prior to approval, so First Article shall have been made from approved drawings.

First Article Inspection (FAI) - A formal inspection of a First Article production used to establish the level of quality and workmanship that will be maintained for the balance of the components produced, including observation in three dimensions by the Engineer, the Contracting Officer, etc., to see what could be seen only on two-dimensional drawings up to that point. If the First Article Inspection is of a component that the Contractor is purchasing, rather than manufacturing, the First Article Inspection discloses details that were not previously visible through Contractor submittals. The First Article Inspection is usually the first point at which maintainability of the component can be evaluated, inasmuch as it is the first point at which relationships between elements can be discerned. The Engineer may approve the design that is revealed at the First Article Inspection, or may require changes to the component in order to meet the requirements of the Contract.

Inspector - The person or firm designated by SCRRA, the Project Manager, and/or the Engineer as its quality assurance representative.

Interface - The points at which two (2) or more systems, subsystems, or structures meet, transfer energy, or transfer information.

Jerk Rate - Time rate of change of acceleration and deceleration, equal to the second time derivative of velocity.

Jumper - A short piece of wire or cable with appropriate terminations on each end to permit connection to terminals within a terminal board or to an adjacent terminal strip. Also, a single or multi-conductor cable used to carry current or trainline signals between coupled cars and/or locomotives.

Left Hand Side - The side of the car to the left when standing at the B-end of the car and facing the A-end of the car.

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 SCRRA maintenance staff.

Mean Distance Between Failures (MDBF) - The reliability of the components, systems, and cars expressed as the mean operating mileage between independent failures of the components, systems, and cars.

Mean Time Between Failures (MTBF) - The reliability of the components, systems, and cars expressed as the mean operating time between independent failures of the components, systems, and cars.

Mean Time To Repair (MTTR) - A measure of maintainability defined as the time required to restore a car system or car to proper operating condition.

Mileage, Operating - The total distance traveled by the car during scheduled and un-scheduled movements over established routes as recorded by SCRRA.

Operating Speed - Speed at which cars are run by the Authority during revenue service.

Operating and Support Hazard Analysis (O&SHA) - Analysis performed primarily to identify and evaluate hazards associated with the environmental, personnel, procedures and equipment involved throughout the operation of a particular system/element. The O&SHA may be performed on such activities such as testing, installation, modification, maintenance, support, transportation, ground servicing, storage, operations, emergency escape rescue, and training. The O&SHA may also be selectively applied to facilities acquisition projects to make sure operation and maintenance manuals properly address the safety requirements.

Pilot Car - The first of each car type which undergoes manufacturing and testing processes and, once each stage of work is approved, serves as the standard to be in manufacturing the balance of the cars.

Preliminary Hazard Analysis (PHA) - The initial effort in hazard analysis during the system design phase or the programming and requirements developmental phase for facilities acquisition. It may also be used on an operational system for the initial examination of the state of safety.

Reliability - The probability of a component, system, or car of performing a specified function without failure and within design parameters, for the period of time intended, under normal operating conditions.

Right Hand Side - The side of the car to the right when standing at the B-end of the car and facing the A-end of the car.

Shipment - The physical departure of the car from the Contractor's facility to SCRRA's designated receiving site.

Shop Drawings - Drawings or sketches prepared by the Contractor for use in its manufacturing or other activities related to the Contract work, whether manufactured from raw materials or purchased from others in a ready-to-use condition.

Slide, Wheel - The condition that occurs when the braking force (deceleration) overcomes the available adhesion at the wheel/rail interface, resulting in the wheel rotating at a speed less than that of pure rolling contact between the tread and rail.

Stop, Emergency - The stopping of a car or train by an emergency brake application.

Stop, Service - The stopping of a car or train by application of service braking.

Tamperproof - Designation for fasteners selected so that they cannot be easily loosened with common tools.

Tight (used as a suffix) - Designation indicating that when apparatus is "watertight," "dust-tight," etc., it has been constructed so that the enclosing case will exclude the specified material.

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

Vital Circuit - Any circuit and its elements, the function of which affects the safety of vehicle or train operations or both.

Warp, Track - The vertical distance between the plane of any three (3) or four (4) rail head contact points (two (2) on each rail) forming a plane and the remaining point.

Waterproof - The design, construction, and/or treatment of a device, component, apparatus, or structure that allows the device, component, apparatus, or structure to operate or function normally with its intended level of reliability for the duration of its design life without detrimental effect from the presence of moisture or water resulting from leakage or condensation in its operating or functional environment.

Watertight - The design, construction, and/or treatment of a device, component, apparatus, or structure that precludes the entrance of moisture or water into that element under any and all operating, maintenance, servicing, and test conditions.

Weight, Actual - The measured weight of a finished empty car (AW0), ready for passenger carrying service, and with full water and biocide tanks.

1.3.2 Abbreviations

The abbreviations provided in this Section are meant to supplement and complement those included elsewhere in the Contract. The following is a list of abbreviations used in the Specification. The list is provided as information and is neither intended to be all-inclusive nor are all abbreviations necessarily used herein.

A	Ampere
AAR	Association of American Railroads
AATCC	American Association of Textile Chemists and Colorists
AC	Alternating Current
ADA	Americans with Disabilities Act of 1990 as amended
AFBMA	Anti-Friction Bearing Manufacturer’s Association
AFI	Air Filter Institute
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
AMCA	Air Moving & Conditioning Association
ANSI	American National Standards Institute
APA	American Plywood Association
API	American Petroleum Institute
APS	Auxiliary Power Supply
APTA	American Public Transportation Association
APU	Auxiliary Power Unit
AREA	American Railway Engineering Association
AREMA	American Railway Engineering & Maintenance-of-Way Association
ARI	Air Conditioning and Refrigeration Institute
ASC	Automatic Speed Control
ASES	Advanced Speed Enforcement System
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
ASIC	Application Specific Integrated Circuit
ASM	American Society for Metals
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATC	Automatic Train Control
ATS	Automatic Train Stop
AWG	American Wire Gauge
AWS	American Welding Society
BCH	Bose-Chaudhuri Hochquenghem (Error Correcting Digital Cards)
BHP	Brake Horsepower
BTE	Bench Test Equipment
Btu	British Thermal Unit
^{o}C	Degree Celsius
^{o}CDB	Degrees Celsius Dry Bulb

°CWB	Degrees Celsius Wet Bulb
C	Capacitance
CAD	Computer Aided Design
CD	Compact Disk
CDPD	Cellular Digital Packet Data
CDRL	Contract Deliverable Requirement List
CDS	Central Diagnostic System
CEM	Crash Energy Management
CER	Critical Engineering Review
CFD	Computational Fluid Dynamic
cfm	Cubic Feet per Minute
CFR	Code of Federal Regulations
CLDS	Car Level Diagnostic System
CMF	Central Maintenance Facility
COTS	Commercial Off the Shelf
COT&S	Clean, Oil, Test & Stencil
CPM	Critical Path Method
CPU	Central Processing Unit
CRC	Cyclic Redundancy Check
CRF	Critical Radiant Flux
CS	Communication System
CSS	Cab Signal System
CSLDS	Car System Level Diagnostic System
DAU	Data Acquisition Unit
dB	Decibel
dBA	Decibel, A-Weighted Scale
DBU	Disc Brake Unit
DC	Direct Current
DCN	Data Car Network
DCS	Door Control System
DDU	Driver Display Unit
D_s	Specific Optical Density
DTMF	Dual-Tone Multi-Frequency
DTN	Data Trainline Network
DUART	Dual Universal Asynchronous Receiver/Transmitter
E	Modulus of Elasticity
ECR	Engineering Change Request
ECU	Electronic Control Unit
EEPROM	Electrically Erasable Programmable Read Only Memory
EER	Energy Efficient Radio
EIA	Electronic Industries Association
EMC	Electromagnetic Compatibility
EMCP	Electro-Magnetic Compatibility Plan
EMF	Equipment Maintenance Facility also see CMF
EMI	Electromagnetic Interference
EPA	Environmental Protection Agency

EPIC	Electro-Pneumatic Integrated Control
EPROM	Erasable Programmable Read-Only Memory
ERTIS	En Route Transit Information System
^{o}F	Degrees Fahrenheit
^{o}FDB	Degrees Fahrenheit Dry Bulb
^{o}FWB	Degrees Fahrenheit Wet Bulb
FAI	First Article Inspection
FAP	Frequency Allocation Protocol
FAR	Federal Acquisition Regulations
FCC	Federal Communications Commission
FDA	Food and Drug Administration
FEA	Finite Element Analysis
FMECA	Failure Mode Effects and Criticality Analysis
FTA	Federal Transit Administration
fpm	Feet Per Minute
FRA	Federal Railroad Administration
FRACAS	Failure Reporting and Corrective Action System
FRB	Failure Review Board
FRP	Fiberglass Reinforced Plastic
g	Gravitational Acceleration
GP	General Purpose
GPS	Global Positioning System
GTO	Gate Turn-Off
HAZ	Heat Affected Zone
HCFC	Hydro chlorofluorocarbon
HDLC	High Level Data Link Control
HEP	Head End Power
HFC	Hydro fluorocarbon
HP	Horsepower
HVAC	Heating, Ventilation, and Air Conditioning
Hz	Hertz
I/O	Input/Output
IC	Inter-communications System
ICEA	Insulated Cable Engineers Association
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronic Engineers, Inc.
IEM	Interactive Electronic Manual
IES	Illuminating Engineering Society
IFD	Indentation Force Deflection
IPC	Institute of Printed Circuits
IPER	In-Process Engineering Review
IPS	Iron Pipe Size
ISO	International Standards Organization
I_s	Flame Spread Index
JEDEC	Joint Electronic Device Engineering Council
kHz	Kilohertz

kVA	Kilo Volt Ampere
kW	Kilowatt
LAN	Local Area Network
LAHT	Low Alloy High Tensile Strength (Steel)
lb	Pounds
lbf	Pounds Force
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LLRU	Lowest Level Replaceable Unit
LVDB	Low Voltage Distribution Bus
LVDN	Low Voltage Distribution Network
LVPS	Low Voltage Power Supply
MA	Motor Alternator
MC	Master Controller
MDBF	Mean Distance Between Failure
MDS	Monitoring and Diagnostics System
MDU	Maintenance Display Unit
MHz	Megahertz
MIL	Military Specification
mph	Miles Per Hour
mphps	Miles Per Hour Per Second
mphpsps	Miles Per Hour Per Second Per Second
MRB	Material Review Board
MS	Margin of Safety
ms	Millisecond
MS-DOS	Microsoft Disc Operating System
MTBF	Mean Time Between Failure
MTTR	Mean Time To Repair
MU	Multiple-Unit
μA	Micro Ampere
NBS	National Bureau of Standards
NBR	Net Braking Ratio
NEC	National Electrical Code
NEMA	National Electrical Manufacturers’ Association
NFL	No Field Lubrication
NFPA	National Fire Protection Association
NTP	Notice To Proceed
OD	Outside Diameter
ODK	Operator’s Display Keyboard
OEM	Original Equipment Manufacturer
OHDS	Overhead Heat Duct Sensor
OSHA	Occupational Safety and Health Administration
O&SHA	Operating and Support Hazard Analysis
PA	Public Address
PC	Printed Circuit
PCB	Printed Circuit Board

PCBs	Polychlorinated biphenyls
PCMCIA	Personal Computer Memory Card International Association
PCU	Pneumatic Control Unit
PDR	Preliminary Design Review
PEI	Passenger Emergency Intercom
PER	Preliminary Engineering Review
PHA	Preliminary Hazard Analysis
PIV	Peak Inverse Voltage
PLDS	Passenger Load Determination System
ppm	Parts Per Million
PROM	Programmable Read-Only Memory
PS	Pressure Switch
psi	Pounds Per Square Inch
psia	Pounds Per Square Inch, Absolute
psig	Pounds Per Square Inch, Gage
PTE	Portable Test Equipment, interchangeable with PTU
PTFE	Polytetrafluorethylene
PTS	Positive Train Separation
PTU	Portable Test Unit, interchangeable with PTE
PWM	Pulse Width Modulation
QA	Quality Assurance
R-22	Refrigerant 22
R-C	Resistive-Capacitive
RAM	Random Access Memory
RDC	Rail Diesel Car (Budd Company Specific)
RFI	Radio Frequency Interference
RH	Relative Humidity
rms	Root Mean Square
ROM	Read-Only Memory
rpm	Revolutions Per Minute
SAE	Society of Automotive Engineers
SCCO	Speed Control Cutout Switch
scfm	Standard Cubic Feet Per Minute
SCI	Software Configuration Item
SCR	Silicone Controlled Rectifier
SCRRA	Southern California Regional Rail Authority
SCS	Speed Control System
SDD	Software Design Description
SDU	Speed Display Unit
SHR	Sensible Heat Ratio
SIC	Standard Industrial Code (U.S. Department of Labor)
SPL	Sound Pressure Level
SSP	System Safety Program
S&I	Service and Inspection Facility
S/N	Signal to Noise Ratio
T_s	Ambient Temperature

T_i	Interior Temperature
TBA	To Be Addressed
TBD	To Be Determined
TBU	Tread Brake Unit
TDMS	Train Data Monitoring System
TFE	Tetrafluoroethylene
TIG	Tungsten Inert Gas
TIR	Total Indicated Runout
TLDS	Train Level Diagnostic System
TSDL	Technical Specification Deliverable List
TOR	Top-of-Rail
TWC	Train To Wayside Communications
TXV	Thermal Expansion Valve
UA-Factor	Total Carbody Heat Transmission Value
UL	Underwriters Laboratories Inc.
UNC	Unified National Coarse (Thread)
UNF	Unified National Fine (Thread)
URL	Uniform Resource Locator
US	United States
USASI	United States of America Standards Institute
USDOT	United States Department of Transportation
UV	Ultraviolet
VAC	Volts, Alternating Current
VDC	Volts, Direct Current
VMU	Vehicle Monitoring Unit
VOM	Volt/Ohm Meter
VPI	Vacuum Pressure Impregnation
Vp-p	Voltage peak-to-peak
VSWR	Voltage Standing Wave Radio
W	Watt
WDS	Wayside Diagnostic Systems
WPS	Weld Procedure Specifications
WTB	Wire Train Bus
www	World Wide Web

1.4 ARRANGEMENT OF TECHNICAL SPECIFICATION

The Technical Specification is arranged into twenty (20) sections with each section addressing a specific area of the Contract Work. As is appropriate for the individual sections, a list is included at the end of the section that defines the information that shall be submitted to SCRRA to monitor the work being performed and to demonstrate compliance with the Contract requirements.

Sections 1 and 2 provide SCRRA operating and service information for the Contractor to use in its design, application and implementation of the Contract Work. Sections 3 through 14 are arranged to define the scope of work for the equipment, apparatus and systems that shall be integrated into the multi-level commuter rail passenger cars. These sections give details of the design parameters and describe the work to be performed. Section 15 provides the requirements for the materials that shall be used and workmanship standards that shall apply to the work. Section 16 addresses the quality, reliability and maintainability aspects of the work. Section 17 delineates the qualification, routine and commission test requirements for the equipment and cars. Section 18 provides the minimum level of documentation required by SCRRA to maintain, repair and trouble shoot the cars. Section 18 also addresses requirements for the training program. Section 19 identifies the requirements for the Contractor to demonstrate that the work is to be performed in accordance with the Contract and defines the information required by SCRRA to monitor and approve the Work. Section 20 provides SCRRA Contract drawings and miscellaneous data.

1.5 CONTRACT COMPLIANCE

1.5.1 Rules, Regulations, Standards and Practices

The completed cars shall comply in all respects with the requirements of the applicable laws of the State of California, the requirements of the applicable FRA regulations, EPA regulations, APTA Standards and Recommended Practices, and AAR Mandatory Standards. All references to industry, government, associations and society rules, regulations, standards, specifications and recommended practices are those in effect at the time of Contract award, and it shall be complied with.

1.5.2 Clarifications

The intent of the Technical Specification is to describe that the Work to be performed, workmanship levels to be achieved, and tests to be conducted. In the case that the Work is not sufficiently explained and defined or any aspect is not technically feasible or is inconsistent with the intent of the Work, the Contractor shall notify the Engineer, in writing, requesting clarification and determination of the requirement(s). The Engineer will respond to the request for clarification within twenty (20) days of receipt of the Contractor's request.

1.6 DESIGN DEVELOPMENT AND REVIEW

1.6.1 Design Development and Review Process

Details of the process and its requirements are provided in Section 19. The process commences with a joint review and discussion of the specification requirements and the development of a detailed Design Requirements and Traceability Report. This report shall identify the supplier/subcontractor for each vehicle system; interfaces among the vehicle systems and the vehicle itself; specification requirements for each vehicle system and each interface (hardware and software); and the entity responsible for satisfying the requirements identified. This report provides the framework for defining the design concepts being developed and shall be approved by the Engineer prior to submitting any preliminary design review packages.

The Contractor shall submit drawings of the outline and sections of the cars showing proposed configuration of each car type, locations of equipment, and block diagrams showing interfaces between the vehicle and all vehicle systems. These drawings shall present the concepts that will be developed through the design review process.

1.6.2 Mock-up Review

To support the development of the design and suitability for the application, the Contractor shall present no later than two hundred ten (210) days after Notice to Proceed or earlier if required by the Contractor's schedule, full-scale mock-ups for approval by the Engineer. The Contractor shall include in its schedule no fewer than two (2) reviews to be conducted for the complete mock-ups. After completion of the delivery of the first of each car type, the mock-ups shall be delivered to SCRRA or as directed by the Engineer.

The mock-ups shall be utilized to accurately demonstrate the capability to remove equipment, open doors, provide access for maintenance and service tasks. The mock-ups shall also demonstrate ergonomic characteristics for both passengers and crew. The mock-ups shall remain intact as approved or, if changes are made, kept current with these changes. Approved changes shall be incorporated into the mock-ups within sixty (60) days of approval of the changes by the Engineer. The final design of the mock-ups shall be approved by the Engineer before the car design is submitted to the Engineer for Final Design Review and approval.

The Contractor shall develop full-scale car mock-ups showing:

- Cab: Detail arrangement showing the locations of all controls, switches, indicators, circuit breaker panels, front and side windows, doors, heaters, partitions and other apparatus used by the Operator. The mock-ups shall be arranged such that the Operator's field of vision looking forward and to both sides can be evaluated.
- Passenger door entry: The mock-ups shall include a complete functional doorway including emergency release mechanism.
- Passenger seats: The mock-ups shall include sufficient quantities of each seat type, including bulkhead seats, transverse fixed and flip-up seats, longitudinal flip-up seats, to demonstrate the relationship of the seats to the side walls, to the aisle and to each other, and to allow the passenger comfort and passenger flow to be evaluated.
- Toilet room: The mock-ups shall include the complete toilet room with all furnishings and appointments with all items requiring maintenance and routine service identified. The mock-up shall also be used to evaluate ADA compliance.
- Bicycle storage: The mock-ups shall include retaining mechanism for bicycle storage.

The final mock-ups shall be designed and constructed utilizing actual production configuration equipment and components wherever possible.

1.6.3 Design Review

The Contractor shall conduct formal design review(s) with the Engineer for the carbody (structure and assembly), cab area, passenger area, major equipment and assemblies, each system and the integration of each system into the cars. The purpose of the design review is to insure the requirements of the Specification are met by the design. The design review process shall be coordinated with the drawing submittal, review and approval process. Approval of a system design shall not relieve the Contractor of the responsibility for the design and manufacture of the multi-level commuter rail passenger cars to comply with the requirements of the Contract.

The Contractor's technical documentation submitted to support the design review process shall clearly define the systems and vehicle designs, production processes, testing and operational criteria, and compliance with the Contract requirements. Interfaces between the various systems, between structural elements and their sub-assemblies, and between the structural elements and the attached apparatus, equipment, wiring, piping, and hardware shall be clearly detailed in the technical documentation and design drawings. As a minimum, two (2) reviews, preliminary and final, shall be conducted. Each review may require several iterations to complete. All action items, outstanding issues and requests for clarification from the preliminary design review shall be satisfactorily resolved prior to commencing final design reviews. Refer to Section 19.4 for detail of design review requirements. Formal design reviews shall be scheduled no sooner than fifteen (15) working days after receipt of said design review package by the Engineer.

All drawings shall be prepared using a CAD format, approved by the Engineer. All "as-built" drawings shall be prepared in accordance with ANSI standards and shall be submitted as electronic documents using an AutoCAD format approved by the Engineer.

1.6.4 Review and Approval

The Engineer shall review each submittal, as furnished by the Contractor within thirty (30) days of its receipt. Upon completion of the review the Engineer shall notify the Contractor in writing of the status of the submittal with one of the following dispositions:

- Approved – The Contractor may proceed with the work addressed in the submittal.
- Approval Pending – The Contractor must not proceed with the work affected by the noted comments until the Contractor has responded to the comments; the comments have been reviewed; and the status of the submittal has been changed from "Approval Pending" to "Approved."
- Not Approved – The Contractor must not proceed with the work. The Contractor must revise and resubmit the submittal. The revised submittal shall address to the satisfaction of the Engineer all the comments provided in the Engineer's writing.
- Information – This disposition is provided for submittals presented to explain an "approved equal" submittal, a concept and/or an approach to the work, and appropriate conditions. The Contractor must not proceed with the work addressed in such submittals until the concept has been finalized and "Approved."

The Contractor shall respond in writing to comments provided by the Engineer within fifteen (15) days of their receipt by the Contractor. The Contractor shall not release any designs for manufacture before approval of the final design by the Engineer.

1.6.5 Changes

Requests for changes and “approved equal” shall be made in writing to the Engineer through the engineering change request process. Refer to Section 19.3 for details of request for change requirements. Each request shall include all pertinent information to verify that the item offered is equal to or exceeds the Specification requirements. Any test requirements in the Technical Specification that pertain to an item under consideration shall be included in the request submittal package. Sample components may be submitted to the Engineer to facilitate the evaluation of the proposed alternative item. Such samples shall become the property of SCRRA.

The Engineer may request the Contractor to dismantle and/or functionally test such samples to establish the equality or superiority of form, fit, and function. The Contractor shall fulfill such requests.

1.7 RESPONSIBILITIES OF CONTRACTOR

1.7.1 Systems Design and Integration

The Contractor shall be responsible for the proper functioning and integration of all systems and their interrelation with all other parts of the cars. The Contractor shall provide complete systems’ integration services during the design, manufacturing, and testing phases of the Contract. The Contractor shall be responsible for coordinating all electrical and mechanical interfaces between the vehicle subsystems, the vehicle, the wayside and shop, and electrical interference control and SCRRA’s existing fleet. The Contractor shall perform the necessary design tasks to perform the work, and shall prepare and submit all necessary detail drawings, design calculations, other specified technical documentation and Contract required submittals. The Contractor shall submit such additional or revised drawings, diagrams, calculations, tests results, etc. as the Engineer deems necessary to confirm the completeness and accuracy of Contractor’s submittal. All drawings shall be submitted in AutoCAD format approved by the Engineer, and all reports shall be submitted in MS Word ® format.

1.7.2 Drawings

The Contractor shall develop as part of the design review process complete and comprehensive drawings of the complete car, equipment assemblies their installations and arrangements, cab area, passenger area, electric and pneumatic diagrams and schematics, and exterior elevations. The drawings shall identify equipment interface and installation requirements, access points, its weight and center of gravity, and work space envelope requirements.

Sufficient details shall be included in the drawings and technical documentation to convey the concept, design dimensions, maintenance, operation, overall assembly, and interfaces. Drawings and documentation submitted by subcontractors and suppliers shall be reviewed and approved by the Contractor prior to their submittal to the Engineer for review and approval.

1.7.3 Test Procedures and Reports

The Contractor shall perform or arrange for the performance of all tests specified. Test procedures and reports shall cover subcontractor tests to be completed at their plant, all Contractor tests to be completed at its plant and all tests to be completed at SCRRA. No tests shall be conducted prior to its approval by the Engineer. All test procedures shall be approved by the Engineer at least thirty (30) days prior to the scheduled test date. The Contractor shall ensure that all test procedures and reports are reviewed and approved by its Engineering department prior to submittal. All test reports pertaining to routine acceptance and for equipment specific to a car shall be included in the Car History Book. A pre-revenue service acceptance testing plan in accordance with FRA 238.111 shall be developed as appropriate to the truck and vehicle design. This plan shall include the test data necessary to support SCRRA's waiver for operation at 4 inches of cant deficiency.

1.7.4 Submittal Requirements

Each submittal shall be complete, legible, orderly, in English, and of logical sequence as agreed to between Contractor and Engineer to enable the Engineer to perform his review. Each submittal shall be accompanied by a letter of transmittal. Each letter of transmittal shall identify the appropriate Contract Section that the submittal addresses. Each submittal revision shall be accompanied by a similar transmittal letter.

1.7.5 Experience

At a minimum, the Contractor shall have experience in the design, manufacture, testing, and delivery of passenger rail cars over the past ten (10) years. Experience shall be demonstrated by providing evidence (customer letters, documenting dates of Notice to Proceed, vehicle shipping notices, schedules of actual deliveries and letters from customer confirming the information is accurate) of the following:

- Contractor has been responsible for the design, manufacture, testing, and delivery of passenger rail cars or carshells for at least 3 separate passenger rail car projects within the last 10 years, September 1, 1995 to September 1, 2005.
- Contractor has been responsible for the design, manufacture, testing and delivery for at least 300 passenger rail cars or carshells within the last 10 years, September 1, 1995 to September 1, 2005, that were accepted by the client and placed into service.
- Contractor has shipped multiple (minimum of 3) passenger rail cars per month from the same production line/run for a period of at least 4 consecutive months during the last 5 years, September 1, 2000 to September 1, 2005.

1.7.6 Production and Final Assembly Facilities

Contractor shall have adequate facilities to perform all Work defined by these Specifications. At a minimum, the production facilities shall support the following activities:

- Parts warehousing
- Design drawing and control
- Production processes and control
- Primary parts cutting and assembly
- Carbody shell assembly with assembly jigs
- Welding operations
- Weld testing
- Painting
- Equipment installation
- Interior materials installation (insulation, interior panels, flooring, etc.)
- Wiring Installation
- Piping Installation
- Truck Assembly
- Watertightness testing
- HVAC testing
- Carbody structural testing
- Truck structural testing
- Car functional testing
- Test track
- In-coming, in-process and pre-shipment inspections

Contractor shall have final assembly facilities that support all Buy America Requirements for final assembly facilities defined by 49 CFR 661 and FTA's Dear Colleague Letter March 18, 1997 letter number C-97-03. At a minimum, the final assembly facilities shall support the following activities:

- Installation and interconnection of propulsion control equipment, propulsion cooling equipment, brake equipment, energy sources for auxiliaries and controls, heating and air conditioning, communications equipment, motors, wheels and axles, suspensions and frames;
- Inspection and verification of all installation and interconnection work; and
- In-plant testing of the stationary product to verify all functions

1.8 MANAGEMENT SYSTEMS

The details of the management requirements are described in Section 19.

1.8.1 Program Management

The Contractor shall have an organization established to properly manage this Contract and ensure on-time performance of the Work. The Contractor shall manage the Contract to ensure all required design, and configuration reviews are addressed and all required deliverables are submitted as specified.

1.8.2 Systems Engineering Management

The Contractor shall treat the cab cars and trailer cars in the performance of the work as a single system rather than as an assembly of independently engineered and manufactured elements. The Contractor shall integrate the Contract specified requirements for reliability, maintainability, safety, quality, testing, and human factors into the total engineering effort. The technical and performance requirements of the Contract shall be integrated into the Contractor's review process to ensure physical and functional interfaces are optimized throughout the design, manufacture and test phases.

1.8.3 Configuration Control Management

The Contractor shall maintain accurate and current configuration control records that are available to SCRRA and its inspector throughout the performance of the work and warranty period. The records shall identify the configuration to the lowest level required to ensure repeatable performance, quality and reliability.

1.9 INSPECTIONS

The details of the inspection requirements shall be fully addressed in the Contractor's Quality Assurance Plan described in Section 16.

1.9.1 Inspection Requirements

The Contractor shall inspect and physically and/or functionally test all items to be delivered under the terms of this Contract. Inspection and testing shall occur at appropriate points in the manufacturing sequence to ensure compliance with drawings, process and test specifications, quality procedures and standards. The Contractor shall ensure that inspections and tests are based on the latest approved design. When modifications, repairs, reworks and replacements are required there shall be a re-inspection and re-test of the affected item. All inspection procedures shall include provision for reporting defects, exceptions, deficiencies and questionable work to the Engineer.

1.9.2 Access to Plant and Subcontractor Facilities

SCRRA and/or its authorized representative(s) shall have access at all times, during working hours, to those areas of the Contractor's plant(s) and its subcontractor's plant(s) involved in the design, manufacture and test of the cars, equipment, apparatus and components. The Contractor shall extend and shall ensure that its subcontractors extend to SCRRA and its representative's full cooperation and necessary facilities to permit the proper inspection and testing of materials, work and equipment supplied.

1.9.3 Authority's Inspectors

SCRRA may station its own inspector at the Contractor's or its subcontractors' facilities during the execution of the Work. The inspector shall be authorized to inspect all work performed, inspect materials furnished, determine quality of work performed and make periodic assessment(s) of the work. Contractor provisions for SCRRA inspectors shall be as per Section 16.1.17.8

1.9.4 Defective Work

Should the SCRRA inspector have evidence that defective work or defective materials have been used, the Contractor and its subcontractor, if appropriate, shall provide the facilities and labor to conduct such inspections of the work or materials in question as may be required. The Contractor shall provide all inspection data reports showing the inspections and testing of the work and materials conducted to date of the item(s) under investigation. Any defective work and materials that are disclosed shall be corrected promptly. If the investigation discloses no defect, the delay caused by such investigation will be considered as beyond the Contractor's control.

1.9.5 Rejected Work

The SCRRA inspector shall have the right to reject any materials and/or workmanship that does not comply with the Contract requirements or with approved Contractor's and subcontractors' drawings and specifications.

1.9.6 Source Inspection

Components, equipment and apparatus that require inspection prior to shipment to the Contractor's facility shall be identified in the Quality Assurance Plan as per Section 16.1.17.5. The Contractor shall maintain records of these inspections with item part numbers, associated correspondence, drawings, test data, and dates when inspections were conducted and by whom. Samples of approved materials shall be maintained throughout the Contract.

1.9.7 First Article Inspection Requirements

First Article Inspections (FAI) shall be required for all Contractor and subcontractor furnished systems, assemblies, subassemblies and components. An FAI shall be conducted by the Contractor at the point of manufacture on the first piece, component, assembly and system constructed using production tooling and approved or approval pending drawings. Drawings and procedures shall be approved by the Engineer before the FAI is scheduled. A procedure shall be submitted by the Contractor and approved by the Engineer prior to conducting the FAI. If any system, assembly, subassembly or component differs between the cab car and the trailer car, a separate FAI shall be required for each.

The objective of the FAI is to demonstrate that the FAI articles comply with the Contract requirements, conform to design documents, and set an acceptable standard for production workmanship. At the time the FAI is conducted, or earlier if required by the Engineer, the Contractor shall present for review documentation of the physical inspection of the article and required test and inspection reports. The FAI results shall be documented in a report submitted to the Engineer for review. Photographs shall be taken and included in the report to document the FAI results. The Contractor shall preserve all First Articles until the end of production of the vehicles, unless otherwise approved by SCRRA.

As a minimum, First Article Inspections shall be conducted for the following:

- Underframe structure,
- Side frame structures,
- CEM crush zone elements,
- Roof structure,
- End structure without CEM features,
- End structure with CEM features,

- Floor structure,
- Assembled carbody structure,
- Assembled and integrated cab,
- Assembled truck,
- Truck castings and weldments,
- Air suspension controls,
- Wheel/Disc/Axle Assemblies,
- Each car type assembled and complete,
- Exterior paint;
- Exterior decals and/or graphics,
- Coupler, yoke, and draft gear,
- Door operators and controls (passenger entry, end-of-car, toilet room),
- Master controller,
- Brake equipment and controls,
- Windows (each type),
- Reservoirs,
- Wheel slide detection/correction system,
- Seat assembly (each passenger type and operator’s),
- HVAC system and controls (complete including all blowers, fans, diffusers, etc.),
- Low Voltage Power Supply including battery charger,
- Batteries – each type,
- Battery boxes,

- Inverters,
- Converters,
- Wire and cable,
- Light fixtures – each type, (interior and exterior)
- Communication system and controls (radio, PA/IC control panels, speakers, information signs, etc.),
- Interior panels,
- Flooring and floor coverings,
- Signage, decals and/or graphics
- Door panels – each type (side entry, end-of-car, toilet room, equipment compartments, etc.),
- ATS system and controls,
- Event recorder,
- Train monitoring system and controls (including alerter and ATS), and
- Handbrake system.

1.10 DELIVERY AND ACCEPTANCE

Upon completion of manufacture of each car, the Contractor shall conduct a complete and comprehensive visual inspection of the car and its mechanical and electrical systems to ensure proper assembly and to verify the level of workmanship. Operational tests shall be performed to check for proper operation and performance of all car systems. A written report of these checks, inspections and tests shall be submitted to SCRRA prior to shipment and included in the Car History Book. This report shall include any defects, exceptions, and deficiencies noted in the performance of the work and the remedial actions taken or planned to correct them. All production work and tests shall be completed at the Contractor's facility and accepted by SCRRA prior to shipment of the car. After delivery and prior to Acceptance, the Contractor shall perform the required post delivery tests. SCRRA shall provide the facilities and crew required to operate the car for these tests. The Contractor shall provide the test personnel and test equipment required to properly conduct these tests.

When all tests are completed in accordance with the Contract, the required reports are received and approved, the car is totally responsive to the Contract such that no corrective actions are required, and the Car History Books are received and approved, the cars shall be Accepted by SCRRA.

1.11 MANUALS, TRAINING, SPECIAL TOOLS, AND TEST EQUIPMENT

The details of the manuals and training program requirements are described in Section 18.

1.11.1 Manuals

The Contractor shall supply one (1) electronic copy (on CD) in an approved software format and one (1) master camera-ready hardcopy of all manuals. All master hard copy materials shall be printed on durable sheets.

The Contractor shall provide a separate illustrated parts catalog that includes sufficient detail for SCRRA to procure parts to service, maintain, trouble-shoot and repair the cars.

The Contractor shall provide a maintenance manual that includes the information required for SCRRA to inspect, service and maintain the car and its systems. The manual shall address requirements for lubrication, maintenance, adjustments, heavy maintenance and trouble-shooting and problem diagnosis.

The Contractor shall provide an Operator's Instruction Manual that includes information for the location, function and control of components and equipment used in the operation of the cars.

1.11.2 Training Program and Support Material

The Contractor shall provide the materials required for SCRRA to conduct a training program for these cars. The training program shall include car familiarization, systems operations, trouble-shooting, running maintenance, daily inspections, periodic inspections and maintenance, and operator's training. The Contractor shall supply one (1) electronic copy (on CD) in an approved software format and one (1) master camera-ready hardcopy of all training program materials. The training program materials shall include instructor's guide/manual, student handbook, overhead transparencies, videos, training aids, mock-ups (if applicable) and student tests. The program should assume spare parts from SCRRA's inventory are available to be used to support the training program requirements.

1.11.3 Special Tools and Operating Instructions

The Contractor shall furnish a list of special tools, jigs, and fixtures required for maintenance testing and trouble-shooting of the cars. The instructions for the proper use and periodic inspections and tests of the tools, jigs and fixtures shall be included in the maintenance manuals and training program. As appropriate for the specific item, each tool shall be accompanied by diagrams, schematics, maintenance and calibration instructions for the device itself. The Contractor shall make any modifications to tools that are required because of changes and modifications made to the vehicle or any of its systems.

Any items not manufactured by the Contractor shall be identified by the original equipment manufacturer and the equipment manufacturer's catalog/part number. If the Contractor cannot supply the item or identification of the manufacturer, the Contractor shall supply drawings and specifications appropriate for the procurement of the items by SCRRA.

1.11.4 Test Equipment and Instructions

The Contractor shall furnish a list of test equipment required for the servicing, maintenance, trouble-shooting and repair of the cars. The instructions for the proper use and periodic inspections and tests of the test equipment shall be included in the maintenance manuals and training program. The test equipment shall be accompanied by test procedures, maintenance and trouble-shooting procedures for the associated car borne system and equipment. As appropriate for the specific piece, each piece of test equipment shall be accompanied by diagrams, schematics, maintenance and calibration instructions for the device itself. The Contractor shall make any modifications to test equipment that are required because of changes and modifications made to the vehicle or any of its systems.

Any items not manufactured by the Contractor shall be identified by the original equipment manufacturer and catalog/part number. If the Contractor cannot supply the item or identification of the manufacturer, the Contractor shall supply drawings and specifications appropriate for the procurement of the items by SCRRA.

1.12 PRODUCT SUPPORT

1.12.1 Contractor's Representative

Prior to delivery of the first car, the Contractor shall designate, subject to SCRRA approval, a product support/field service representative who shall;

- Be responsible for on-site vehicle testing and commissioning,
- Supervise any required warranty work,
- Process warranty claims,
- Provide on-site technical support,
- Coordinate technical support by subcontractors,
- Support SCRRA maintenance, repair, and trouble-shooting activities, and
- Provide documentation, drawings and schematics to support maintenance and repairs.

The representative shall be on-site when the first car is delivered, and be available for the term of the warranty period of the last car. Duties and responsibilities of the Contractor's representative are provided in Section 19.1.8.

1.12.2 Requirements

The Contractor's representative shall have a solid understanding of the operation of the cars and their subsystems, and shall be able to trouble-shoot and analyze operating anomalies and service defects. The representative shall be able to diagnose system defects, locate faults to removable component level and repair the defects.

The Contractor's representative shall demonstrate the proper use of all special tools and test equipment defined in Sections 1.11.3, 1.11.4, and 18.

1.13 TOOLS, PATTERNS, AND FITTINGS

The Contractor shall not permit the destruction of dies, patterns and tools such as, drill and assembly jigs, welding fixtures, inspection fixtures, etc., used to perform the work for these cars at any future date without first offering SCRRA the opportunity to acquire the affected item(s).

1.14 SPARE PARTS AVAILABILITY

The Contractor shall be responsible for developing lists of spare parts as defined in Section 19.5.4. Any spare parts supplied by a company consisting of several divisions/departments shall be identified on spare parts lists by part number from the original manufacturer division. All electronic components shall be available from recognized electronic distributor sources in the United States. Spare parts are to be available for twenty (20) years after delivery of the last car.

End of Section

SECTION 2

DESIGN CRITERIA

SECTION 2

DESIGN CRITERIA

TABLE OF CONTENTS

SECTION 2

DESIGN CRITERIA

2.1 GENERAL DESIGN REQUIREMENTS

This section establishes performance, environmental and general design criteria for the multi-level trailer cars and CEM cab cars (vehicles) to be utilized in push-pull commuter service by SCRRA. The cab cars shall have a full set of CEM features as described in Section 3.10. Included in Section 2 are configuration, capacity, dimensional, performance, environmental, noise and vibration, weight, and other requirements which impact vehicle system and subsystem design. These requirements shall apply to all aspects of vehicle and equipment design.

On the basis of SCRRA maintenance practices and industry-accepted operating procedures, the vehicles shall be designed for a maximum Operating Speed of 110 mph. The design shall provide a minimum service life of thirty (30) years in the specified environment based on annual mileage of 80,000 miles per vehicle.

The vehicles shall be manufactured to operate successfully in SCRRA environment. All requirements identified herein shall be met. If questions or conflicts arise within this Specification, SCRRA shall be notified by the Contractor so that the subject questions or conflicts can be resolved without impact to design and manufacturing schedules. If the Contractor requires clarification to meet system and component interchangeability with existing SCRRA commuter rail vehicles as required by the Specification, a sample of the vehicle(s) in question will be made available by SCRRA for inspection by the Contractor at a designated SCRRA facility.

2.2 OPERATING AND SUPPLY VOLTAGES

All apparatus, except where otherwise stated, shall have operating characteristics which shall provide a ratio of actual performance to specified performance not less than the ratio of actual voltage (within the limits specified in the following paragraphs) to the rated operating voltage of the apparatus.

2.2.1 Primary Voltage – 480 VAC

The primary source of electric power supply for the cars shall be a dedicated Head End Power (HEP) alternator or inverter on the locomotive. This system generates 480 VAC +/- 10 percent, 60 Hz, 3-phase power. This system is designated “480 VAC” throughout this specification. Power shall be distributed to the cars through the 3-phase trainlines which are described in Section 5. Heating, air conditioning, battery charging, and lighting transformers shall operate from this source.

2.2.2 Secondary Voltage – 120 VAC

A secondary voltage of nominal 120 VAC, 60 Hertz, single phase power shall be obtained from a delta connected, 3-phase transformer of adequate capacity or two (2) single-phase transformers connected to the 480 VAC trainline on each car as described in Section 10.7. This system shall supply power for lighting, HVAC control, convenience outlets, and other miscellaneous loads. This system is designated “120 VAC” throughout this Specification

2.2.3 Low Voltage –72 VDC

A low voltage DC power supply and battery charger operating from the 480 VAC system and batteries shall be provided on each car. The low voltage system shall be regulated for 72 VDC, +/- 1.0 VDC and the nickel-cadmium storage batteries shall be of a nominal 64 VDC. This voltage system is designated “72 VDC” throughout this Specification.

2.2.4 Low Voltage – 36 VDC

Ungrounded, 36 VDC power shall be provided to retain compatibility with existing SCRRA cars. The 36 VDC power shall be derived from the 72 VDC system through a DC to DC converter.

2.2.5 Design Requirements

All equipment shall be protected from damage and improper operation due to high voltage transients across the supply terminals of that equipment and from high voltages impressed between supply terminal and the carbody. All equipment shall be protected from damage and improper operation from long term over-voltage and under-voltage conditions from any cause including equipment failure.

2.3 VEHICLE DIMENSIONS AND CAPACITIES

This Section lists the required basic car dimensions, capacities, and normal loading conditions under which the cars will be operated. Areas where wheelchair and mobility aid users are to be accommodated shall comply with all applicable requirements of ADA. These data, combined with the drawings included in this Technical Specification, comprise the descriptive requirements for the cars. The following characteristics shall apply to both cab and trailer cars unless indicated otherwise.

2.3.1 Dimensions

Length of car over coupler pulling faces	85’
Truck centers	59’-6” to 64’-0”
Maximum width of carbody over thresholds (With 59’-6” on truck centers)	10’-6”
Maximum width at carbody over the threshold (With 64’-0” truck centers)	9’-9”
Height TOR to the top of the side door step	18”
Minimum clear aisle width	28”
Height, TOR to top of lower level finished floor	25”

Height, TOR to top of intermediate level finished floor	51” (+0.5”, -0”)
Maximum height TOR to top of roof	15’-11”
Minimum vertical interior finished clearance (Finished floor to ceiling and/or stairs)	6’-7”
Coupler centerline height above TOR (nominal)	34.5”
Maximum height above floor, to bottom of window	34”
Minimum height of clear window opening	24”
Widths of side door clear opening	52” to 60”
Minimum width of end door opening (A-end and B-end)	28”
Minimum width of end door opening (F-end, Cab Car)	22.5”
Minimum height of side door and end door opening	6’-4”
Distance of jacking pad from coupler pulling face	5’
Distance of waste outlet (Right Hand Side) from B-end coupler pulling face	16’ to 18’
Distance of B-end side door centers from B-end coupler pulling face	26’ to 29’
Distance of A-end side door centers from A-end coupler pulling face	23’ to 29’
Truck wheel base	8’-6”
Wheel diameter (new)	33” to 36”
Radial wheel wear	1.5”
Minimum vertical clearance above TOR for all carbody under floor mounted equipment and truck elements (except wheels) under all conditions	2.75”
Minimum seat pitch	32.5”

2.3.2 Capacities

Minimum potable water storage	60 US gallons
Minimum sanitizer storage	20 US gallons
Minimum waste tank storage	55 US gallons
Minimum number of seats (cab/trailer)	135/140
Maximum number of standees	215
Main réservoir pressure (Nom. /Max.)	135psi/140psi

2.4 WEIGHTS

2.4.1 General

Every effort shall be extended to keep vehicle weight to a minimum consistent with the strength and other specified requirements. The weights of each car type shall not exceed those defined in Section 2.4.2. A Weight Control and Weight Balance Plan shall be submitted for review and approval by the Engineer and kept current on a monthly basis. **[CDRL 2-001]** Liquidated damages shall apply to any car that exceeds the approved weight by 1,000 pounds or more.

2.4.2 Definitions

Weight limits are based on a maximum ready to run AW0 car weight. Weight limits for loads AW1, AW2 and AW3 are calculated at 165 lbs. per seated and standing passenger and 350 lbs. per wheelchair passenger.

AW0 – Ready to run and no passengers	
Maximum Cab Car Weight	146,000 lbs
Maximum Trailer Car Weight	140,000 lbs
AW1 – Full seated:	
Cab Car Weight	AW0 + 135 passengers
Trailer Car Weight	AW0 + 140 passengers
AW2 – Full seated with 80 standees:	
Cab Car Weight	AW0 + 215 passengers
Trailer Car Weight	AW0 + 220 passengers
AW3 – Full seated with 215 standees:	
Cab Car weight	AW0 + 350 passengers
Trailer Car weight	AW0 + 355 passengers

2.4.3 Weight and Balance

All vehicle borne equipment shall be arranged so that each complete car with all necessary apparatus shall meet the following weight balance requirements:

- Difference in weight carried by A-end and B-end trucks shall not exceed 5 percent.
- Lateral imbalance shall not exceed 30,000 inch-pounds.

2.4.4 Car Weighing

Each car’s weight record shall be recorded in the Car History Book and on the Car Marking Plate. Details are provided respectively in Section 19.7 and 4.15. Details of weighing are provided in Section 17.7.3.

2.5 VEHICLE PERFORMANCE

This Section provides the performance criteria and requirements for the vehicles. Performance minimums required by FRA and other United States Government requirements are presented. The Contractor shall design the vehicles to meet or exceed these requirements and shall demonstrate compliance through tests and analysis approved by the Engineer.

Vehicles shall be capable of operation at maximum allowable speed on trackage which meets only minimum requirements of the FRA Track Safety Standards (49 CFR 213) for all classes of track up to and including Class 6 track. The vehicles shall comply with the requirements of 49 CFR 213.329 and shall undergo the qualification testing detailed in 49 CFR 213.345. The vehicles shall be designed and shown through analysis to be capable of safe, comfortable operation up to 110 MPH. The vehicles shall be tested for operating speeds up to 90 MPH. The Contractor shall perform and submit for review and approval a dynamic analysis to assess the vehicle stability on tangent track at all speeds up to maximum speed (110 MPH) as the vehicle transverses FRA Class 6 lateral alignment deviations in track with otherwise ideal geometry. The analysis must, as a minimum, determine the vehicle dynamic response to a combined lateral and vertical track geometry deviation of Class 6 magnitude at a single location on the outside rail in a curve at 4 inches cant deficiency. All wheel/rail forces and carbody and truck accelerations for the tangent and curve track sections must be within the vehicle track interaction safety limits established in 49 CFR 238. Based upon the results of this initial analysis, SCRRA may require additional analysis including, but not limited to, AAR Chapter XI geometry deviations. As part of the design review, the Contractor shall develop a simulation model to analyze the dynamic performance of the car. The analysis shall use NUCARS, VAMPIRE, or other SCRRA approved rail vehicle dynamic modeling software.

Maximum number of cars in train	10
Maximum Operating Speed	110 mph
Average annual distance operated per car	80,000 miles
Full service blended brake rate	2.0 +/-0.2 mphps
Emergency brake rate	120% of Full Service Rate
Cant deficiency operation	4 inches

2.5.1 EPA Factors

The Contractor shall ensure that the vehicle meets all current applicable Federal, State, and Local Environmental Regulations.

2.5.1.1 Drains, Sumps and Pans

The vehicle shall be equipped with sumps and drain pans, as required, and shall be capable of operation without fluid leakage.

2.5.1.2 Undercar Equipment

Undercar equipment containing liquids shall be designed for maximum protection and minimum spillage in the event of accidents.

2.5.2 Noise and Vibration

Vehicle noise and vibration characteristics shall comply with FRA regulation, APTA Standards and Recommended Practices and Specification requirements. Performance shall be tested as specified in Section 17.

2.5.2.1 Audible Noise

The noise environment created by the car shall be in compliance with the Specification, 40 CFR 201 and 49 CFR 210. Where conflict exists between the requirements of the Regulations and the Specification, the more restrictive shall apply.

2.5.2.2 Interior Noise Levels

2.5.2.2 (a) Cab

The noise level exposure in the cab during normal operation shall not exceed 74 dBA for 12 hours exposure per day. The absolute upper noise level limit, including operation of air horns, bell, or air brake exhaust, shall be 115 dBA per 49 CFR 229.121.

A stainless steel badge plate shall be permanently affixed to the rear of the Operator's cab wall, with stainless steel hardware, and shall contain wording stating the successful compliance with both the cab level noise requirements of 49 CFR 229.121, as well as the requirements of 49 CFR 210.29. A sample of the badge plate and its location shall be submitted for review and approval during the design review of the cab mock-up area. **[CDRL 2-002]**

2.5.2.2 (b) Passenger Area

When a completely assembled and operating car moving at any speed up to 80 mph on FRA Class 4 jointed track without special track work or level crossings and with wheel tread and railhead conditions in operational minimum condition with tangent, at-grade, ballast, and tie (either concrete or wood) track, with all auxiliaries operating simultaneously at normal conditions and with the vehicle operating in any specified mode of acceleration, deceleration, or coasting, the noise level in the cars' interior without passenger load, measured at all locations, shall not exceed:

Upper level	-	70 dBA
Lower Level	-	75 dBA
Door Vestibules	-	76 dBA
Intermediate level	-	74 dBA

Noise levels shall be measured at approved locations inside the car not less than 12 inches from the finished surface, except at door locations where measurement shall be taken not less than 24 inches from the finished surface of the door.

With the same car at rest immediately following the preceding test and with the lights, air conditioning, and ventilating equipment operating, the noise level in the car's interior measured at all locations shall not exceed 70 dBA. Measurements, methods, locations, and instrumentation used shall be the same as those used in the running test.

Noise produced by the operation of all side doors on one side of the car, with all auxiliary systems operating simultaneously under normal conditions, shall not exceed 78 dBA on the "Fast" scale when measured inside the car at least 2 feet from the door and/or side wall surfaces and 5 feet 3 inches above the floor.

2.5.2.3 Wayside Noise Levels

Car produced noise levels shall not exceed 75 dBA when measured at a distance of 15 feet from the track centerline on each side of the car at a height of 64 inches above top of rail with the car at rest and all auxiliary equipment operating simultaneously.

For pass-by noise levels, the cars shall comply with 40 CFR 201 and 49 CFR 210 for all operation conditions.

2.5.2.4 Vibration

Equipment and auxiliaries mounted anywhere on the car, carbody, or trucks shall not cause vertical or horizontal vibrations anywhere on the car floor, walls, ceiling panels, and seat frames in excess of 0.10 inch peak-to-peak amplitude between 0 and 1.4 Hz, and in excess of 0.01 g peak acceleration between 1.4 Hz and 14 Hz, and in excess of 0.045 inches per second peak vibration velocity for the frequency range above 14 Hz.

All vehicle equipment shall be designed to operate without damage or degradation of performance when subjected to vibration and shocks encountered during normal service at all speeds up to 10 percent above maximum Operating Speed. Carbody mounted components shall be designed to withstand continuous vibrations of not less than 0.2 g at frequencies up to 100 Hz and randomly oriented shock loads of 2 g. Tests shall be conducted in accordance with IEC 61373, 1999 Railway Application, Rolling Stock Equipment, Shock and Vibration Tests.

The car interior shall be free from excessive vibration while in motion at any speed. Visibly or audibly apparent vibration shall not be acceptable while the car is in motion.

2.5.2.5 Noise and Vibration Attenuation

The Contractor shall devote particular attention to the design of the car and its auxiliary equipment to obtain quiet operation and shall ensure that the noise and vibration criteria specified herein are not exceeded. Particular attention shall be given to the design of all equipment to ensure minimum generation of noise and vibration and to the attenuation of airborne and solid-borne noise and vibration along the path from source to passenger and Operator. Vibration isolators, enclosures or baffles, seals, acoustical absorption, mass, bracing, carbody panels with adequate sound transmission loss, or panels with adequate sound transition or other appropriate methods, shall be incorporated into the car design to adequately attenuate noise and vibration generated by wheels and rails, wind, motors, rotating equipment, and all other car elements and equipment to ensure that the limitations on interior noise and vibration are not exceeded.

Noise levels from equipment not specifically mentioned herein shall be controlled by the Contractor to ensure that the interior noise and vibration limits for the complete car are satisfied.

All equipment shall be designed to eliminate rattling and audible resonance at all speeds up to 10 percent above maximum Operating Speed by the use of gaskets, vibration dampers, resilient mounts, bracing, or similar methods.

Included in this requirement, but not limiting the generality thereof, are such components and accessories as: windows, lighting fixtures and covers, seats, safety bars, wiring, hand rails, piping, barriers, ducts, grab handles and stanchions, grilles, fire extinguishers, doors partitions, and body panels.

2.5.3 Ride Quality

Ride quality shall be evaluated according to ISO 2631-1:1997(E)/ ISO 2631-4:2001(E). The root mean square (rms) acceleration values for each measurement point shall not exceed 1.03 feet per second squared for operators, seated and standing passengers. Also, the vibration total value (root sum of squares summation) for each measurement point shall be calculated, and shall not exceed 1.64 feet per second squared. Where appropriate, frequency weighting W_b shall be used instead of W_k. Acceleration data shall be evaluated over the range of 0.5 Hz. to 80 Hz. Details of testing provided in Section 17.5.12.

2.5.4 Electromagnetic Compatibility

The Contractor shall comply with the requirements of and follow the guidelines provided in APTA SS-E-010-98 Standard for Development of an Electromagnetic Compatibility Plan. The Electromagnetic Compatibility Plan (EMCP) shall be identified in the Design Requirements and Traceability Report (refer to Section 1.9.4.2) and shall be submitted for design review. **[CDRL2-003]** Tests shall be performed in accordance with the requirements of Section 17.

2.6 SYSTEM PERFORMANCE

2.6.1 Multiple Unit (MU) Operation

Multiple Unit Operation shall be accommodated with locomotive Multiple Unit (MU) control, car control and communication (PA and Intercom), and 480 VAC three-phase power, including ground and control interlock circuits, by means of intercar trainline connections.

2.6.1.1 Electrical Trainline Connections

Electrical trainline connections for locomotive MU control shall be provided. Trainline connections for car control including train communication (PA and Intercom), and 480 VAC three-phase power, including ground and control interlock circuits, shall also be provided. Locomotive control, car control, as well as HEP trainline connectors mounted on each end of the vehicles shall be similar to connectors and configurations found on passenger locomotives and rolling stock operated by SCRRA. Details of SCRRA fleet trainlines are provided in Section 5 and Section 20. Final configuration of all trainline connections shall be approved by the Engineer. **[CDRL 2-004]** All external cables between locomotives and multi-level cars shall function without pinching or stretching and shall not part under all normal track and operating conditions. See Section 2.7.1 for curve negotiation requirements.

2.6.1.2 Push-Pull Operation

The vehicles shall be so designed that movements in either direction including "dead-in-train" movements shall cause no harmful effects within the specified maximum speed. The electrical and communications systems shall be trainlined to allow for control from either the locomotive or a cab car. The cars shall be configured for operation in any orientation with respect to other cars in the train (A-end to A-end, B-end to B-end, and A-end to B-end).

2.6.2 Interchangeability and Compatibility

2.6.2.1 Interchangeability

All apparatus supplied by the Contractor and sub-contractors for installation on the multi-level vehicles under this Contract shall be interchangeable among all other multi-level vehicles of this order. Replaceable components of any such apparatus shall be fully interchangeable, without adjustment to any part or system of the car. The Contractor shall identify any systems, subsystems, components, or parts that are not interchangeable. The reasons for any lack of interchangeability shall be submitted to the Engineer for review and approval. **[CDRL 2-005]**

2.6.2.2 Compatibility with Existing SCRRA Locomotives and Rolling Stock

The vehicles shall be compatible with existing SCRRA equipment, including locomotives and multi-level cars. Compatibility is defined for this purpose as the ability to couple cars mechanically, electrically, and pneumatically, and safely operate a mix of these cars in the same train consist in revenue service with corresponding functionality and performance. The Contractor shall provide a diagram showing the manner proposed to provide all car and locomotive control trainlines and functions. **[CDRL 2-006]**

2.6.2.3 Compatibility with Amtrak and California Locomotives and Rolling Stock

The vehicles shall be compatible with current Amtrak and California commuter equipment, including locomotives, multi-level and single level designs. Compatibility is defined in Section 2.6.2.2. Some functions, such as passages between vehicles and door control, may not be directly compatible with Amtrak cars and vehicles specifically purchased for other commuter operations. The Contractor shall provide a diagram showing the manner proposed to provide full car and locomotive control train lines and where conflicts or discontinuities may exist.

2.6.3 Maintainability

The Contractor shall perform a Maintainability Analysis for each system on the car and prepare a Maintainability Program for each car type. The analysis shall be the basis for development of maintenance tasks procedures, methods, and techniques. This analysis shall establish the maintenance concepts to be incorporated in the design, taking into consideration the requirements for safety, reliability, accessibility of apparatus, and the skills available for performing maintenance. Maintainability Analysis shall include all tasks required at each level of maintenance (daily, ninety two (92) days, one hundred eighty-four (184) days and annual), the task frequency, the time required, required labor resource, skill levels, and the necessary tools and support equipment. The Maintainability Analyses shall be a continuing effort during design and shall provide data for consideration in the review of the design of each system. The Maintainability Analyses and Maintainability Programs shall be presented during design reviews and kept current during design and manufacture of all cars. Additional details for Maintainability Analyses and Maintainability Program are provided in Section 16.3.

2.6.3.1 Vehicle and Components Design

Maintainability of the vehicle and its components shall be given prime consideration by the Contractor in the design and construction of the vehicle and its individual sub-systems.

2.6.3.2 Maintenance Period

No component of the vehicles shall require scheduled maintenance more frequently than every ninety two (92) days, normal inspection and servicing excluded.

2.6.3.3 Access and Replacement

Apparatus or components requiring frequent inspection or attention shall be readily accessible and replaceable. The Contractor shall ensure there shall be no sharp edges or corners where operation or maintenance personnel may sustain injury. High-voltage electrical power areas shall be suitably marked to warn personnel of danger. These safety requirements shall also apply to components supplied by sub-contractors.

2.6.4 Reliability

In general, reliability of the vehicles shall be attained by adherence to service-proven designs of equipment. In certain areas, the equipment presently used on SCRRA vehicles can be improved upon. Some of these areas are identified in this Specification. New equipment proposed for the vehicles shall attain equal or superior levels of reliability through the following criteria:

- Use of systems and components, the reliability of which has been proven in service equivalent to the service of these vehicles. Proof of service shall be provided.

- Use of the simplest possible equipment to attain the desired functions. Where a function requires highly complex equipment, the Contractor shall suggest alternative functions which require simpler equipment.
- System or component de-rating.
- Increased factors of safety.
- Selection of high-quality components.

Additional details regarding the reliability program, goals and demonstrations are provided in Section 16.2.

2.7 OPERATING ENVIRONMENT AND TRACK LIMITATIONS

The vehicles shall be designed and manufactured to operate successfully in SCRRA environment. All requirements identified herein shall be met.

2.7.1 Track Limitations

The vehicles shall be capable of operation at maximum allowable speed on trackage which meets the minimum requirements of the FRA Track Safety Standards (49 CFR 213) for all classes of track from Class 1 through Class 6. In addition, the vehicles shall comply with the requirements of 49 CFR 213.329 and shall undergo any required qualification testing detailed in 49 CFR 213.345. Vehicles shall be designed to operate over the following track conditions:

Track Gauge – nominal:	4' 8.5"
Maximum Track Gradient:	3.5% - ½ mile, 2.2% normal
Maximum Superelevation:	6"
Minimum horizontal curve radius at centerline of track with coupled cars:	250'
Minimum vertical curve radius:	2,000'
Crossovers:	
• #6 turnout:	13' 0" track centers
• #9 turnout:	12' 0" track centers
• #8 turnout at carwash:	13' 0" track centers

2.7.2 Clearances, Yard and Station Interfaces

The vehicles shall be capable of operation throughout SCRRA rail system without touching, damaging or disturbing any wayside object, device or structure.

The vehicle profile cross section shall not exceed the boundaries of SCRRA facilities and platforms, the Amtrak Clearance Diagram for Bi-Level Cars or California Public Utilities Commission (CPUC) G.O. 26D clearance diagram. Slight exceptions to the profile for cosmetic purposes may be allowed provided the vehicles remains capable of operating throughout SCRRA rail system as described above. Any exceptions to the profile will be subject to approval of the Engineer.

2.7.2.1 Vehicle Clearance Diagram

The Contractor shall provide, for review and approval by the Engineer, static and dynamic outlines of the proposed Vehicle to demonstrate compliance with the specified clearances. **[CDRL 2-007]**

Dynamic outline of the vehicle showing clearance diagrams shall reflect all undercar, side, or roof mounted equipment under conditions which consider the maximum truck lateral, vertical, and roll suspension limits and maximum wheel wear. The Contractor shall identify the set of conditions that result in the worst case of vehicle excursion.

2.7.2.2 SCRRA Central Maintenance Facility Interfaces

The vehicles shall be compatible with all existing SCRRA Central Maintenance Facility Interfaces. The vehicles shall not require any changes to the existing facilities for performance of maintenance, inspection, trouble-shooting and operating tasks.

2.7.2.3 SCRRA Platforms

The vehicles shall be capable of operating within the clearances of SCRRA system platforms.

2.7.2.4 Amtrak Clearance Diagram

The vehicles must be capable of operating within the clearances of the Amtrak Clearance Diagram for Bi-Level Cars. The clearance diagram is provided in Section 20 for reference.

2.7.2.5 CPUC G.O. 26D Clearance Diagram

The vehicles must be capable of operating within the clearances CPUC G.O. 26D.

2.7.3 Ambient Conditions

All equipment on the vehicles shall be designed for normal, safe operation at the most severe specified ambient conditions assuming maximum and minimum power supply tolerances. The ambient is defined as the temperature, humidity, and environment of the area around the

vehicles. Actual temperatures and conditions within the Vehicle body, or above or under it, may be more severe.
The design ambient conditions shall be as follows:

Temperatures:	Ambient temperatures from -10°F to 125°F
Relative Humidity:	5% to 100% non-condensing
Wind Velocity:	Sustained maximum 40 MPH with gusts to 80 MPH
Rainfall:	1 inch per hour, 4 inches per day maximum
Freezing rain/sleet:	0.50 inch per hour, 2 inches per day maximum
Snow:	2 inches per hour, 24 inches per day maximum
Maximum Altitude:	Full performance to 4500 Feet

These temperatures represent only ambient conditions. The effect of increased temperature due to solar radiation on the carbody and heat produced during operation of equipment under the environmental extremes specified above shall not result in degradation of equipment performance or reliability. Also, the effects of prolonged low temperature and wind shall not result in degradation of equipment performance reliability.
The equipment shall operate as specified in the atmosphere commonly found in and around the location of car control apparatus. The most common contaminants likely are silica, iron, carbon, petroleum vapor, water vapor, ozone, copper, oxides of nitrogen, hydrogen sulfide, sodium chloride, and commercial cleaning solutions.

Underfloor mounted equipment and enclosures shall be watertight even when subjected to wheel spray, car washing and hose cleaning, driving rain, and snow. Seals shall be service proven with respect to material and design with a service life of not less than ten (10) years. The enclosures shall have drain holes fitted with approved simple drain mechanisms for discharge of condensation and leakage due to damaged or deteriorated seals.

End of Section

Contract Deliverables Requirement List

CDRL No.	Title	Car Type	Reference Paragraph
2-001	Weight Control Plan	All	2.4.1
2-002	Sample Cab Sound Level Badge Plate and Location	All	2.5.2.2
2-003	Electromagnetic Compatibility Plan	All	2.5.4
2-004	Configuration of All Trainline Connections	All	2.6.1.1
2-005	Identification of All Non-interchangeable Systems, Subsystems, Components, and Parts	All	2.6.2.1
2-006	Diagram of Full Car and Locomotive Control Trainline Compatibility	All	2.6.2.2
2-007	Static and Dynamic Vehicle Clearance Diagrams	All	2.7.2.1

SECTION 3

CARBODY

SECTION 3

CARBODY

TABLE OF CONTENTS

SECTION 3

CARBODY

3.1 GENERAL REQUIREMENTS AND FEATURES

3.1.1 Arrangement

The carbody shall be designed to the normal and expected base set of requirements established by 49 CFR 238, APTA SS-C&S-034-99, Rev. 1, and this Specification. In addition, Crash Energy Management (CEM) features are required as an overlay on the base set of requirements. CEM requirements are in Section 3.10, and are based on the results of FRA research to date as described in the various FRA technical papers and presentations listed in the CEM Research Bibliography in Section 20.

Apparatus requiring frequent inspection or attention shall be readily accessible and replaceable, including any element of the CEM system that requires periodic inspection to confirm serviceable condition. Apparatus requiring attention more frequently than every one hundred eighty (180) days, or in emergencies, shall be accessible from the side of the car or from the inside of the car unless specifically approved by the Engineer. All other underfloor apparatus shall be arranged to provide ready access from maintenance pits and/or from the side of the car. Large apparatus shall be capable of ready replacement by forklift truck from the side of the car or by overhead crane through appropriately sized roof access panels. The frequency of required service shall govern the degree of accessibility. The general arrangement and location of apparatus shall be similar to the existing SCRRA fleet. Proposed locations shall be submitted to the Engineer for approval under the design review requirements of Section 19.4. The general arrangement of the subcomponents shall be approved by the Engineer during the mock-up and design review process.

All exterior fasteners exposed to passengers shall match the surface being joined and shall be installed such that the fastener is flush with the mating surface.

Apparatus supports and housings shall be incorporated into the underframe structure, equipment compartments, and equipment lockers so that the maximum usefulness of metal is obtained, and that the apparatus, as supplied by the manufacturers, may be mounted interchangeably.

All protective devices on the car that are not specifically required to be located inside the carbody, or to have provisions for resetting from within the carbody, shall be located undercar at the side or in the overhead equipment compartments or other equipment compartments approved by the Engineer. Provision shall be made for access to such devices without encroaching upon the clearance limit outline. For purposes of this paragraph, protective devices shall include air brake cut outs, circuit breakers, fuses, latching protective relays, and other devices requiring replacement or resetting to move the car or cause auxiliaries to function. All specified equipment on the car shall be arranged so that the proportion of the vehicle tare weight carried by each truck of the car shall be within 5 percent of each other. Similarly, the lateral imbalance shall not exceed 30,000 inch-pounds. Locations for all protective devices shall be identified on arrangement and installation design drawings and approved by the Engineer.

3.1.2 Physical Requirements

The carbody shall be designed and constructed in full compliance with the Technical Specification along with any and all applicable FRA Regulations, AAR Standards and APTA Standards and Recommended Practices, including but not limited to: 49 CFR 238 Passenger Equipment Safety Standards; APTA SS-C&S-034-99, Rev. 1 Standard for the Design and Construction of Passenger Railroad Rolling Stock; 49 CFR 223 Safety Glazing Standards – Passenger Cars; 49 CFR 239 Passenger Train Emergency Preparedness.

In addition, cab cars shall incorporate CEM as required by Section 3.10.

The carbody structure shall permit lifting or jacking of a car, with or without trucks attached, without damage to or deformation of the structure or equipment. Eyes for lifting of the car shall be provided at the top of the end door collision posts at each end of the car. Jack pads shall be provided on the side sill structure over the tracks. Lifting eyes and jack pads shall be arranged and designed as per Section 3.3.10. The lifting area shall have a suitable removable cover sealed to prevent ingress of water.

The carbody shall be designed to provide watertight performance without requiring topically applied sealant. Where sealant is used to enhance the watertight performance; it shall be applied in compression between assembled parts. Sealants shall have a service life of at least thirty (30) years.

The carbody structure shall provide for the mounting of all ancillary equipment; the applicable mounts and the applicable equipment shall be designed and constructed in accordance with requirements of the FRA regulations, and the APTA Standards (reference Section 5.7 of APTA SS-C&S-034-99, Rev. 1) that require equipment to withstand the forces caused by the accelerations shown below:

Vertical: 4G

Longitudinal: 8G

Lateral: 4G

Housings for externally mounted equipment shall be completely watertight- when covers are in place, excluding battery boxes, which are ventilated.

Drain holes shall be provided in underframe shear plates. All carbon steel surfaces of the underframe structure shall be shotblasted and thoroughly cleaned before priming, painting, and undercoating.

The vehicle shall be designed for at least, but not necessarily limited to, the worst loading case arising out of the possible simultaneous combinations of the following loads acting on the vehicle:

- Car tare weight
- Crush passenger load (AW3)
- Vertical, lateral and torsional dynamic load due to wheel/rail interaction

- Loads due to vehicle pitching caused by braking
- Snow or ice loads
- Aerodynamic load
- Side wind loads: Compressive and lateral loads caused by another train passing in the opposite direction on an adjacent track with relative speeds of 220 mph
- Buff load
- Standing on maximum super-elevation with full standing and seated load upstairs and other reasonable conditions from above to give the worst combination. (See Section 2.7)

3.2 MATERIALS

Materials used in carbody construction shall be in accordance with the provisions of APTA SS-C&S-034-99, Rev. 1 and requirements of Section 4 and Section 15 of this Specification. The carbody, except for the underframe, shall be constructed of stainless steel or aluminum. All welding shall conform to the requirements of Section 15.5.

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

All aluminum structural members shall be made of alloys 6061-T4 or T6 or 5083-H111. Gusset plates shall be made of alloys 6061-T6 or 5083-H321, H323, or H343. Side sheets and roof sheets shall be made of alloys 6061-T6, 5083-H321, H323, or H343, 5052-H32 or H34, 5086-H3. Alloys 3003-H14 or H16, Alclad 3003-H14 or H16, or Alclad 3004-H14 or H16 may also be used for roof sheets.

The structural use of any 2000 series and 7000 series aluminum alloys and of castings of any aluminum alloy is expressly prohibited. All surfaces of all aluminum portions of the carbody, except exterior surfaces, shall be cleaned and given one coat of zinc chromate primer with the process to be approved by the Engineer. Use of aluminum shall comply with all requirements of Section 15.9.

Where aluminum is in contact with other metals, the surfaces and joints shall be designed against corrosion in accordance with ALCOA Report 524, “Specifications Covering Use of Aluminum in Passenger Carrying Railway Vehicles.”

Low alloy, high tensile steel (LAHT) shall be used for the end underframe assembly, as described in Section 3.3.2.2. LAHT shall be used for the underframe of an aluminum body car. The use of LAHT steel shall comply with all requirements of Section 15.7. Dissimilar metals shall not be used at connections requiring disassembly for removal and replacement of equipment.

3.3 CARBODY STRUCTURE ARRANGEMENT AND DESIGN REQUIREMENTS

3.3.1 General

The car structure shall be designed as a modified girder, using the roof and the floors as the chord members, connected by the sides, which shall carry the shear. The car shall be designed and constructed so that, for the life of the car, the camber between bolsters will be positive, but not in excess of 0.50 inch under AW1 load, and shall not be less than zero under AW3 load. Reference Section 2.4.2 for definition of passenger loads.

Carbody camber shall be defined as its vertical curved shape as viewed in side elevation. Carbody camber shall be a smooth arc from end to end of the carbody, and shall be measured from a datum line drawn between the intersection of the arc with the centerline of the body bolsters to a line tangent to the arc midway between bolsters. The maximum difference between the cambers of each side sill, measured at the location of maximum deflection, shall not exceed 0.125 inch. Service proven designs without camber shall be permitted if operational data is provided demonstrating no operational issues with the door mechanisms and when approved by the Engineer.

A sufficient number of jigs, fixtures, and templates shall be used to assure interchangeability of components and uniformity of structure throughout the fleet. Such parts of the bodies as underframes, side frames, end frames, and roofs shall be built on jigs. All weld and bolt patterns shall be identical on all cars. All equipment hangers shall be interchangeable on all cars without the use of shims or elongated holes.

The design load requirements of this section shall be analyzed and included in the stress analysis as required by Section 3.4. The analyses submitted shall not be limited to only those where specific reference to the analysis is provided.

3.3.1.1 Structural Connections

All connections between structural members shall be capable of developing the full strength of the weaker member. The anchor rod bracket specified in Section 3.3.12 is a permitted deviation with approval of the Engineer.

Emergency load cases that result in permanent deformation shall be analyzed as specified in Section 3.3.1.6 and then re-analyzed with the load magnitude increased until calculations show that structural member crushing has commenced. It shall be shown that the connections of the primary structural members have not failed. The specified over-load conditions shall include the end sill, coupler, collision posts, corner posts, truck-to-carbody connection and bolster anchor bracket loads.

Rivets or bolts used in combination with welds in a structural connection shall not be considered as sharing the load with the welds. When used in a structural connection, welds shall be designed to carry the entire load across the connection as required by AWS D1.1.

All mechanically fastened connections shall be designed using a factor of safety of 1.5 based on the proof load of the fastener. Clamping force friction shall be ignored in the design and analysis of mechanically-fastened connections.

There shall be no attachment to the primary carbody structure by welding subsequent to completion of primary carbody structure manufacturing procedures. An exception shall be made for hangers resistance spot-welded for attachment to the web of a beam. Welding to the end of such hangers at a distance 0.8 inch or more from primary structure shall be permitted when approved by the Engineer.

Intermittent fillet welds on tension members shall be prohibited. Plug or slot welds on tension members and intermittent groove welds shall be prohibited. Stud welding to carbody structure shall not be permitted. Stud welding to non-load carrying stiffeners and secondary structure shall be permitted.

Self-tapping screws shall not be used. With the exception of attachment points for floor panels, interior panels, and trim, there shall be no tapped holes in the car structure. Structure with tapped holes shall meet the requirements for tapping plates.

Tapping plates may be used if approved by the Engineer, and, if used, shall be attached to the car structure with mechanical fasteners unless considerations of reduced material properties and stress concentrations have been considered in the original design and analysis. The tapping plate shall be equal to or greater in thickness than the diameter of the bolt for which the tapping plate is intended, and clearance hole shall be drilled in the structure for the bolt. Tapping plates shall be designed to the same strength standards as the equivalent nut.

Rivets, blind rivets, and lock-bolts shall be set with power tools. All holes for mechanical fasteners shall be clean and free of burrs. The Contractor shall devise a method for removing the burrs on the far (blind) side of a blind rivet hole and a method for its inspection. The method shall be submitted to the Engineer for approval.

3.3.1.2 Exposed Rivets and Lockbolts

Exposed exterior rivets or lockbolts shall have flush heads in dimpled or countersunk holes. The head of the fastener shall be flush on the outside surface unless otherwise approved by the Engineer.

The rivets or lockbolts shall be arranged in regularly spaced patterns. Rivets and lockbolts shall be stainless steel except where all the joint members are aluminum. Aluminum rivets or lockbolts shall be permitted when all the joint members are aluminum. Where used in contact with aluminum stainless steel rivets or lockbolts shall be coated with zinc chromate or approved equal before installation. Where possible, only the head and the shank of the rivet or bolt shall be in contact with the aluminum part when secured in place. Bushings providing protection in compliance with Sections 15.9.3 and 15.9.4 may be used in lieu of the zinc chromate paste. Structural calculations shall include the reduced cross section in areas that are drilled and countersunk.

3.3.1.3 Exposed Welds

Exposed exterior spot welds, located on unpainted surfaces on the sides and ends of the cars, and shall be arranged in regularly spaced patterns. All other exposed welds shall be sufficiently finished to be unnoticeable except by close visual inspection.

3.3.1.4 Floor Level

The difference in height of the four corners of the finished car shall not exceed 0.375 inch measured at the end sills, with the suspension air springs both inflated and deflated. The measurement shall be made on the completely assembled and equipped car mounted on its completed trucks. The measurement maybe made from any suitable structural member of the underframe.

3.3.1.5 Under Car Clearance

Except for the pilot which is addressed in Section 3.3.11, the minimum allowable clearance above the running rail for the carbody in the worst condition of fully worn wheels, solidly compressed, broken or deflated springs, maximum passenger load, carbody deflection below zero camber, etc., shall not be less than 4.5 inches.

3.3.1.6 Carbody Strength

The strength of the carbody shall equal or exceed the requirements of 49 CFR 238, Subpart C and the APTA Manual of Standards and Recommended Practices for Passenger Rail Equipment, Construction and Structural Standards & Recommended Practices. In addition, cab cars shall be designed with CEM features as specified herein and in Section 3.10.

In the selection of the type and thickness of material to be used, the Contractor shall be guided by the need to attain the maximum strength and reliability with the minimum weight obtainable at reasonable cost.

The framing and sheathing of the carbody shall form an integrated structure capable of resisting, without permanent deformation or fatigue failure, the buffing and other stresses inherent in the type of service for which the cars are intended.

The carbody strength shall be sufficient to permit operation with up to AW3 loading for the design life of the car thirty (30) years without structural damage, including fatigue cracks. The carbody shell shall meet the static and dynamic strength requirements stated in this section.

The carbody structure shall be designed to absorb the kinetic energy of the collision impact to minimize passenger accelerations.

The Contractor shall base its structural design on the specific loads, deflections, and properties of structural sections called for in this Specification. For structures not specifically covered by this Specification, the Contractor shall base its design on its experience, subject to successful stress analysis and structural testing, and the approval of the Engineer. The structure and equipment supplied shall resist the specified loads with load factors consistent with those that have been shown to be successful for railway passenger equipment.

The stress analysis shall show that in no case shall the stress be greater than the following with the appropriate load factors applied:

Structural Element and Design Condition	Load Factor
a) Post Chord Stresses:	
1. Allowable fatigue stress range at the appropriate vertical load variation with seated passenger load (Notes i and iv)	1.5
2. Ultimate load carrying capacity of the members stress (Note v)	
• Symmetrical jacking at jack pads and also at coupler carriers (Note ii)	2.0
• Asymmetrical jacking (Note iii)	1.5
b) Allowable shear panel stresses shall be the ultimate load carrying capacity of the members (Note v)	
1. Normal maximum vertical carbody loading (Note i)	2.0
2. Symmetrical jacking at jack pads and at coupler carriers (Note ii)	1.5
3. Asymmetrical jacking (Note iii)	1.0

Notes:

i. At 10,000,000 cycles for ferrous materials and aluminum alloys.

ii. All jacking conditions shall be based on an empty carbody with trucks attached.

iii. Asymmetrical jacking conditions shall be based on the most outboard diagonally opposite jack pads with trucks attached.

iv. Allowable fatigue stress of welded elements shall be determined from AWS D1.1, for steel and AWS D1.2, for aluminum. Where insufficient information is available due to the lack of published data on this subject, the allowable fatigue stress shall be determined experimentally through testing by the Contractor.

v. Stability calculations of stainless steel elements shall include consideration of the effects of the anisotropic behavior of stainless steel, and of reductions in elastic moduli with increasing stress. Calculations shall follow the methods described in Lincoln and Watter's Strength of Stainless Steel Structural Members as Function of Design, or the AISI Stainless Steel Cold Formed Structural Design Manual, or the ASCE Specification for the Design of Cold-Formed Stainless Steel Structural Members (with safety factors modified as noted above), or another method acceptable to the Engineer.

The completely equipped carbody shall be designed to carry its AW0 carbody weight (not including truck weight) plus a uniformly distributed passenger load equal to the passenger portion of AW3. The stresses in the carbody, under an applied AW3 load less the truck weight load, shall not exceed the lesser of 50 percent of the guaranteed minimum material yield strength, or the buckling strength.

Notwithstanding the previous paragraph, for each joint design, the static stress at the AW3 carbody load shall be less than the stress that determines the allowable fatigue stress range.

The allowable fatigue stress range shall be computed by multiplying the static stress at the AW3 load by the dynamic factor (fatigue load range). This stress range shall be within the design fatigue stress range (fatigue limit) obtained from AAR C-II, Section 7.2, or AWS D1.1, and as approved by the Engineer.

The Contractor shall conduct fatigue tests to determine allowable fatigue stresses for joint designs not covered by AAR C-II, Section 7.2, or AWS D1.1.

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

The natural frequency of the carbody under AW3 load, and rigidly supported at the bolsters, shall be no less than 2.5 times the natural frequency of the car's secondary suspension system. An analysis of the natural frequency of the car shall be submitted as part of the Structural Analyses (Section 3.4).

3.3.2 Underframe Structure

3.3.2.1 Underframe

The underframe assembly shall be composed of the center sill (if used), end underframes, floor beams, subfloor, cross bearers, and body sills. All parts of the underframe shall be constructed of stainless steel or low alloy high tensile steel except the end underframes that, in all cases, shall be constructed of low alloy high tensile steel.

The side sill may be of aluminum on cars of aluminum body construction. The Contractor shall consider the effect of the reduced properties relative to steel of aluminum in the fire and compression tests.

Alterations to the underframe such as drilling, cutting, welding, heating, burning, etc. during fabrication assembly not previously incorporated on the drawings is expressly forbidden without the written approval of the Engineer.

The cab car carbody shall meet the standard for carbody end compressive strength of APTA SS-C&S-034-99, Rev. 1 as it applies to designs with CEM, except that the minimum end strength on the line of draft shall be 800,000 pounds. End compressive strength of trailer car carbody structure shall be in accordance with section 5.1.1 of APTA SS-C&S-034-99, Rev. 1.
Under an end compression load equal to 800,000 pounds applied longitudinally to the line of draft of a carbody loaded to AW0, the following criteria shall be met:

1. There shall be no permanent deformation in any structural member, including CEM elements, sheathing, the anti-climber, and its fasteners.

2. The maximum stress in any material shall not exceed the lesser of the yield or critical buckling stress.

3. The vertical deflection of each side of the carbody with respect to the body bolsters shall not differ from the analytically determined value by more than 10 percent. The points to be measured shall be at the outer-bottom edge of the side sill.

3.3.2.2 End Underframe

An end underframe unit, including but not limited to the body bolster, draft sill, end sill, draft gear pocket, coupler support structure, and collision post stubs shall be provided at each end of each car and shall be fabricated of low alloy high tensile steel conforming to the requirements of Section 15.7.

The end-underframe assembly shall be heat treated after welding if required for stress relief or to attain the required strength level.

Drainage, as approved by the Engineer, shall be provided for all cavities to preclude the retention of water. All cavities shall be painted after welding and/or heat treating.

The end underframe weldment shall provide for continuity of flanges and webs at any place where load-bearing members intersect. The end underframes shall be designed so that, in case of excessive impact, failure shall be by buckling or crushing of structural elements rather than by shearing of structural elements or by failure of connections between elements.

The end underframe shall be constructed of LAHT, assembled by arc welding in accordance with Section 15.5 and AWS D1.1, using AWS pre-qualified complete-joint penetration groove welded joints as defined by AWS D1.1, wherever primary loads are carried across the joint in tension or compression. AWS pre-qualified partial joint penetration groove welded joints may be used, when approved by the Engineer, where primary loads are carried in shear along the length of the weld. Fillet welds may be used in joints which do not carry primary loads.

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

In order to avoid difficulties in attaching the light-gauge floor pans to heavy underframe members, brackets or clips may be provided on the underframe for subsequent attachment of floor pans.

3.3.2.2 (a) End Sill

The end sill shall include the buffer beams, the anti-climbing arrangement, and the collision post stubs and shall be securely attached to the collision posts, side sills, and the draft sill. The collision post stubs shall extend down to the bottom plate of the end sill and shall be securely welded to both the top and the bottom plates.

The end sill shall be designed to transmit the required anti-climber, end sill, and coupler loadings into the collision posts and draft sill without exceeding the yield strength of the end sill structure. It shall also be capable of transmitting into the draft sill without failure of the end sill structure, the loading and bending moments which can be applied by the collision posts when they are loaded at 18 inches above the floor to their ultimate bending strength, and when they are loaded just above the floor to the ultimate shear capacity of the collision post/stub post combination.

The coupler, support structure, buffer beam above the coupler, and its attachment of the end underframe shall withstand a 100,000 pound vertical load in either direction for any horizontal position of the coupler, without permanent deformation of the coupler and support structure and supporting structure in the end underframe, or otherwise without ultimate failure.

3.3.2.2 (b) Anti-climbing Mechanism

The carbody design shall provide an anti-climbing arrangement at each end of each car designed in accordance with 49 CFR 238.205 and Section 5.5 of APTA SS-C&S-034-99, Rev. 1.

An analysis of the anti-climbing arrangement(s) shall be included in the stress analysis required by Section 3.4. The analysis of the anti-climbing mechanism shall include an analysis of the attachment of the coupler/draft gear and draft gear carrier plate to the underframe.

3.3.2.2 (c) Coupler Carrier

A coupler carrier shall be provided as part of each end underframe assembly, and shall be designed in accordance with the requirements of 49 CFR 238.207. In addition, the coupler carrier, and those portions of the carbody to which it is attached, shall be designed to withstand the loads caused by supporting one end of the car on the coupler carrier, with the truck attached, such as might occur during emergency jacking or lifting with a crane in the event of a derailment. Under this coupler carrier load, the allowable design stress of the coupler carrier, or any part of the carbody structure to which it is attached, shall be the yield, the critical buckling stress, or 80 percent of ultimate whichever is lower.

The coupler carrier element on which the coupler shank slides shall have a 0.25 inch thick wear plate of manganese steel welded to the surface upon which the coupler shank rests. This part and its supporting springs shall be interchangeable among cars.

Provision shall be made for safely lifting the extreme ends of the cars with a crane in the event of a derailment. The carbody structure shall be designed to permit lifting both ends of an empty car simultaneously with trucks attached, without damage or yielding on any part of the car. The Contractor shall demonstrate this, the lifting procedure, during the inspection of the first car of each type. The procedure and design shall be submitted to the Engineer during the design review of the car for his approval. Four (4) car sets of eyebolts and fitting hardware shall be provided as part of the Contract. **[CDRL 3-001]**

3.3.2.2 (d) Collision Post Shear Reinforcement

If reinforcement is used to provide the specified collision post shear strength at the floor, it shall be designed to transmit the specified shear and other loads into the end underframe. The cab end reinforcement shall be continuous from the bottom of the end sill up to at least 30 inches above the top of the underframe, then gradually taper to a point not less than 42 inches above the top of the end sill. The non-cab end reinforcement shall be continuous from the bottom of the end sill up to at least 18 inches and then taper to a point at 30 inches.

If shear reinforcement is not used, the post shall be arranged to penetrate the end underframe unit and weld to the top and bottom plates of the end underframe unit.

The connections and supporting structure at the tops of the collision posts shall be designed to develop sufficient horizontal, vertical, and bending strength, so that if one or both posts, whichever is more critical, is overloaded in bending to ultimate strength, the post top connections and supporting structure, if stressed beyond their yield strengths by the resulting horizontal, vertical, and bending loadings, shall deform plastically by buckling and bending of the members to accommodate the post plastic bending failure. The ultimate strength of the connection fasteners and welds shall be sufficient to prevent their failure, even with severe plastic deformation of the collision posts and of the top connecting and supporting structural elements.

Overload of collision post bottom connections shall result in buckling and crushing of the underframe structural members to which the collision posts and any collision post reinforcements are attached, rather than by shearing or fracturing of the posts.

3.3.2.2 (e) Body Bolster

The body bolster shall be designed to transmit loads between the truck and the carbody, and between the draft sill and the body and side sills. The design shall provide clearance for the truck in all positions and accessibility for truck maintenance and de-trucking. Positive stops shall be provided on the carbody and truck bolsters to limit the vertical and transverse movement of suspended trucks when the carbody is lifted. The stops shall meet the recommended practice of APTA SS-C&S-008, Section 5.0.

The design and construction of the bolster shall consider the high fatigue environment in which it will be operating. Fatigue-resistant design shall be a prime requirement of the body bolster structure. Welding shall be as per AWS D1.1.

3.3.2.2 (f) Draft Sill

The draft sill shall extend longitudinally from the end sill to the body bolster and shall include the coupler support structure. It shall be designed to transmit the specified longitudinal loadings from the anti-climber and coupler into the body bolster. The draft sill shall be compatible with the CEM design.

3.3.2.3 Corner Post

A structural post shall be installed at each corner of the car. The corner posts shall meet the requirements of APTA SS-C&S-034-99, Rev. 1 and 49 CFR 238.213. The posts shall be continuous from the bottom plate of the end sill to the roof. The posts shall be connected to the top and bottom plate of the end sill, side frame, roof structure, and intervening structural shelves. The attachment of each corner post at the bottom shall be sufficient to develop its full shear value. If reinforcement is used to provide the shear value, such reinforcement shall have full value from the bottom of the end sill, for the cab end corner posts to 30 inches above the top of the end sill, then taper to a point not less than 42 inches above the top of the end sill connection. For the non-cab end corner posts, the reinforcement shall have full value from bottom of end sill to 18 inches above the top of the end sill, then taper to a point not less than 30 inches above the top of the end sill connection. Overloading of the corner posts at the level of the top of the end sill shall result in the buckling and crushing of underframe members to which the posts are connected rather than the shearing-off of the posts themselves.

The corner post shall be connected to the side frame, end frame, and roof structures such that the yield strength of the connections and the supporting structure will not be exceeded when the corner posts are loaded to their yield strengths, as described above. In addition, the roof and roof connections shall resist, without failure, the top load of the corner post, when the corner post load is increased to the ultimate bending strength of the post.

The corner posts shall be continuous closed sections from the bottom of the end sill to the roof unless shear reinforcement is used. If shear reinforcements are used, the corner posts shall be welded to the shear reinforcement at the floor, to the intermediate side frame rails and sheathing, and to the roof rails to develop the full strength of the posts.

3.3.2.3 (a) Corner Post Load 18 Inches Above Floor

Each cab end corner post shall resist, without yielding or exceeding the critical buckling stress, an inward load of 100,000 pounds applied in any direction from longitudinal to transverse, at the level 18 inches above the end sill connection. Each non-cab end corner post shall resist a load of 30,000 pounds applied in the same manner. The connections of the posts to the supporting structure, and the supporting structure itself, shall develop the ultimate load carrying capacity of the posts. If the posts are designed to support more than the specified capacity, the supporting structure shall be strong enough to support the increased capacity of the posts; the posts shall fail before the supporting structure.

3.3.2.3 (b) Corner Post Shear Load at Floor

Each cab end corner post shall have an ultimate shear value of not less than 300,000 pounds at a point even with the top of the end sill to which it is attached. The load application shall be inward in any direction from longitudinal to transverse in a horizontal plane. Each non-cab end corner post shall have an ultimate shear value of not less than 150,000 pounds applied in the same manner. The shear value shall be based on the depth of the web in the direction of the applied load, which is the depth of the member times the web thickness. In cases where the load application is not in the direction of the web, the load shall be divided into vector components parallel to web elements, and the shear value calculated for each element.

3.3.2.3 (c) Corner Post Strength along its Length

The load carrying capacity of the corner post, when loaded any where from the top of the underframe to the roof in a horizontal plane any direction from longitudinal to transverse, shall be a minimum of 45,000 pounds for cab-end corner posts and 20,000 pounds for non-cab end corner posts, with no permanent deformation in the carbody.

3.3.2.3 (d) Corner Post Strength at the Point of Attachment

The load carrying capacity of the corner post, when loaded at the point of attachment to the roof shall be a minimum of 45,000 pounds for cab-end corner posts applied longitudinally and 30,000 pounds for non-cab end corner posts applied in any direction from longitudinal to transverse, with no permanent deformation in the carbody.

3.3.2.3 (e) Corner Post Energy Absorption at 30 Inches Above Floor

Each corner post on the cab end of a flat end cab car shall be capable of absorbing a minimum of 120,000 foot-pounds of energy when loaded longitudinally at a height of 30 inches above the top of the underframe. At the moment that the corner post has absorbed this minimum energy:

- The post shall not permanently deflect more than 10 inches into the operator’s cab or passenger seating area and,
- There shall be no complete separation of the post, its connection to the underframe, or its connection to either the roof structure or A-T Plate (if used).

Cab end corner posts and supporting structure on non-flat end cab car designs shall either meet the severe deformation requirements defined above or meet the deflection criteria above and meet an equivalent energy absorption requirement as submitted for review and approval by the Engineer.

3.3.2.4 Side Sills and Body Sills

Side sills, extending between car ends, shall be provided on both sides of the car. They shall be fastened to:

- Floor Beams,
- Cross Bearers,
- Carbody Bolsters,
- End Sills,
- Sub-Floor Panels (underframe shear panels),
- Transition Members.

Side sills shall have a fine grit scratch finish with grain horizontal. The side sills shall form a structurally continuous bottom chord for the side frame. The side sills shall be designed to resist the combined vertical and longitudinal loads resulting from the specified design loads. Longitudinal or body sills, located inboard of the side sills, may be used, if necessary, to carry longitudinal loads through the underframe. For trailer cars, and to the extent possible for cab cars without conflicting with CEM design requirements, the side and body sills shall be designed so that any failure of the carbody will begin in the draft sill outboard of the coupler support structures rather than in the region between the coupler support structures when longitudinal loadings exceed the specified values.

Center sills, if used, shall be of one piece members extending between body bolsters. If provided, the center sill shall be welded to transverse floor members and bolsters and shall be braced by cross-bearers. The center sill and body bolster shall provide for continuity of flanges and webs where the members intersect.

3.3.2.5 Cross Bearers and Floor Beams

Cross bearers shall be provided to transfer the applied vertical loading from the center sill (if used) to the side framing. Floor beams shall be provided to transfer the vertical floor loads to the side sill, center sill if used, and side framing. The cross bearers and floor beams shall be fastened to the center sill, if used, so that they stabilize the center sill against column failure, both vertically and laterally.

The spacing and sizing of the floor beams shall limit floor panel (described in Section 4.3) deflection to a maximum of 0.0625 inches under an evenly distributed vertical crush load.

With the vehicle floor loaded to simulate a uniformly distributed AW3 passenger load plus loads of all interior equipment, such as seats, interior liners, and equipment boxes, the floor beams shall not deflect more than 1/250 of the span between supports, up to a maximum of 0.0625 inches, and the maximum stress in the floor beams shall be less than the critical buckling stress or 50 percent of the yield strength of the material, whichever is less.

3.3.2.6 Sub-Floor, Intermediate, and Lower Levels

A stainless steel sub-floor shall be provided throughout the length and width of the car. At the intermediate level, the sub-floor and its attachments to adjacent structural members shall be capable of resisting the shear resulting from the specified compression loading without permanent deformation. The sub-floor pans shall be securely fastened to the bottom flanges of the floor beams and to the center sill, if used, draft sills, and side sills. The sub-floor shall be sealed, in a manner approved by the Engineer, to close off air leaks for car pressurization. Between the carbody bolsters, the sub-floor shall be attached to the above mentioned members in a manner to allow for easy replacement of damaged panels and yet provide the attachment and sealing required to meet the structural, car pressurization, and fire safety requirements.

The sub-floor pan shall contain the underfloor thermal and acoustic insulation. The pans shall be suitably stiffened to prevent resonant noise and vibration and “oil canning” under any operating condition.

If the floor pans are separate sheets, they shall be securely fastened to the car structure. A weather-proofing sealant shall be applied to the edges of the sheets immediately before installation. The fastening and sealing system shall prevent moisture, dirt, dust, and debris entry into the sub-floor for the life of the vehicle and shall be approved by the Engineer.

Approved equal sub-floor construction that meets all other specification requirements may be used subject to approval by the Engineer.

3.3.2.7 Upper Level Floor

The upper level floor shall be supported by a suitable system of longitudinal and cross members. The allowable deflection of the upper level floor under its dead weight plus the maximum passenger load including seats and work tables shall not exceed 0.0625 inch. Additional support for the upper level floor system shall be provided by the permanent partitions available in the lower level floor area. The stresses in any member of the upper level floor, or its support structure under maximum passenger loading (AW3) shall not exceed half the yield strength of the material.

All members of the upper level floor shall permit the fastening of equipment and the installation of the air conditioning system, wiring, lighting fixtures, and other equipment for the lower level ceiling appurtenances in a secure manner. The framing shall be arranged so that lower level equipment can be replaced and maintained through removable panels without disturbing carbody structural members. Ducting for circulation of conditioned air for the lower level shall be fastened to the upper level floor framing arrangement, consistent with the air distribution requirements of the HVAC system. Clip nuts shall not be used.

3.3.3 Roof

The car roof framing shall consist of carlines (transverse) and purlins (longitudinal), all suitably fastened to the side and end framing to provide a strong, rigid, integrated structure adequate for the service intended and the requirements of this Specification. The roof shall meet 49 CFR 238.215, APTA RP-C&S-001-98 and APTA SS-C&S-034-99, Rev.1. All members of the roof framing shall be designed and arranged to permit the installation and fastening of the air conditioning system, roof wiring, lighting fixtures, equipment, ventilation ducts, and other required apparatus in a secure manner. The roof framing shall be arranged to allow the replacement and maintenance of overhead mounted equipment through removable interior ceiling panels without disturbing the carbody structural members. Ducting for the circulation of conditioned air shall be coordinated with the roof framing arrangement and configured to be consistent with the air distribution requirements of the heating and air conditioning systems described in Section 8. The roof shall be properly reinforced and braced with the structural members to carry the weight, stress, and vibration due to roof mounted apparatus.

Roof framing shall permit the degree of interchangeability of equipment specified in Section 2.6.2. The roof shall be framed and reinforced around openings. All reinforcement shall be welded stainless steel or aluminum as appropriate. Reinforcements on the roof shall be made watertight by welding or soldering. No through-roof mechanical fastening is permitted. The roof sheathing and structure shall be designed to support the specified roof loads. Both ends of the roof shall be designed to support the tops of collision posts and distribute the specified collision and corner post loads.

All parts of the roof structure, sheets, equipment covers, roof walkway, screens, and other guards shall have sufficient strength to withstand, without exceeding the yield strength, 80 percent of ultimate strength and critical buckling stress under any of the following conditions: a) the loads imposed by a mechanical car washer consisting of a pressure of 60 pounds per square foot over a 12 inch wide band extending transversely across the carbody, b) concentrated loads of 250 pounds applied anywhere over a 3 inch square, spaced 30 inches apart, and c) uniform load of 15 pounds per square foot. Roof sheets may be corrugated in the area above the sight line on a smooth sided car. The roof shall also support without yielding the loads imposed by normal operating conditions, including loads imposed by roof-mounted equipment, passenger-seat support stanchions and handholds, and specified collision and jacking loads.

Antiskid treatment shall be applied from one end to the other of the roof walkway.

Equipment mounted under the roof suspended from the roof structure shall be bolted to the framing members. The framing members shall be reinforced in subassembly to accept the equipment load.

The design loads for equipment and apparatus attached or mounted to the roof, including gutters, air scoops, antennae, lights, equipment supports and supporting roof framing shall be 8 g longitudinal, 4 g vertical and 4 g lateral. Such loading may develop the ultimate load carrying capacity of the member being investigated.

Deflecting plates shall be installed at the ends of the roof to prevent water from cascading between cars. The design arrangement and installation of roof equipment shall not permit accumulation of water. Drainage provisions shall be subject to approval by the Engineer.

Approved equal designs that meet the Specification requirements shall require approval of the Engineer.

3.3.4 Side Structure

Side frames shall consist of vertical members such as window posts and door posts, and longitudinal members such as roof rails, side sills, window top rails, and belt rails. It shall include sheathing and internal skin stiffening members. Structural posts shall be located at the sides of door and window openings and elsewhere as required to limit deflection and fatigue stresses. Structural posts shall be continuous between side sill and roof rail if the upper level floor support side rail is not designed to be a primary load carrying member. If the upper level floor support side rail is designed to be a primary load carrying member, the side posts shall be continuous from the lower side sill to the upper side sill and continuous from the upper side sill to the roof rail. At the upper side sill, gussets shall be used to reinforce connections to effectively make the posts continuous between the lower side sill and the roof rail. Where longitudinal rails are interrupted by posts, gussets shall be used to reinforce connections to effectively make the rails continuous. All gussets shall be full height. The side frame posts or stub posts (between side sills and belt rails) shall transmit applied vertical loadings from the body bolster ends, cross bearer ends, and jack pads into the side frame sheathing. The belt rail (the horizontal rail member at the bottom of the window openings in the side frame) and its supports shall be designed to resist the specified side load in accordance with APTA SS-C&S-034, Rev. 1 and shall comply with the requirements of 49 CFR 238.217. All posts shall be formed sections.

Intermediate structural elements between the side frames shall transfer all seat and floor loads to the side-frame posts. Passenger seats shall be supported by continuous structural members fastened to the side-frame posts. The carbody side and side-frame posts shall be capable of supporting AW1 loads with a minimum safety factor of 2.0, based on yield strength, without permanent deformation, at a deflection not to exceed 0.125 inches. The side frame shall conform to APTA SS-C&S-034, Rev. 1 and 49 CFR 238.217.

3.3.4.1 Side Impact

The carbody structure shall be designed to resist an inward transverse load of 40,000 pounds applied anywhere along the side sill, and 7,000 pounds applied anywhere along the belt rail. These loads shall be applied separately over the full height of the member for a distance of 8 feet along its length. The allowable stress shall be the lesser of yield or the critical buckling stress except that, for the purposes of the calculation of stress to show compliance with this requirement, local yielding of the side skin adjacent to the side sill and belt rail shall be allowed.

Approved equal designs that meet the Specification requirements shall require approval of the Engineer.

3.3.4.2 Roll Over

Car body structures shall be designed to rest on their sides, uniformly supported by the roof rail at the top of the side frame, by the side sill at the bottom of the side frame, and the longitudinal member at the edges of intermediate floors in compliance with requirements of APTA SS-C&S-034-99, Rev. 1 and 49 CFR 238.215. The allowable stress in the structural members of the occupied volumes for this condition shall be the lesser of one-half yield and one-half the critical buckling stress. Local yielding to the outer skin of the passenger car is allowed provided that the resulting deformations in no way intrude into the occupied volume of the car.

Each passenger car shall also be designed to rest on its roof so that any damage in occupied areas is limited to roof sheathing and framing. Other than roof sheathing and framing, the allowable stress in the structural members of the occupied volumes for this condition shall be the lesser of one-half yield or one-half the critical buckling stress. Deformation to the roof sheathing and framing is allowed to the extent necessary to permit the vehicle to be supported directly on the top chords of the side frames and end frames.

3.3.5 Side Sheets

Smooth metal side sheets shall be structurally fastened to the outside of the side frame posts. Smooth side sheets may be stiffened by corrugations or similar sections fastened to the side sheet hidden face or as approved by the Engineer. All the exterior surfaces of the carbody shall be stainless steel or aluminum. Samples of the exterior finish specifying the direction of the grain and the flatness shall be submitted to the Engineer for review and approval. **[CDRL 3-002]** Dents, gashes, or other surface imperfections shall not be permitted. The side sheets shall comply with the requirements of APTA SS-C&S-034-99, Rev.1 and 49 CFR 238.217 (b).

Side sheathing shall be resistance spot welded to the outside of the side frame posts between the side sill and the roof. Side sheets may be stiffened by corrugations or similar sections resistance welded to the inside face of the side sheet. For an aluminum carbody, GTAW or GMAW slot welds may be used instead of the afore mentioned resistance spot welds. Weld spacing shall be in accordance to Section 15.5.9. Flat side sheathing shall be a minimum of 0.059 inch thick. Sheets under the windows, if corrugated, shall be of 0.042 inch thickness.

Horizontal lap joints shall be permitted where flat side sheets are connected to corrugated side sheets provided the direction of the joint sheds water and the joint is seam welded. The Contractor shall propose passenger entry doorway rain gutters for review and approval by the Engineer. **[CDRL 3-003]**

Weather strips shall be applied at door openings and seal the doors as per Section 4.9. Approved equal designs that meet the Specification requirements shall require approval of the Engineer.

All exterior surfaces shall be free of ripples and buckling. The maximum acceptable variation from a flat plane shall be as follows:

1. All exterior surfaces except the non-operating end frame.
   a. The side shall be as smooth as possible on the outside with a maximum acceptable variation from a straight line on flat surfaces of 0.125 inch (peak to valley) in 3 feet measured in any direction;
   b. Areas within 8 inches of the side doors and car ends may have a gradual slope (less than 0.188 inch over 8 inches) towards the doors and ends with a maximum deviation of 0.188 inch (peak to valley) from the side sheet contour;
   c. The ends of corrugations shall be permanently sealed against air and water by capping or controlled crushing. Samples of the method must be submitted for approval at the design review and maintained per Section 3.4.
2. Non-operating end frame exterior surface.

   Sheets shall be smooth and flat such that waves and ripples shall not exceed 0.313 inch (peak to valley) in 3 feet measured in any direction.

The required appearance of exposed welds shall be as described in Section 15. Three (3) samples of all exterior finishes shall be submitted to the Engineer for approval; this includes samples of 2B (bright cold rolled) and scratch finishes and samples of all exposed resistance welding conditions illustrating the various metal build ups and configurations. **[CDRL 3-004]** If proposed, samples of exposed butt joints and finished arc welds shall be included. These samples shall be used throughout the program to maintain quality.

3.3.6 End Frame

The car end frames shall consist of two (2) corner posts, one (1) each at the juncture of the front end and side frames, two (2) collision posts located at the approximate third points of the end frame width, but in any case not more than 40 inches apart, an end door, a structural shelf, framing posts, and sheet metal sheathing connected to the structural framing members as necessary. It shall be designed to resist the specified vertical, transverse, and torsional loads as required by APTA SS-C&S-034-99, Rev. 1. The door posts and header shall be designed to carry the end door while maintaining weather tightness.

For the cab car, in addition to requirements in the following sections, the cab end frame collision and corner post design shall be in accordance with the proposed requirements in the related sections of revision of APTA SS-C&S-034-99, Rev. 1, currently being distributed to the PRESS Task Force for review. The proposed requirements, among other things, include new details regarding permanent deformation and energy absorption for the elastic-plastic load cases.

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

A diaphragm shall be provided at the end of all cars in accordance with Section 3.8.

3.3.6.1 Collision Posts

Collision posts shall meet the requirements of APTA SS-C&S-034-99, Rev. 1 and 49 CFR 238.211. The car end structures shall be provided with vertical collision posts at both sides of the end openings, fastened securely into the roof structure at the top and welded to the top and bottom plates of the end underframe. The collision posts shall be constructed of stainless steel or LAHT.

The collision posts shall be continuous closed sections from the bottom of the end sill to the top of the roof unless shear reinforcement is used. If shear reinforcement (stub posts) are used, the posts shall be welded to the shear reinforcement at the floor, to stub posts, and to the roof to develop the full strength of the posts. The cab car F-end carbody doors shall be mounted on the collision posts.

The cab end collision post and the non-cab end collision post shall meet all applicable requirements as specified in Section 3.3.1 and in APTA SS-C&S-034-99, Rev. 1, if shear reinforcement (stub posts) are used. Reinforcement to provide the specified shear strength shall meet all applicable requirements of the APTA and FRA and as specified in Section 3.3.1.

The connections and supporting structure at the tops of the collision posts shall be designed to develop the necessary level of horizontal, vertical, and bending strength to ensure that if either one or both collision posts, whichever is more critical, is overloaded in bending to its ultimate strength, the post top connections and supporting structure shall deform plastically by buckling and bending of the members to accommodate the collision post plastic bending failure. The ultimate shear and tensile strength of the connection fasteners and welds shall exceed that required by this deformation, to ensure that failure of the fasteners and welds shall not occur, even with severe plastic deformation of the collision posts and of the top connecting and supporting structural elements.

Overloading of the collision post bottom connections shall result in buckling and crushing of the underframe structural members to which the collision posts and collision post reinforcements are attached rather than shearing or fracturing of the posts.

For the stress analysis for bending in the plastic range of the material, the reduction in modulus of elasticity and its effect on the stability of the post compression flange shall be considered and included in the strength calculations. The calculation method outlined in the AAR Manual of Standards and Recommended Practices, Section C, Part II, Paragraph 4.2.2.16, or another method approved by the Engineer shall be used. The calculations shall be based on extended stress strain curves determined experimentally by the Contractor if these data are not otherwise available, at the midpoint of the shelf, assuming the shelf to be a beam simply supported at its ends. The shelf may be integrated with the control console on the cab side.

Lifting eyes, as per Section 3.3.10, shall be installed at the extreme top edge of each collision post. It shall be possible to lift the car at AW0 load with an overhead crane or boom at only one end with trucks attached and supported by the opposite end truck, without exceeding 50 percent of the yield strength of the material.

Preliminary layout drawings and supporting calculations of the cab end frame members shall be submitted for approval before the end frame design is finalized. The drawings shall be clearly marked to indicate conformity to the requirements of this Section.

The stress analysis required by Section 3.4 shall include an analysis of the collision posts and corner posts together with their connections and supporting structure.

3.3.6.1 (a) Collision Post Load 18 Inches and 30 Inches Above Floor

The load carrying capacity of each cab end collision post when loaded in a horizontal plane, +/- 15 degrees of the longitudinal axis of the vehicle, shall be a minimum of 200,000 pounds at a point 30 inches above the top of the underframe, without exceeding the ultimate strength of the material. Each non-cab end collision post shall resist, without exceeding the ultimate strength of the carbody, a horizontal load of 300,000 pounds, applied anywhere between floor and a point on the collision post 18 inches above the top of the underframe, and in any direction within 15 degrees of the longitudinal axis of the car.

3.3.6.1 (b) Collision Post Shear Load at Floor

The ultimate horizontal shear strength of the cab end collision stub post shall be 500,000 pounds, and the non-cab end shall be 300,000 pounds, when the load is applied in any direction within 15 degrees of the longitudinal axis of the car at a point even with the top of the underframe to which the posts are attached. The shear strength of the collision posts shall be based on the area of the web, which is the depth of the member, in the direction parallel to the applied load times the web thickness. This shear strength shall be carried to the bottom of the end underframe.

3.3.6.1 (c) Collision Post Strength along Its Length

The load carrying capacity of the collision post, when loaded at any point from the top of the underframe to the roof in a horizontal plane within 15 degrees either side of the longitudinal axis of the vehicle, shall be a minimum of 60,000 pounds for the cab end collision posts and 50,000 pounds for the non-cab end collision posts, with no permanent deformation in the carbody.

3.3.6.1 (d) Collision Post Energy Absorption at 30 Inches Above Floor

Each collision post on the cab end of a flat end cab car shall be capable of absorbing a minimum of 135,000 foot-pounds of energy when loaded longitudinally at a height of 30 inches above the top of the underframe. At the moment that the collision post has absorbed this minimum energy:

- The post shall not permanently deflect more than 10 inches into the operator’s cab or passenger seating area and,
- There shall be no complete separation of the post, its connection to the underframe, or its connection to either the roof structure or A-T Plate (if used).

Cab end collision posts and supporting structure on non-flat end cab car designs shall either meet the severe deformation requirements defined above or meet the deflection criteria above and meet an equivalent energy absorption requirement as submitted for review and approval by the Engineer.

3.3.6.2 Structural Shelf

A structural shelf shall be provided just below the cab end windows, connected securely to the corner post and the collision post. The structural shelf and its connections to the collision and corner posts shall resist without yielding, buckling, or tearing a load of not less than 15,000 pounds applied anywhere along its span. With the approval of the Engineer, the shelf may be integrated with the control console on the cab side.

3.3.6.3 End Frame Sheathing

Sheathing shall be provided on the end frame of the cab car F-end. The sheathing material shall be equivalent to a 0.5 inch thick steel plate with a 25,000 psi yield strength. Material of higher yield strength may be used to decrease the required thickness of the material provided an equivalent level of strength is maintained. The sheathing shall be designed to inhibit the entry of fluids into the occupied cab area. The sheathing shall be connected to the underlying framing member such that it will develop the full strength of the sheathing.

3.3.7 Equipment and Boxes Mounting Supports

All equipment boxes and mounting supports shall meet the requirements of APTA SS-C&S-034, Rev. 1.

Equipment shall be installed in compartments on the intermediate level over the trucks or at other approved locations inside the car. Brackets and other means of support for the equipment shall be designed and installed to facilitate access for maintenance and servicing and for removal and re-application. Fasteners shall be conveniently accessible. Equipment boxes shall be of polyurethane painted LAHT steel, fiberglass-reinforced polyester plastic, painted anodized aluminum or painted aluminum as approved by the Engineer, or stainless steel.

There shall be no under floor equipment other than piping, conduit, electrical boxes and wiring, and accessories associated therewith, unless approved by the Engineer. As approved by the Engineer, the following equipment may be mounted under the car: horn, bell, air reservoirs and ATS equipment.

Interior equipment compartment walls and doors shall be thermally and acoustically insulated. An interior equipment compartment is any enclosed area which is interior to the car structure/exterior skin and encloses equipment or components to isolate the equipment or components from the passengers or crew. All compartments shall be provided with hinged doors for access. Hinges shall not protrude above the surface of the door. Exterior doors shall be gasketed to be water and dust tight.

Equipment access panels shall be provided only on one side of each compartment to permit removal and replacement of all components. In addition, it shall be possible to perform such service functions as battery removal, watering, and flushing, from the exterior of the car. Although one (1) side access door for each equipment area is preferred by SCRRA, other configurations that address human factors and are practicable may be submitted for review and approval by the Engineer. The access panel configuration shall be submitted to the Engineer for review and approval. **[CDRL 3-005]**

The car side equipment compartment access panels and doors shall be constructed so as to harmonize structurally and esthetically with the car sides. The equipment access panels shall be removable. When closed, they shall be held fast with structural bolts so as to comprise an effective structural segment of the side. The side access doors shall swing outward and have appropriate latching, operable from both sides.

When closed, the access doors shall have a positive seal, which is effected by a dog, wedge, or similar device. A lock operable by the standard SCRRA key shall be provided.

Side access panels and doors shall have an interior finish of stainless steel, suitably insulated, if aluminum construction is used.

Side access panel and door construction shall be of aluminum or stainless steel to match with the carbody. The panels shall be of a rigidity and strength comparable to the adjacent car side areas. All joints and edges shall be thoroughly sealed and drain holes provided to permit the drainage of entrapped moisture. Doors shall not rattle or vibrate during operation.

The openings with close-off panels shall be reinforced by additional side frame structure surrounding the opening. The panel to close off the opening is to be structural and bolted to the basic side frame structure with stainless steel structural bolts so as to become an integral load bearing component of the side frame. The entire installation shall be watertight.

The battery box shall be constructed of stainless steel and shall be properly vented to prevent accumulation of gasses. The vents shall be covered with screens and deflectors to preclude entry of dirt and water. Large drain holes with deflectors shall be installed in the bottom.

Supports for equipment boxes and apparatus shall be low alloy high tensile steel. Where possible, supports for heavy apparatus shall rest on the horizontal flanges of side sills, roof rails, or body sills. Attachment of these supports to structural members shall be by mechanical fasteners, not by welding, and shall be subject to the approval of the Engineer.

Internal structure and sub-plates shall be provided within the compartments to support the equipment, and equipment shall be bolted to the substructure. No equipment shall be bolted directly to the walls.

Equipment box structures, mounting brackets, hinges, lids, covers, access doors, vents, and interior panels shall be designed to withstand the loadings received in the intended railroad service. The design loads for all equipment, any part of equipment, equipment boxes, equipment hangers, standby supports, safety hangers, and carbody supporting structure shall be not less than 8 g in the longitudinal direction, 4 g vertical and 4 g lateral. The loadings shall be applied separately; such loading may develop the ultimate load carrying capacity of the member being investigated.

Equipment within an equipment box need not meet the above criteria provided it can be shown that the equipment will not penetrate the walls of the equipment box when exposed to these g levels. The equipment box shall conform to these load criteria with the rearranged equipment in addition to its normal arrangement.

In no case shall the strength of a fastener or the shearing of the fastener through the base material be the limit of the carrying capacity of a member. Fasteners are not always torqued correctly and sometimes the nut shakes loose. Analysis of all the attachments considering loose bolts should be considered. The analysis of the connection shall include considerations for fastener shear, pull out, and fastener tension.

Covers on the exterior of the car shall fit tightly and be gasketed to prevent the entrance of water (including both driving rain and high pressure car wash spray), dust, and snow. Seals on covers shall be of a material that shall insure water tightness, remain resilient, and remain intact for a period of at least ten (10) years. Only one common type of gasket shall be used on all covers, of a hollow closed tube or similar design, using a positive mechanical means of attachment. Flat foam strips or glue-on attachments shall not be permitted. The design shall allow for ease of gasket replacement, without use of adhesives.

All equipment boxes, which are required to be watertight, shall be given a water test. Junction boxes are required to be watertight. For the purposes of this test, adjustable cover latches shall be adjusted to compress the cover seals no more than 50 percent of the compressible height of the seal for covers so equipped.

The access panel and cover/door seal shall be hollow neoprene rubber bulb type permitting at least 0.25 inch compression using the latches and edge design proposed for each door. The edge of the access panel and cover/door shall not deflect (bow) more than 0.0625 inch between latches when the latches compress the seal 0.25 inch. No permanent deformation of the door shall be possible with any combination of latch settings. The seal shall be mounted on a lip on the box and the cover shall seal against it. Foam seals shall not be allowed.

The seal shall be a clamp-on type that shall fit over a lip on the box and be mechanically clamped to it as are trunk lid seals on automobiles. This automotive type of installation shall provide easy replacement of damaged seals and secure attachment until replacement is required. Adhesive bonding of seals to the box or cover shall not be permitted. Samples shall be submitted to the Engineer for approval. **[CDRL 3-006]**

Undercar equipment with a direct line of sight to a wheel for any possible truck orientation shall be protected from water splash and flying rock ballast or other missiles thrown by the wheel. If separately mounted solid metal shields are used to provide such protection, they shall not hinder the flow of air to a degree that might cause heat damage to wiring or apparatus.

No apparatus over 25 pounds shall be supported by bolts in tension. The Contractor may submit to the Engineer, for specific approval, an alternative apparatus support design utilizing bolts in tension provided that such design includes an adequate stand-by support arrangement. The design of the stand-by support arrangements shall include the effect of the equipment dropping from its mount. Apparatus requiring removal and replacement for other than accident damage shall be supported so that both the bolts and nuts are accessible. Bolts used to mount or support underfloor equipment shall not be less than 0.625 inches in diameter and shall meet the requirements of Section 15.4. Dissimilar metals shall not be used at connections requiring disassembly for removal and replacement of equipment. Equipment supported on resilient mounts shall have safety straps or other devices that will support it in case of a failure of the resilient mounts. The design of the safety straps shall include the effect of the equipment dropping from its mounts. Under no circumstances shall equipment be supported by bolts, in holes, that are tapped into the underframe.

Boxes required by Section 3.1.1 to be accessible from the side of the car shall be as flush as possible with the side of the car consistent with the car clearance diagram and shall be provided with top hinged access covers on the outboard side and, if required, the inboard side. Outboard covers shall raise a minimum of 90 degrees for quick examination of the interior without removing the covers. Inboard covers shall open to the maximum extent possible, but in no case less than 60 degrees. All hinged covers shall also be readily removable without more than 12 inches swing out and without the use of tools. Openings provided upon removal of covers shall be of sufficient size to permit removal and replacement of any component in the box and easy access to equipment in the box for inspection and maintenance. All covers shall have a "hold open" feature built into the hinge configuration. The “hold open” feature shall in no way interfere with or impede the easy removal or replacement of the cover.

All access covers shall be provided with quick-release, spring-loaded latches which operate with a toggle-type action. The latches and keepers shall be arranged so that they do not protrude beyond the bottom of the box or cover in the latched position. The latches shall be adjustable to compensate for seal relaxation. The latch and all its components shall be fabricated from an austenitic stainless steel and shall be Nielsen/Sessions #265-30 series mounted to a Nielsen/Sessions dished (recessed) mounting.

A spring-loaded safety catch shall be provided at the center of each underfloor box cover. The safety catch shall be designed to engage and retain the cover at all operating speeds without the cover latches engaged.

Conduit shall be connected to equipment groups, using watertight connectors as manufactured by Universal, Erickson, or approved equal. Entrance of conduit into the top or bottom of equipment boxes shall not be permitted.

Materials used in underfloor equipment box assemblies and the workmanship involved in the assembly and finish of underfloor equipment boxes shall conform to the applicable requirements of Section 15.

Bolted connections shall be designed based on SAE Grade 2 strength using bolts of not less than 0.375 of an inch diameter. However, SAE Grade 2 bolts shall not be supplied; all bolted connections in equipment supports shall be supplied with minimum SAE Grade 5 bolts, plated for corrosion resistance in accordance with Section 15.4.2.

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

3.3.8 Buffer Walkway Plate and Face Plate

The construction of the walkway plates, buffer, and side stems shall be such that there shall be no metal to metal contact between moving parts, in order to prevent noise, minimize wear between all parts, and require no lubrication.

The walkway plates, buffer, and side stems shall be so arranged to permit coupled cars to negotiate minimum radius curves and crossovers, as described in Section 2.7.1, without any binding of the mechanism.

3.3.8.1 Buffer Walkway Plates

Hinged stainless steel walkway plates, having a safety tread surface, shall be provided at each end of the car to provide a continuous flat and level walkway between coupled cars. The design of the walkway plate shall be coordinated with the end door threshold on the ends of the cab cars and trailer cars and the buffer specified herein. The walkway plate shall rest upon the buffer and be readily removable. The buffer walkway plates shall be similar to and compatible with those provided on the existing SCRRA multi-level commuter cars.

3.3.8.2 Buffer

A buffer, as further described in Section 3.9, shall be provided at each end of the car. The buffer shall be designed to accept the diaphragm specified in Section 3.8. The buffer shall be free to move in a direction parallel to the length of the car to the extent required to maintain contact with a coupled car buffer for the track curvature and crossover conditions listed in Section 2.7.1. The buffer face plate shall be guided and held against the buffer face plate of a mating car by a tubular side stem and compression spring arrangement. The face plate shall be a minimum 6 inches high to prevent pass-over of two (2) adjacent buffers with maximum vertical movement of two (2) coupled cars. The face plate shall be covered with “Duraguard” sound deadening material, manufactured by the Dayco Corporation, or approved equal. The guiding means for the tubular side stem rods shall be provided with non-metallic material with both sound deadening and low friction non-lubricated capabilities.

3.3.9 Gutters

Water deflecting gutters shall be installed over all side doors. They shall prevent water from dripping into or in front of the side door opening when the car is stopped. Gutters shall also protect the entire end of the car. Deflecting plates shall be installed on both ends of the roof to prevent water from cascading between cars or down in front of the operating cab. Gutters, deflecting plates, and air scoops, if provided, shall be designed to withstand the loads, as stated in Section 3.1.2, and also those imposed by a brush type car wash without permanent deformation. Gutters shall be made from the same material as the shell, roof, and side sheets. Deflection air scoops, if provided, on the A-end of the cab car shall be made of stainless steel and designed to withstand loads and brush whipping action of car washes from either direction.

3.3.10 Jack Pads and Lifting Eyes

The carbody structure shall be designed so that jacks or cradles may be used for lifting the car at the jacking pads. Four (4) jack pads similar to the existing SCRRA fleet shall be installed on the side sill in approved locations, to prevent damage to the carbody structure when lifting a car. The jack pads shall be 5 feet from the coupler face and a minimum of 32 inches above top of rail. The jackpads shall be of an approved size with a suitable surface to avoid slippage. Four (4) other jack pads shall be provided, so it shall be possible to jack up a complete car, or either end of a car, utilizing portable jacking devices and to subsequently support the car with portable stands with trucks remaining on the rails and remove the portable jacks. It shall be possible to manually roll the trucks from under the end of the car when supported on jack pads.

The car shall be designed to permit jacking of either of the car ends for truck removal or re-railing with the opposite ends of the car resting on its truck, without damage to the truck attachment, underframe, or any of the underfloor apparatus. It shall be permissible on the cab car to remove the pilot to fulfill this requirement. The design vertical load for each jacking pad shall not be less than one half the empty weight of a ready to run (AW0) car. The design horizontal load shall be 10 percent of the design vertical load. The horizontal load shall be applied simultaneously with the vertical load in any direction to produce the worst stress condition. The allowable design stress shall be yield or 80 percent of ultimate, whichever is lower, or the critical buckling stress of any part of the jack pad or the structure to which it is attached. Jacking pads shall extend 0.50 inches to 1 inch below the bottom of the side sill. There shall be no permanent deformation when the car is symmetrically jacked from any combination of pads with the car at AW0 with the trucks attached.

The empty carbody, with trucks attached (AW0), shall be capable of being lifted on the outboard most diagonally opposite jack pads without resultant permanent deformation on any element of the carbody structure. An analysis of the carbody structure under torsional loading of the diagonal jacking, all symmetric jacking, and all lifting conditions defined in Sections 3.1 and 3.3 shall be included in the stress analysis required by Section 3.4.

Lifting eyes shall be installed at the extreme top edge of each collision post of both ends of all cars to allow lifting the car with overhead cranes or a boom. Procedures and designs shall be submitted to the Engineer for approval during the design review of the car. **[Part of CDRL 3-001]** The lifting eyes shall be arranged such that they are readily accessible. The top of the collision posts, including lifting eyes, shall not extend above the surface of the roof. The collision post lifting area shall have a suitable removable cover sealed to prevent ingress of water. It shall not require special tools to remove the cover.

The stress analysis required by Section 3.4 shall include an analysis of the collision post lifting eyes under all torsional loading showing all stresses on the carbody and all attachments during lifting of the car from both ends when ready-to-run in the following conditions:

- Car upright,
- Car lying on Left Hand Side,
- Car lying on Right Hand Side.

For lifting from either the Left Hand Side or the Right Hand Side, the car shall be analyzed with equal lifting load applied to one (1) collison post lifting eye on each end of the car. Stresses shall not exceed yield with a load factor of 1.1.

3.3.11 Pilot

A Pilot, which meets the requirements of 49 CFR 229.123, shall be provided at each cab end. A complete package, consisting of all detail drawings for each part of the Pilot together with an FEA on the structure and its attachment to the car, shall be submitted to the Engineer for approval. **[CDRL 3-007]** This package shall be submitted at least one hundred eighty (180) days in advance of delivery of the first car. The Pilot shall also be considered in the CEM Analysis of Section 3.4.4.7.

The Pilot shall be constructed of low alloy, high tensile steel properly coated for corrosion resistance in accordance with Section 15.3.6. It shall be as large and as low as possible, to prevent objects from being rolled under the car. Clearance above the rail shall be 6 inches maximum and 5.5 inches minimum with all new parts on an empty ready to run car. Pilots shall be interchangeable among all like cars.

The Pilot shall be strong enough to perform its intended functions, but, as a minimum, shall be designed to resist loadings not less than the following:

Longitudinal load at rail location, at bottom of pilot	50,000 lbs., on each side applied simultaneously.
Longitudinal load at centerline of car, at bottom of pilot	20,000 lbs., applied separately.
Transverse load, on lower edge transverse member	30,000 lbs., applied separately.

The allowable design stress shall be yield or 80 percent of ultimate whichever is lower or critical buckling stress.

The portions of the carbody to which the Pilot is attached shall be substantially stronger than the Pilot, so that if the Pilot is overloaded, damage to the portions of the car to which it is attached will be minimized. Longitudinal struts shall be provided to carry the longitudinal loads at rail location into the carbody, and their inboard ends shall be attached to the bottom of the draft sill in the region of the draft gear installation. Pilots shall be attached to the carbody by mechanical fasteners; the connection shall be designed and constructed to facilitate installation and removal and to permit interchangeability among cars. Analysis of the fastener strength shall be provided to the Engineer for review and approval. **[CDRL 3-008]** The design shall provide for easy removal of the Pilot, when required for jacking of the car from one end, as described in Sections 3.1 and 3.3.

3.3.12 Bolster Anchor Brackets

Bolster anchor rods and brackets shall be provided to transmit the longitudinal loads between the carbody and the truck. They shall be positioned to minimize longitudinal vibration to the carbody. Two (2) bolster anchor rods and brackets shall be provided on each truck connecting the carbody to the bolster.

The anchor rod bracket shall be frangible, i.e. the anchor rod bracket shall fail and fall away under load before the carbody structure is damaged. Any horizontal load which develops the ultimate load carrying capacity of the anchor rod bracket shall not develop a stress greater than yield, 80 percent of ultimate strength, or the critical buckling stress in the side sill or other car structure. The load shall be applied in any direction in the horizontal plane of any part of the anchor rod bracket below the side sill. A specially designed joint, which breaks at a predetermined load, shall be permitted subject to the approval of the Engineer.

The attachment of the anchor bracket to the carbody shall be by mechanical fasteners, designed and constructed to permit interchangeability among cars, and arranged to permit removal of the bracket from outside of the carbody without interference from the car structure.

The rods shall extend horizontally from brackets attached to the side sills to brackets attached to the ends of the truck bolster. Elastomeric pads shall be installed between the radius rod assembly and anchor brackets to permit vertical movement. Bolster anchor rods shall be designed and located to eliminate longitudinal vibration from the car. The design and location shall be approved by the Engineer. **[CDRL 3-009]**

Each of the rods shall, as a minimum, withstand a longitudinal load equal to two (2) times the weight of the complete truck, including brakes, and other apparatus mounted thereon, without exceeding the yield strength of the materials used. Each of the brackets, by which the bolster anchor rods are attached to the truck, the truck bolster, and/or the carbody, and the members to which these brackets are attached, shall, as a minimum, withstand a longitudinal load equal to three (3) times the weight of the complete truck assembly without exceeding the yield strength of the material used. Furthermore, both radius rods together must also support the load that can occur if the maximum main reservoir pressure is applied to the brake cylinders assuming perfect wheel/rail adhesion. Perfect wheel/rail adhesion is defined as that condition where the wheels continue to roll (sufficient adhesion to prevent the wheels from sliding) with the brakes applied at maximum main reservoir pressure. This may be more or less than coefficient of friction of 1.0.

3.4 CARBODY STRESS ANALYSES

3.4.1 General

No later than two hundred seventy (270) days after NTP and prior to carbody and truck testing, the Contractor shall prepare and submit, for review and approval, stress analyses of the carbody and truck structure and equipment supports for any element of equipment weighing over 150 pounds in accordance with APTA SS-C&S-034-99, Rev.1, Section 7.0. Stress analyses for supports for safety related items weighing less than 150 pounds shall be included in the analysis. For non-safety related items, stress analysis may be requested for review at the discretion of the Engineer.

The Contractor shall use the stress analysis as an engineering tool to aid in the design of the lightest weight car and truck in compliance with the requirements of the Specification. Structural tests shall be conducted in accordance with the requirements of Section 17.5.1 to confirm the accuracy of the analyses as required by Section 3.4.5.

The approved stress analyses, including crashworthiness analysis, shall be a prerequisite for approval of the structural test procedures and structural drawings required by this Specification and shall be used as an aid in determining strain gauge locations during the tests. **[CDRL 3-010]**

The stress analyses shall indicate the calculated and allowable stresses and margins of safety for all elements, for all specified load conditions. The stress analyses shall, as a minimum, include finite element analyses (FEA) using recognized computer programs such as NASTRAN, ANSYS, ALGOR, or approved equal, supplemented as necessary by manual or computer calculations of stresses at joints.

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

All stress analysis reports shall conform to the requirements in Section 3.4.4.

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

3.4.1.1 Permanent Deformation

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

a) The minimum yield strength as published by ASTM for the specified material and grade is exceeded. For materials or grades not covered by an ASTM specification, the minimum yield strength as guaranteed by the Manufacturer is exceeded. For materials without a specific yield point, the 0.2 percent offset method shall be used to determine yield strength.

b) The material has buckled or deformed and does not return to its original shape or position after the load is released.

3.4.1.2 Ultimate Load Carrying Capacity

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

3.4.1.3 Margin of Safety

Margin of Safety (MS) is:

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

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

3.4.1.4 Load Factor

Load factor is a number by which the actual or specified load is multiplied in computing the calculated stress. The load factor shall include all applicable safety factors.

3.4.2 Stress Analyses and Test Plan

Carbody and Truck Stress Analyses and Tests Plan shall be submitted for approval no later than one hundred twenty (120) days after NTP. **[CDRL 3-011]** The Plan shall address the requirements of Section 6.0 of APTA SS-C&S-034-99, Rev. 1 regarding a CEM and Survivability Plan. It shall be discussed during the first design review meeting. The Plan shall be a working document and updated as the design develops. When the plan for the analyses and testing is revised, it shall be updated and resubmitted no more frequently than monthly. Each revision shall include revision level indications.

The Stress Analyses and Tests Plan shall include an outline of the procedure the car builder shall use to analyze and test the design of the carbody and truck. It shall also include the following:

1. A listing of all load conditions to be used during analysis and test, including load magnitudes and points of application, with Specification references.
2. A description of the analysis to be used for each load condition.
3. Acceptance criteria for each load condition.
4. Diagrams displaying loads applied externally to the carbody and truck and points of support for each load case for each analysis.
5. Diagrams displaying loads applied externally to the carbody and truck and points of support for each load case for each test.
6. A table of material properties showing the engineering properties of each grade and temper of each material used in the car and truck structures. This table shall include the material designation, yield strength, ultimate strength and elongation, Young's modulus for tension, compression, shear elastic moduli, and CEM material data required by

3.10.6. For all material properties, an acceptable source for those properties shall be cited. In each case, minimum-guaranteed values from the specifications for the corresponding grade and heat treatment of the material shall be used. Materials, grades, and tempers not used in the carbody construction shall not be included in the tables.
A1 The table shall list the properties of the fasteners and the welds. **For implicit and** A1
A1 **explicit (Large Deflection) non-linear load cases, input shall include modeling of** A1
A1 **non-linear material properties in accordance with the online help for the FEA code** A1
A1 **used or equivalent source. The non-linear material properties shall be derived** A1
A1 **from conservative values of basic mechanical material properties (Young's** A1
A1 **modulus, yield and ultimate stress strain) as appropriate to the model.** A1

7. A description of all the major assumptions used in the stress analyses.
8. A description of how analyses results shall be correlated with test results.
9. A list of all connections deemed "potentially critical," e.g. all corner and collision post connections, all connections of the end underframe to the carbody and the underframe.
10. A list of all structural tests to be conducted on carbody and truck along with acceptance criteria.
11. Diagrams displaying all boundary conditions including symmetry and asymmetry boundary conditions.
12. An introduction page referencing all the related Stress Analysis documents to be submitted.

The Stress Analyses and Tests Plan shall be approved prior to submittal of the Stress Analysis Report required by Section 3.4.4. The Plan shall be made a volume of the Stress Analysis Report. The Plan shall follow the general requirements of the report in Section 3.4.4.

3.4.3 Finite Element Model Report

The Contractor shall submit the carbody and truck elastic Finite Element Analysis (FEA) model for review and approval prior to performing the analyses. **[CDRL 3-012]** The element grid, all assumptions, and all input data such as loads, section properties, and material properties shall be included as part of the preliminary submittal and again as part of the complete analyses. Solid elements shall be used for major structural areas of the truck frame and bolster.

The Contractor shall submit the complete electronic FEA input data files and output results files (for carbody and trucks) in a format readable by analysis software, such as ANSYS, FEMAP or approved equal. If a solid model was used to develop the Finite Element Model (FEM), the parameters of the model shall be supplied as electronic input on CD ROM. The first model report shall be submitted no later than one hundred eighty (180) days after NTP. **[Part of CDRL 3-012]** The Engineer shall specify the selected program prior to submittal. The submittal of the input data files and output results files shall be part of the review and approval of the Stress Analyses. Submittal of the model shall be required with the FEM Report and at any time thereafter that the file is revised and changed but no more frequently than monthly. All re-submittals shall include a list of changes to the model.

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

The FEM Report shall include a structural diagram (layout) of the carbody (including sheathing) and truck showing the locations of all members and shapes, and indicating the material and dimensions of each in accordance with APTA SS-C&S-034-99, Rev. 1, and Section 7.2. Methods of joining shall be completely defined. As a minimum, the following views shall be included on the carbody structural sketch: side elevation, top view of the roof and the underframe, and typical cross-sections of the carbody at a window, side doors, and full-height side-frame posts. For the truck, the following views shall be included in the structural sketch: side elevation, top and bottom views, and typical cross sections at key changes of geometry and weld types. Cross-sections of the structural members with shape, dimensions, material, and thickness shall be shown.

The FEM Report shall include a list of drawings, with revision levels, used to develop the model. As drawings are revised, the model shall be updated to reflect the changes, or there shall be documentation to indicate that the drawing changes do not affect the FEA results to be included with the next FEM submittal.

3.4.4 Carbody and Truck Stress Analyses

3.4.4.1 General

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

The stress analysis shall include calculations of stresses in joints, joint elements, and other important elements. It shall include FEA results, connection, buckling, natural frequency, and fatigue analyses.

In computing the shear strength of a beam, only that portion of the beam, which is in line with the force vector, shall be considered as resisting the force. If the force is skewed to the web of the beam, the force vector shall be divided into components, one in line with the web and the other in line with the flange. The shear resistance shall then be computed separately for each component. There shall be a table showing geometric properties, such as area and section moduli.

3.4.4.2 Finite Element Analysis

As part of the stress analysis, a linear-static finite element analysis (FEA) of the complete carbody and truck shall be performed. The FEA shall be a recognized computer program such as NASTRAN, ANSYS, ALGOR or approved equal. The purpose of the carbody and truck FEA, along with other supporting analyses, calculations, shall be to show that the design meets the requirements of the Specification.

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

At the discretion of the Engineer, finite element models (FEM) and results shall be reviewed during the conferences conducted within three (3) weeks after each submittal. At these conferences, SCRRA shall have full access to the FEM input, output, and use of the software on the computer used for the analysis.

Color plots shall be prepared showing the following:

a) Deflections in all three axes.
b) Von Mises or other approved combination stresses.
c) Maximum and minimum principal stresses.
d) Direction of maximum and minimum principal stresses.
e) Meshing accuracy index.
f) Maximum shear stress.

All plots shall show the maximum and minimum values and all values which are greater than 80 percent of the specified maximum value. Each drawing or plot shall include a triad showing the direction of the global axes. Plots at high magnification shall be keyed to a plot showing the structure to an extent sufficient to orient the high-magnification plots.

The report shall include all reaction forces, summed totals of reaction forces and moments, and a table to show static equilibrium for each load case. The FEA input and output data shall also be submitted on electronic media as approved by the Engineer. **[CDRL 3-013]** The electronic files shall be in a format readable by SCRRA software, such as ANSYS or FEMAP, the specific format to be determined by the Engineer prior to submittal. Submittal of the electronic data files is required with the Report and at any time the file is changed, but no more frequently than monthly. Criteria for final approval of the stress analysis shall include the Contractor's submittal of the fully configured input and output data files as required by this paragraph. This can be combined with the requirements of Section 3.4.3.

Upon completion and approval of the final design, the FE model and analysis report shall be updated to represent the final configuration of the structure.

3.4.4.3 Connections

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

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

The Report shall include analyses of all critical and highly loaded connections, showing that the joint is stronger than the weakest member being joined, as required by Section 3.3.1.1.

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

3.4.4.4 Buckling

The inelastic buckling strength of structural members subjected to any combination of compression and shear shall be calculated. The variation in the stainless steel compression modulus with stress shall be considered in calculating compressive stability of stainless steel members.

The buckling values shall be used as the basis for the allowable stress values for the specified load cases. Any member in any of the elastic static analyses with a calculated compressive stress equal to, or greater than, 35 percent of its material's yield strength shall be included.

3.4.4.5 Natural Frequency

The natural frequency of the carbody under AW3 load, and rigidly supported at the bolsters, shall be calculated. Also refer to Section 3.3.1.6.

3.4.4.6 Fatigue

An analysis of fatigue life of the car and truck shall be included in the stress analysis report as required by Section 3.3 and Section 11. It shall include a tabulation of the Contractor's selection of allowable fatigue stresses, with data sources and assumed fatigue stress ranges, for structural members which are critical in fatigue.

The minimum allowable fatigue stress range for the carbody is computed by multiplying the static stress at the AW3 load by the dynamic factor. The dynamic factor shall be determined by the Contractor but shall not be less than +/-20 percent. The allowable fatigue stress range shall be based on a calculated car shell lifetime of 10 million cycles. This stress range must be within the design fatigue stress range obtained from one of the following sources as approved by the Engineer:

a) For carbon and low alloy steel members, the stress range shall be obtained from AAR C-II, Chapter VII, or AWS D1.1.

b) For aluminum members, the stress range shall be obtained from Aluminum Association Aluminum Design Manual, "Specifications and Guidelines for Aluminum Structures," 2000 Edition, Section 4.8.

c) For spot welded structures, the Contractor shall conduct a sufficient number of fatigue tests to determine the fatigue properties of the welded structure. The Contractor shall consider the effect of multiple spot welds and different spot weld arrays when planning the test program.

d) The Contractor shall conduct fatigue tests to determine allowable fatigue stresses for materials or joint designs not covered by the above requirements.

The fatigue stress range and acceptance criterion for the trucks is detailed in Section 11 and Section 17.3.8.3.

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

3.4.4.7 CEM Analyses

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 Test and Analyses Plan in Section 3.4.2. The Contractor shall provide a CEM System Analyses Plan for review and approval by the Engineer. **[CDRL 3-014]** The CEM System Analyses Plan shall include as a minimum the analyses included in this Section and Table 3-1 CEM System Analyses Matrix.

The Contractor shall submit a CEM Analysis as per Section 6.0 and 7.4 of APTA SS-C&S-034-99, Rev. 1 for review and approval by the Engineer. **[CDRL 3-015]** The analysis shall be provided for the cab cars and the trailer cars based on the Evaluation Scenario provided in Section 3.10.2. The following shall be analyzed:

1. Individual energy absorbing structural elements,
2. Individual frangible structural elements,
3. Each crush zone, consisting of the validated energy absorbing and frangible elements,
4. The global carbody, including representative portions of the remainder of the carbody structure.

Compliance shall be demonstrated by meeting the following acceptance criteria as defined by the specified Evaluation Scenario:

1. Preserve interior spaces occupied by passengers.
2. Preserve cab interior space for Operator except as provided for by Section 3.10.8
3. Secondary Impact Velocity (SIV) for 2 ft of relative displacement shall not exceed 22.5 mph for Operator, 20 mph for cab car passengers, and 15 mph for trailer car passengers.

In addition to and in support of the CEM Analysis as per Section 6.0 and 7.4 of APTA SS-C&S-034-99, Rev. 1, the CEM system design validation shall be provided by the Contractor's submittal of reports for, as a minimum, the analyses included in Table 3-1 CEM System Analyses Matrix. The CEM System Analyses Reports shall be submitted for review and approval by the Engineer. **[CDRL 3-016]**

Table 3-1
CEM System Analyses Matrix

	Analysis	Spec	Type	Car End	Level	Input Parameter	Criterion	
	PEAM Energy Absorption	3.10.7	Non-Linear FEA	Both	Component	Energy Absorption	Minimum Target Value	
	PEAM Initiation Load	3.10.7	As Appropriate, FEA or manual analysis	Both	Component	Initiation Load	Within Target Range	
	PEAM Support Structure	3.10.7	Linear FEA	Both	Car	Maximum PEAM Load	No Permanent Deformation	
	CM Energy Absorbed	5.3.1	Non-Linear FEA	Both	Component	Energy Absorption	Minimum Target Value	
	CM Initiation Load	5.3.1	As Appropriate, FEA or manual analysis	Both	Component	Initiation Load	Within Target Range	
	CM Support Structure	5.3.1	Linear FEA	Both	Car	Maximum CM Load	No Permanent Deformation	
	Non-Cab End LDM/LTM Deformation	3.10.6	Linear FEA	Non-Cab	Component	Maximum Design Stroke	No Material Failure as defined by 3.10.6.	
	Cab End LDM/LTM Deformation	3.10.6	Non-Linear FEA	Cab	Component	Maximum Design Stroke	No Material Failure as defined by 3.10.6.	
A1	Cab End **LDM/LDM** Geometry	3.10.6	Drawing Verification	Cab	Car	Location/Size	Within Specified Dimensions	**A1**
	Force/Crush Characteristic	3.10.7	Non-Linear FEA	Both	Car	Exhaust Crush Zone	Verify Target Characteristic	
	Kinematics	3.10.7	Non-Linear FEA	Both	Car	Exhaust Crush Zone	Controlled Crush/Sequence	
	Retention	5.3.1	Non-Linear FEA	Both	Car	150,000 lbf Draft after Crush	Resist Draft Load	
A1	LTM-Only **(no CM Contact)**	3.10.6	Non-Linear FEA	Cab	Car	Contact and Crush LTM Only	Controlled Crush	**A1**
	Offset Impact	3.10.4.1	Non-Linear FEA	Cab	Car	Exhaust Crush Zone	Target Energy Absorption, Controlled Crush	
	Protected Operator Cab Space	3.10.8	Non-Linear FEA	Cab	Car	Car maximum design stroke and energy absorption	No intrusion	
A1	CM Service	**3.10.5** 5.3.1	1D Lumped	Both	Train	5 mph Impact	No CM Push Back Initiation	**A1**
A1	PEAM Bump	**3.10.5**, 5.3.1	1D Lumped	Both	Train	**12** mph Impact	No PEAM Initiation	**A1**
	Collision Scenario	3.10.2	1D Lumped	Both	Train	25 mph Impact	Crush & SIV Target Values	

A1 PEAM – Principal Energy Absorption Mechanism
CM – Principal Energy Absorption Mechanism
LTM – Load Transfer Mechanism
LDM – Load **Distribution Mechanism** **A1**
SIV – Secondary Impact Velocity

3.4.4.8 Manual Analysis

A manual analysis may be conducted to closely examine details of the carbody and truck (weld connections, welded and/or bolted joints, and fatigue conditions) that are not readily handled by the FEA in accordance with APTA SS-C&S-034-99, Rev. 1, and Section 7.3. Load cases that the Contractor prefers to analyze by manual methods shall be listed in the Carbody and Truck Stress Analyses and Tests Plan as required by Section 3.4.2. The manual analysis format shall consist of a title, sketch of item to be analyzed with dimensions and applied forces, drawing reference, material properties, allowable stress, detailed stress analysis, and conclusions.

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

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

3.4.5 Validation of Stress Analyses

Validation of the FEM shall be accomplished by comparing the carbody and truck structural test results for each test required by Section 17 with the corresponding stress analysis results. This information shall be tabulated and submitted with the carbody and truck structural test reports for each test.

In the test procedure for each test to be used for validation, there shall be a pre-selected list of strain gauges to be used for the comparison, which shall not be less than half of the total number of strain gauges used during the test. This table shall include gauge number, element number, location, stress analysis strain value in the direction of the gauge, direction of gauge on carbody and truck, a column for the strain gauge value, and a column for notes. The test report shall include tables that compare stresses calculated from the test strain gauge readings with analytical stresses from the FEA and shall include the test stress value, the analytical stress value, the percent difference between the two (2) values, and a space for annotation. The report shall include a graph plotted in MS Excel comparing the stresses calculated from test strain gauge readings with analytical stresses from FEA.

The percent difference between the two (2) values shall be within 15 percent for 75 percent of the compared values of the test results and analytical results.

If the analyses results do not agree with the test results within the above-specified tolerance, the Contractor shall revise the stress analyses, update the FEM, and re-run all FEA. All manual analyses using data from the FEA shall be recalculated using the corrected values. This process shall be repeated until agreement of results is within the specified tolerance. The stress analysis report shall be revised and re-submitted. All results from re-analysis shall meet specification requirements. The design shall be corrected if such requirements are not met.

For any of the remaining 25 percent of the compared values, if the analytical values disagree with the test value by more than 15 percent and the test value is equal to or greater than 35 percent of the yield strength of the material, a detailed explanation of the reasons for the excessive variance shall be included in the carbody and truck test report. This explanation may include supporting manual calculations.

Approval of the carbody and truck test report shall depend, in part, on the adequacy of the analyses of excessive variance between analytical and test stress values.

3.4.6 Stress Analysis Report

The Stress Analysis Report shall be prepared and submitted for review and approval not later than sixty (60) calendar days prior to scheduled commencing manufacture of any carbody and truck structural parts. **[CDRL 3-017]** The Contractor shall submit the required Stress Analysis report in compliance with the format and content specified herein. If a cited reference is not readily available to SCRRA, the Contractor shall provide the reference or copies of the pertinent pages. All references shall be in English. If an English reference cannot be found, an English translation shall be provided, and both the original and the translation shall be included in the report.

The report shall demonstrate that all structural members satisfy the requirements of this Specification on compliance with each design load and condition and of good practice in the rail transit industry. The report shall be organized and in sufficient detail so that the Engineer can readily follow the theory and its application to the car. The Contractor shall certify that the analysis and calculations have been reviewed and checked before the report is submitted to the Engineer.

A summary of the results of calculations of stresses in all structural framing members and shear panels shall also be included. The locations where calculated stress levels equal or exceed 80 percent of the allowable stress criteria specified in Section 3.3 and Section 11 shall be shown in a separate table along with the design and operating conditions (loads) which precipitate them.

The report shall include detailed calculations of stresses with Margins of Safety (MS) in all structural framing members and sheathing. There shall be a summary table listing the Margin of Safety of all major members and any other member where the Margin of Safety is less than 0.20 together with the affected joints under all specified loads. The table shall include:

1. The identity of the member
2. Its location

3. The load condition
4. The Margin of Safety
5. The page on which the analysis can be found
6. The material of that member
7. The allowable stress of the members.

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

1. A Table of Contents.
2. The algebraic statement of all formulas and equations before the related calculations are performed, along with the definitions of all terms and the values and units to be applied to these terms. In addition, the pages that show the development and interpretation of the formulas or data shall be included.
3. Units with all quantities.
4. References for all formulas, calculation procedures, buckle coefficients, material strengths, fatigue strengths, and other physical and mechanical properties where these items appear in the stress analysis.
5. Each page, including all stress analysis sheets, shall be numbered, dated, and initialed by the author, or analyst and checker, and in the event of a revision, the revision letter, date and initials of the analyst and checker.
6. Particular reference to, but not limited to, the following:

    a) Side sill
    b) Body sills (if used)
    c) End sill
    d) Anti-climber
    e) Draft sills
    f) Coupler supports
    g) Side frame rails
    h) Side frame posts
    i) Transverse and longitudinal sections at doorways
    j) Body bolster
    k) Floor and floor beams
    l) Collision posts

m) Corner posts
n) Structural shelf
o) Roof structure
p) Equipment supports
q) Connections between structural elements
r) Truck frame
s) Truck bolster
t) Truck equalizer beam
u) Axle
v) Bolster anchor rod and bracket
w) Pilot
x) Truck and attachment.

If tests are conducted to provide the necessary data, the entire test report shall be submitted. This report shall show the test procedure, raw data as well as reduced data, and summary, with detailed discussion of the results.

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

7. A table providing the physical properties of each material (grade and temper) used for the carbody and truck. This table shall include yield strength, ultimate strength, elongation, and tension, compression, and shear moduli. Minimum-acceptable values shall be used and shall be selected from the ASTM (or equal) material specification.
8. A tabulation of the Contractor's selection of allowable fatigue stresses for the carbody and truck material and each type of weld joint and assumed applied fatigue stress ranges for members and weld joints which are either highly or critically loaded.

3.5 TRUCK ATTACHMENT

An approved truck safety mechanism shall be provided in accordance with 49 CFR 238.219 and APTA SS-C&S-034-99, Rev. 1. The cars shall have a truck-to-carbody attachment with an ultimate strength sufficient to resist without failure the following individually applied loads: 2g vertically on the mass of the truck; and 250,000 pounds in any horizontal direction on the truck in any direction parallel to the plane of the car floor, along with the resulting vertical reaction to this load. This horizontal loading resistance shall be designed to cause the truck to function as an anti-telescoping device in the event of derailment and shall be carried down to the wheel horizontal centerline. The connection shall also be designed to resist the vertical component of that force when such horizontal force is applied to the center of the leading axle with the truck in its most adverse position.

The construction shall also provide a connection between the carbody and trucks so that the trucks are raised with the carbody, unless intentionally detached there from. A vertical load factor of 2.0 shall be applied in the design of the connecting elements, and the allowable design stress shall be ultimate. The truck safety mechanism shall not interfere with normal suspension elements for any possible condition of shimming to accommodate for wheel wear variances.

An analysis of the strength of the connection of the trucks to the carbody, calculated for all vertical and horizontal loads, shall be included in the stress analysis required by Section 3.4.

3.6 DOORWAYS AND PASSAGEWAYS

3.6.1 Doorways

All doorways shall be in accordance with 49 CFR 38.93. Each car shall include two (2) side entrance doorways on each side of the car. These doorways shall provide direct access to the lower level of the car. Water deflecting gutters shall be installed over all side doors. The gutters shall prevent water from dripping into and in front of side door openings. Each car shall include end of car doorways. These doorways shall provide access between two (2) coupled SCRRA multi-level commuter cars through the diaphragm passageway. Deflection plates and drains shall be installed on both ends of the roof to prevent water from cascading between cars and down the front of the operating cab. The sizes and locations of the doorways shall comply with the requirements of Section 2 and shall be compatible with SCRRA's existing facilities and fleet. Details of the design, materials' location, and arrangement shall be submitted to the Engineer for review and approval. **[CDRL 3-018]**

3.6.2 Passageways

All passageways shall be in accordance with 49 CFR 38.93. The passageways shall have a minimum width of 32 inches.

3.6.3 Threshold and Door Track

A threshold shall be designed to guide the bottom edge of the side entrance doors and end door of car doors during door operation and mate with the door bottom edge when the door is in the closed position, so as to exclude water and drafts from the vestibule. The threshold and door track shall be provided with adequate drainage to prevent the buildup of water and debris in the track. The door track shall extend the full length of the door travel.

3.7 HVAC DUCTING

Ducting for circulation of conditioned air for the lower level shall be fastened to the upper level floor framing arrangement, consistent with the air distribution requirements of the HVAC system. Duct work shall be specific to the car design and shall complement the interiors in all respect and provide optimum cooling and heating as required.

3.8 DIAPHRAGMS

A non-metallic, modular, maintainable diaphragm shall be provided at each end door of each
A1 car **except as may be required on the F-end of the car to accommodate Section 3.10 CEM** A1
A1 **Design.** Diaphragms shall provide a safe, stable, weatherproof passageway between two (2) A1
coupled SCRRA multi-level cars, and shall exclude water ingress and drafts under all normal operating conditions. Diaphragms shall be made of cloth reinforced molded neoprene which shall be clamped to the structure so that it is easily removable for maintenance servicing and repair. Metal parts may be used for fastening and reinforcing the diaphragms. Diaphragms shall be constructed from materials that comply with requirements of this Specification and as approved by the Engineer. Diaphragm size, arrangement and installation shall be compatible with existing SCRRA commuter rail vehicles and approved by the Engineer.

3.9 BUFFER ASSEMBLY

3.9.1 Buffer Assembly

All cars shall have a buffer foot plate and face plate at each end. The face plate shall accept the diaphragm and be free to move in a direction parallel to the length of the car to the extent required for track curvature. It shall be guided and held against the face plate of a mating car by a tubular side stem and compression spring arrangement. A sound deadening material, Gatke No. 113 or approved equal, shall provide both deadening and low friction non-lubricating capabilities to the tubular side stem rod guides. The front face shall be covered with Gatke type material.

The buffers shall not bind during normal train operation.

3.9.2 Safety Barriers

A safety bar shall be provided at each end of each car. It shall be used to form a transverse barrier between collision posts. It shall be secured to one post on a pivot pin and shall latch securely in both the horizontal and stored (vertical down) positions.

3.10 CEM DESIGN

3.10.1 Background

The Federal Railroad Administration (FRA) has been conducting rail equipment crashworthiness research through the support of the Volpe Center. The approach taken in conducting this research has been to propose strategies for improved crashworthiness and to apply analytic tools and testing techniques for evaluating the effectiveness of those strategies. The information from this research has been used to develop the crashworthiness requirements for Tier II equipment, to develop initial safety regulations for passenger equipment, and to develop draft regulations for locomotives.

FRA Crash Energy Management (CEM) research for Tier I has confirmed that there are significant potential benefits for improved occupant survivability during collisions particularly in train-to-train collisions with closing speeds up to about 30 mph, and that such an approach can be feasibly implemented on Tier I equipment.

A series of full-scale impact tests are currently being conducted on rail passenger vehicles related to the Tier I CEM research. These tests are intended to measure the crashworthiness performance of existing-design equipment and to measure the performance of equipment incorporating CEM. The full-scale tests necessary to measure the crashworthiness of existing-design equipment are nearing completion and the initial tests with CEM equipment have been completed. Details of the results of FRA research and testing can be found in the CEM Research Bibliography in Section 20.

The FRA testing program has confirmed the performance of controlled-collapse coupling systems and crushable structure designs, and the overall performance of a CEM structure design. Recent efforts have been directed towards developing these designs for Tier I commuter rail vehicles to improve the safety of Push-Pull service with cab cars leading. This has led to the requirement of this Specification for CEM design of cab cars.

3.10.2 Evaluation Scenario

The CEM Evaluation Scenario shall be as follows:

1. Equipment

- A1 The initially moving train consists of one (1) leading CEM cab car at **AW1** with A1
  four (4) conventional trailer cars at AW0 pushed by one (1) conventional
  A1 locomotive at 280,000 pounds. **Cab cars and** Trailer cars shall be assumed to be A1
  A1 fitted with push back, energy absorbing coupling mechanism**s as required by** A1
  Section 5.3.1.
- The initially standing train consists of one (1) leading conventional locomotive with a train consist of equal mass to the initially moving train consist. The conventional locomotive shall be idealized as a rigid body with geometry as defined in Section 20. The idealized locomotive drawing and model entities are available as computer files in the various formats compatible with commonly used design, drawing, and structural analysis programs.

2. Initial Conditions

- Level, tangent track
- Impact speed of 25 MPH
- Standing train brakes applied at Full-Service.
- Moving train brakes applied at Emergency.
- A1 **The idealized locomotive model and car coupler knuckles are closed.** A1
  A1 **Coupler Mechanism contact is knuckle to knuckle.** A1

3. Model and Analysis

- One-dimensional, lumped parameter analysis shall be acceptable for train level analysis.
- Force-crush characteristic of the cab car shall be as designed and validated in accordance with the requirements of this Specification.

- If trailer car structure is identical to that of the existing fleet, force-crush characteristic shall be from SCRRA Existing Fleet Force-Crush Characteristic provided for reference in Section 20.
- If trailer car structure is different from that of the existing fleet, force-crush characteristic shall be as determined by the Contractor as the result of a large-deflection analysis of its design with a flat-barrier boundary condition assumption.

4. Results
    - Preserve interior spaces occupied by passengers.
    - Preserve cab interior space for Operator except as provided for by Section 3.10.8.
    - SIV for 2 ft of relative displacement shall not exceed 22.5 mph for Operator, 20 mph for cab car passengers, and 15 mph for trailer car passengers.

3.10.3 Approach

CEM requirements for this Specification are based on the results of FRA research to date, and are consistent with CEM requirements and recommendations in APTA SS-C&S-034-99, Rev. 1 and 49 CFR 238. Please refer to the CEM Research Bibliography in Section 20 for details of the FRA research and CEM requirements development.

For this procurement, cab cars shall be designed with the full set of required CEM functions. Trailer cars will not have CEM implemented, but will have push-back, energy absorbing couplers
A1 in accordance with the relevant requirements of Section 5. **The static and end compression** **A1**
A1 **strength of Section 5.1.2 of APTA SS-C&S-034-99, Rev. 1 shall not be applicable to the** **A1**
A1 **trailer cars.** Trailer car body design shall otherwise be in accordance with the requirements of **A1**
APTA SS-C&S-034-99, Rev. 1, 49 CFR 238 and this Specification as applicable without CEM.

Cab car CEM design may place some or all energy-absorbing mechanisms outboard of the cab. The design of the cab car shall permit operation at any location within consist, including walk-through capability by crew during revenue service and by passengers in emergencies.

3.10.4 CEM Functional Requirements

CEM functions shall be provided by mechanisms as required in this section.

3.10.4.1 CEM Mechanisms

The approach to CEM in this Specification consists of basic CEM functional requirements with general prescriptions of structural mechanisms to provide each of the functions. The required CEM mechanisms are as follows:

Coupling Mechanism (CM);

- Optional Load Distribution Mechanism (LDM) functioning with a
- Load Transfer Mechanism (LTM);
- Principal Energy Absorption Mechanism (PEAM); and
- Protected Operator Cab Space (POCS).

The CEM system shall be designed with the objectives of providing for the engagement of colliding equipment by the mechanisms intended to distribute the collision loads into the LTM, triggering CEM functions sequentially, and permitting load transfer as intended into CEM mechanisms and supporting car body structure.

The cab car CEM system shall be designed to engage locomotives with platform heights from 60 inches to 75 inches above TOR. Within this range of possible platform heights, demonstration of satisfactory CEM system performance in accordance with this Specification shall be limited to an ideal case defined by the standard CEM locomotive model defined in Section 20 interfacing with the cab car with couplers closed and centered at 34.5 inches above TOR, carbodies centered, and the top of the locomotive platform at 64 above TOR.

In addition, two non-ideal cases shall be analyzed:

- Ideal case with locomotive model offset 3 inches down and 3 inches laterally with respect to the cab car model, and
- Same as the ideal case, except with couplers removed from the models.

Pass-fail criteria for the two non-ideal load cases shall be:

- Design PEAM energy absorption,
- Stable operation of the LDM/LTM, and
- Preserve POCS as provided by Section 3.10.8.

3.10.4.2 Sequence of Operation of CEM Functions

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

- Coupling mechanisms of cab car and locomotive contact,
- Coupling mechanism initiates energy absorption,
- Load transfer mechanisms engage,
- Principal energy absorption devices initiate, and
- Crush zone operates to full stroke.

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

Figures are provided in Section 20, for information, to illustrate the intended sequence of operation of CEM functions for a cab car colliding with a locomotive, and for coupled-car interfaces.

3.10.5 Coupling Functions

Couplers shall be provided in accordance with Section 5, and shall meet the requirements of 49 CFR 238, APTA SS-C&S-034-99, Rev.1 and this Specification applying to service couplers.

In addition, the coupling mechanism shall provide CEM coupling functions, including;

- Releasing at a compressive force level as required, and pushing back to permit ends of colliding equipment to engage,
- Absorbing energy in a controlled manner while pushing back, and
- Minimizing vertical and lateral displacement of the ends of colliding equipment during the operation of the coupling energy absorbing function.

Energy absorption requirements for the coupling function can be found in Section 5.

A1 When coupling on level, tangent track **as per the Evaluation Scenario of Section 3.10.2** with one train standing with brakes applied and the CEM equipped cab car operating at speeds up to 5 mph, the energy absorbing feature of the coupling mechanism shall not be triggered. When coupling on level, tangent track with one train standing with brakes applied and the CEM equipped cab car operating at speeds greater than 5 mph but not more than **12** mph, the energy absorbing feature of the coupler assembly shall trigger and absorb energy, but the PEAM shall not initiate. **A1**

While operating as part of the CEM system, the coupling function shall transfer longitudinal and transverse loads resulting from collisions between units. After the push back and energy absorbing functions of the coupling function have operated to maximum extent, the coupling mechanism shall be adequate to transfer the loads required by the design under that condition. In addition, the coupling mechanism shall be adequate to withstand a draft load of not less than 150,000 lbf at any point in the operation of the CEM coupling mechanism, up to and including complete exhaustion.

If provided by the installed couplers, anti-climbing requirements of 49 CFR 238 and climb, bypass, and overturn requirements of APTA SS-C&S-034-99, Rev.1 shall be met with CEM at all times during operation of CEM up to and including complete exhaustion of all CEM functions. If operation of CEM renders the coupler incapable of providing these functions, there shall be another structural mechanism that takes over and provides the functions as they are lost by the installed coupler.

3.10.6 Load Transfer Function

The load transfer function shall be provided by a mechanism that transfers longitudinal and transverse loads between colliding units, and at coupled-car interfaces during collisions. The load transfer mechanism shall resolve collision loads into loads applied to the principal energy absorption mechanism and supporting car body structure such that absorption mechanism operation is stable and controlled as required.

The cab end LTM shall be designed to provide the load transfer function in collisions with locomotives as required by 3.10.4.1. Distribution of collision loads applied by the locomotive deck to the LTM may be by a separate load distribution mechanism (LDM) that functions with the LTM to provide the required function. While engaged, the LTM shall assist to the extent required by the design in providing anti-climbing resistance as required by 49 CFR 238, and climb, by-pass, and overturn resistance as required by APTA SS-C&S-034-99, Rev.1.

The LTM shall act with the other CEM functions as intended to prevent climb and lateral buckling under the conditions of the Evaluation Scenario of Section 3.10.2.

The LTM at the non-cab end may be through end frame structure, including end sill, collision and corner posts, and collision and corner post header. Distribution of collision loads at coupled-car interfaces may be by a separate LDM that functions with the LTM to provide the required function.

A1 **For the analysis of the LDM/LTM required by Section 3.4.4.7, strain shall not exceed the** **A1**
A1 **ultimate value established in the Stress Analyses and Test Plan material used.** Material **A1**
properties used in the calculations shall include the influence of dynamic effects, and shall be based on data from the supplier of the material (tensile test results for example), or if not available from the supplier, data developed in accordance with the recommendations equivalent to those for high strain rate testing from ASM Handbook, Volume 8, "Mechanical Testing and Evaluation", ASM International, Copyright © 2000 (Available Online), latest revision. The source for the data shall be included in the Carbody and Truck Stress Analyses and Tests Plan (Section 3.4.2), and the material property curves shall be included in the required stress analysis report."

For the tests of the LDM/LTM required by Table 17-1 in 17.5.1.14 (b), there shall be no material failure (material separation) in elements of the LDM/LTM specifically designed to crush and
A1 absorb energy in a stable and controlled manner. **Highly** localized material failure will be **A1**
permitted provided the related performance requirements of this Specification are met, and provided that it can be demonstrated that the failure does not affect the repeatability of the results of the test.

3.10.7 Principal Energy Absorption Function

Energy absorption shall be achieved by the coupling mechanism (Section 3.10.5) and principal energy absorption mechanism (PEAM) at the cab and non-cab ends of the cab cars. Approved equal arrangements that do not provide for coupling mechanism energy absorption shall be permitted provided the requirements for total energy absorption and the requirements of 3.10.2 are satisfied.

The PEAM stress analysis criteria and testing “no material failure” criteria are as defined for the Load Transfer Function in Section 3.10.6, Table 3-1 of Section 3.4.4.7 and Table 17-1 of Section 17.5.1.14 (b). Dynamic data shall be filtered in accordance with APTA SS-C&S-034-99, Rev.1.

3.10.7.1 Cab End PEAM

The cab end PEAM shall be arranged to function with the load transfer mechanism to absorb the required amount of collision energy under the conditions of the specified collision evaluation scenario of Section 3.10.2.

Requirements for cab-end energy absorption mechanism are as follows:

- Sufficient capacity such that total cab end energy absorption is a minimum of 3.0 million ft-lbf including coupling mechanism energy absorption,
- Force to initiate crushing 900,000 lbf to 1,400,000 lbf,
- Maximum stroke 38 inches,
- Best-fit straight line approximation of crush load vs. crush distance data has zero or positive slope.
- After all crushing, the end sill shall not be displaced more than +/- 2 inches vertically from its position before crushing with respect to a horizontal datum plane through the carbody bolsters, and shall not be displaced more than +/- 2 inches laterally from a centerline through the carbody bolsters.

An idealized cab end force-crush characteristic curve is provided in Section 20. Its purpose is to illustrate the above requirements, and it is included for reference only. Contractor shall submit the force-crush characteristic curves for the actual car design to the Engineer for review and approval. **[CDRL 3-019]**

3.10.7.2 Non-Cab End PEAM

Non-cab end PEAM shall be arranged to function with the load transfer mechanism to absorb the required amount of collision energy under the conditions of the specified collision evaluation scenario of Section 3.10.2.

Requirements for non-cab end energy absorption mechanism are as follows:

- Sufficient capacity such that total non-cab end energy absorption is a minimum of 2.0 million ft-lbf including coupling mechanism energy absorption,
- Force to initiate crushing 900,000 lbf to 1,400,000 lbf,
- Maximum stroke 24 inches,
- Best-fit straight line approximation of crush load vs. crush distance data has zero or positive slope.
- After all crushing, the end sill shall not be displaced more than +/- 2 inches vertically from its position before crushing with respect to a horizontal datum plane through the carbody bolsters, and shall not be displaced more than +/- 2 inches laterally from a centerline through the carbody bolsters.

An idealized non-cab end force-crush characteristic curve is provided in Section 20. Its purpose is to illustrate the above requirements, and it is included for reference only. Contractor shall submit the force-crush characteristic curves for the actual car design to the Engineer for review and approval. **[Part of CDRL 3-019]**

3.10.8 Protected Operator Cab Space

When subjected to the conditions of the Evaluation Scenario of Section 3.10.2, the cab space shall be undamaged except for 10 inch maximum intrusion permitted for end-frame post energy absorption (Refer to Sections 3.3.2.3 and 3.3.6.1).

The POCS shall be maintained at a minimum of 30 inches in length, 30 inches in width, 63 inches in height. The outboard plane of the POCS shall be 12 inches from the front surface of the operator seat adjusted to its median fore and aft position. The outboard side of the POCS shall be at the lateral extremity of the seat defined by the Right Hand Side arm rest. The cab console may extend into the POCS as necessary for satisfactory ergonomics, but shall remain upright and at the same distance from the mounting of the operator seat to the floor throughout crushing. Refer to Section 20 for Operator Seat Clearance Zone.

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

The front windscreen shall be supported by the structure of the Operator's cab in a manner that resists the windscreen as a whole, whether or not damaged, moving into the Operator's survival space in the Evaluation Scenario. Operation of the cab end CEM system to exhaustion shall not result in any condition that interferes with ready egress from the cab. The design shall provide for the cab seat to remain attached from the initiation of the impact load through the exhaustion of the CEM crush zone stroke.

3.10.9 CEM System Validation Analysis and Testing

CEM system design validation shall be provided according to separate CEM System Tests Plan and CEM System Analyses Plan that shall be integrated into the Carbody and Truck Tests and Analyses Plan. The CEM System Tests Plan shall include as a minimum the tests included in Section 17.1.5.14 and Table 17-1 CEM System Test Matrix. The CEM System Analyses Plan shall include as a minimum the analyses included in Section 3.4.4.7 and Table 3-1 CEM System Analyses Matrix.

End of Section

Contract Deliverables Requirement List

CDRL No.	Title	Car Type	Reference Paragraph
3-001	Carbody Lifting Eye Bolts, Hardware, Design and Procedures	All	3.3.2.2(c)
3-002	Samples of Exterior Finish Specifying Direction of Grain and the Flatness	All	3.3.5
3-003	Passenger Entry Doorway Rain Diverter	All	3.3.5
3-004	Three (3) Samples of All Exterior Finishes	All	3.3.5
3-005	Access Panel Configuration	All	3.3.7
3-006	Samples of Clamp-on Type Seal	All	3.3.7
3-007	Pilot FEA and Drawings	Cab	3.3.11
3-008	Pilot Fastener Strength Analysis	Cab	3.3.11
3-009	Bolster Anchor Rod Design and Location	All	3.3.12
3-010	Approved Stress Analyses	All	3.4.1
3-011	Carbody and Truck Stress Analyses and Tests Plan	All	3.4.2
3-012	Carbody and Truck Element Finite Element Model Reports	All	3.4.3
3-013	Finite Element Analysis Report	All	3.4.4.2
3-014	CEM System Analyses Plan	All	3.4.4.7
3-015	CEM Analysis as per Section 6.0 and 7.4 of APTA SS-C&S-034-99, Rev.1	All	3.4.4.7
3-016	CEM System Analyses Reports	All	3.4.4.7
3-017	Stress Analysis Report	All	3.4.6
3-018	Doorway design, materials and arrangement	All	3.6.1
3-019	Force-Crush Characteristic Curve Cab End and Non-cab End	Cab	3.10.7.1

SECTION 4

INTERIOR ARRANGEMENT, FEATURES, AND APPOINTMENTS

SECTION 4

INTERIOR ARRANGEMENT, FEATURES, AND APPOINTMENTS

TABLE OF CONTENTS

SECTION 4

INTERIOR ARRANGEMENT, FEATURES, AND APPOINTMENTS

4.1 GENERAL REQUIRMENTS AND FEATURES

4.1.1 Interior Materials

Where specific lining materials are called for, it shall be interpreted as only for the purpose of establishing a level of strength, rigidity, clean ability, durability, and resistance to scratching and marking, and shall not necessarily indicate that these materials meet the required fire safety standards nor shall they be considered to be specifically required. The Contractor may submit for approval alternate materials with improved properties. Conformance with the performance and fire safety standards shall be the responsibility of the Contractor, and all materials supplied shall have test data from an independent test laboratory. A Fire Safety Report shall be submitted as per Section 19.5.4. All test results for the Fire Safety Report shall be submitted to the Engineer for review and approval. **[CDRL 4-001]**

"Anti-squeak" tape shall be used between linings and any structure to which they are attached or with which they come in contact. The "anti-squeak" tape used shall be installed to remain attached, and in place and completely functional for no less than ten (10) years. Where linings cover apparatus requiring replacement, or even infrequent maintenance, they shall be fastened with captive, tamper proof machine screws, design to allow ready access for removal and replacement of apparatus.

All interior fasteners exposed to passengers shall be either bright or finished to match the surfaces being joined, and installed such that the fastener head is flush with the mating surface. Self tapping screws are only permitted where they will not be removed for normal maintenance more frequently than once in five years and shall be plated martensitic stainless steel.

Fasteners on access panels, plates, covers, or other components accessible by passengers shall be tamper resistant type approved by the Authority and shall be used for the end-of-car vestibule overhead light, the toilet room "Occupied" light, and the passenger area overhead lights.

Interior component materials shall meet the flammability and smoke emission requirements provided in Section 15.23. Melamine materials, if used, shall have a low glare, 4 to 14 gloss reading on a 60 degree gloss meter, or cashmere finish. Melamine panels shall be of balanced construction to minimize warpage. All gel-coated composite surfaces shall have a high gloss finish with a minimum gloss reading of 85 per ASTM D 523, machine direction, using a 60 degrees gloss meter.

Interior panels shall be designed such that the numbers of exposed joints are minimized. The joints between panels shall align with joints on adjacent panels to present an aesthetically pleasing appearance. Any joints between panels shall be concealed by approved trim strips. All panels shall be properly supported to prevent sagging and drumming, and all joints shall be covered with approved moldings. The interior linings and moldings shall be free of undulations. The maximum allowable variations from a straight line on all interior surfaces shall be 0.125 inch over 3 feet in any direction.

The interior finish at the windows, armrests, and handholds shall be designed to minimize dirt collection. Materials used shall minimize build up of static charge. At all locations, except as approved by the Engineer, where vertical surfaces adjoin the floor, the corner formed by the intersection of the floor and the vertical surface, shall be trimmed by a cove molding of stainless steel with an aesthetically compatible finish/covering approved by the Engineer. All cove moldings and corners shall be designed with a generous radius to facilitate cleaning and sealed to prevent water seepage. Design and installation shall be as approved by the Engineer. **[CDRL 4-002]**

Exposed interior stainless steel shall be approved by the Engineer, and where approved, shall have a 120 grit finish. Grain direction shall be arranged to suit the decorative scheme. The Contractor shall submit at least three different samples of each of the finishes to be applied to interior trim and to interior sheets. The three samples shall demonstrate the range of surface finish of a worn, partially worn, and a new belt.

The use of panels and liners with integrally colored exposed faces shall not require painting. If and where painting is required on the interior of the car, and approved by the Engineer, the paint shall comply with Section 15.3.

The attachment of all interior appurtenances shall be designed to meet the requirements of 49 CFR 238.233 and APTA Standard for Attachment Strength for Interior Fittings for Passenger Railroad Equipment, APTA SS-C&S-006-98.

4.1.2 Industrial Design

The Contractor shall employ the services of an Industrial Designer during the design and manufacturing phases of the Contract. It shall be the responsibility of this Industrial Designer to lead the design effort of the vehicle's interior, exterior, and equipment layout and to finalize SCRRA's industrial design requests in such a manner that the function, value and appearance of its systems are optimized for the mutual benefit of SCRRA and its passengers**.** The Contractor may utilize the service of its own in-house industrial designer.

The Contractor shall provide a minimum of four (4) interior and three (3) exterior finalized color detail renderings for SCRRA's review during the development of the car design. **[CDRL 4-003]** The renderings shall be the basis for SCRRA's selection of the design that will be carried through to production. The Industrial Designer shall place emphasis on safety, human factors (ergonomics), aesthetics, manufacturability, maintainability, and cost, when developing the final design of the car.

The industrial design services shall include, but not be limited to:

- Vehicle exterior and interior aesthetics and seat arrangement
- Vehicle configuration with respect to SCRRA system clearance restrictions
- Cab equipment arrangement and Operator's cab console
- Vehicle exterior and interior equipment arrangement and maintenance access
- Use by elderly, hearing and sight impaired
- Between car barriers

- Stanchion and windscreen designs
- Materials selection and application
- Evaluation of Federal, State, and local ADA compliance issues as they apply to passenger rail vehicles
- Evaluation of maintenance accessibility and maintainability of components and assemblies
- Review issues involving human factors/ergonomic and safety conditions
- Integration of all materials, finishes, colors and arrangements
- Preparation of exterior marking scheme
- Preparation of interior signage and service markings
- Selection of interior fabrics and furnishings and the presentation of interior color and material boards
- Assist in the construction of any mock-ups required to resolve packaging, spaces, equipment location, human factors/ergonomics criteria, or ADA issues

The Industrial Designer shall be identified and presented to SCRRA for approval. Prior experience as an industrial designer for rail vehicle procurement programs is required. SCRRA reserves the right to reject prospective Industrial Designers and/or reporting structure presented by the Contractor for approval.

4.2 THERMAL AND ACOUSTICAL INSULATION

4.2.1 General

An approved insulation material shall be used throughout the doors, roof, floor, side walls, and ends of the car body for thermal insulation. All insulation material shall meet the requirements of Section 15.23.

The insulation material shall provide effective resistance to heat transfer with R-values suitable for the specific application and installation. The insulation material shall be formaldehyde free and shall be unaffected by moisture, oil, grease, and other chemicals and cleaning products used by SCRRA. The material shall not sustain vermin, mold, mildew, rot or otherwise deteriorate. It shall not corrode any other materials, separate, settle, breakdown or sag once installed. It shall not have an odor or be capable of absorbing odors. It shall be capable of performing to an upper temperature limit of 450°F.

Thermal breaks shall be provided between the main conditioned air supply duct and roof structural members, between interior finish panels and any metal primary or secondary structural members which are thermally grounded to the outside surface of the car body skin and at any other location where it is necessary to interrupt an all-metal path between the interior of the car body and the outside of the car body skin.

To reduce structurally borne sound the floors, walls, doors, ceilings, ducts, and other sheets shall include an acoustic insulation approved by the Engineer that ensures compliance with the requirements of Section 2.5.2.2. The acoustic insulation material shall be a spray-applied, water base, non-asphalted, silica-free filled polymer in an emulsion form. Application shall be according to the supplier's recommendations, and as follows:

- The inner surface of the car structural shell, except for the end underframe weldments, shall be coated with sound deadening compound. The inside surfaces of structural members shall be sprayed to the maximum extent possible. The compound shall be applied wet at the supplier’s recommended thickness.
- The outside surfaces of the main air duct, any vertical underfloor equipment ventilation ducts which enter the car body interior through the floor panels, and all ventilation ducts shall be coated with sound deadening compound. The compound shall be applied wet at the supplier’s recommended thickness.
- Duct splitters shall be coated on one side only.
- The ceiling below the main air duct shall not be coated.

A primer shall be applied in accordance with the recommendations of the manufacturer of the damping material.

The Contractor may propose an alternative acoustic insulation system, such as 3M Damping Foil 2552. The alternative acoustic insulation system shall be service proven for commuter rail application and shall demonstrate compliance with the design and performance requirements specified.

The insulation of the air conditioning compartment shall be primarily of an acoustical absorption design. Door cavities shall be insulated with an approved insulating material to provide the required thermal and acoustical insulation requirements.

4.2.2 Performance Requirements

Thermal insulation used in the doors, roof, sides and ends shall be retained in position by the use
of approved mechanical fastenings. **[CDRL 4-004]** Heat transfer through the carbody, using the
A1 independent heaters installed in the car for the test purpose, shall not exceed **1600** Btu/hr/°F at an A1
A1 ambient temperature of 32°F. **The actual carbody heat transfer shall be determined as per** A1
A1 **Section 17.5.5.5.** See Section 2.7.3 for climate room test requirements. A1

The thickness of the acoustic damping material shall be such that it will provide 10 percent of critical damping for the treated surface. The damping material shall have a vibration decay rate of not less than 45 decibels per second (at a temperature of 75°F) as measured by the Geiger plate method. It shall be resistant to dilute acids, alkalis, greases, gasoline, aliphatic oils, and vermin, and shall meet the flammability requirements listed in Section 15.23. It shall be unaffected by sunlight or ozone, and shall not become brittle with age.

4.3 FLOORS

4.3.1 General

The floor shall be constructed so that all applicable noise, vibration, strength, and fire endurance rating requirements are met. The floor design shall be tested to meet the fire endurance rating requirements of Section 15.23 prior to the Contractor's procurement of production material.

The panels shall be insulated from the metallic structure by an approved elastomeric tape or other method approved by the Engineer. Before applying the floor covering, all voids, fastener heads, cracks between floor panels shall be filled and the floor made smooth and true with an approved leveling compound within 0.0625 inch over 3 feet in any direction. When finished and made smooth, the thickness of the leveling compound shall be less than 0.25 inch or not exceed the manufacturer's recommended limits.

As a minimum, the panels shall be composed of 0.750 inch thick composite panels faced on the entire top and bottom surface with 0.100 inch minimum thickness, bi-axial fiberglass fabric impregnated with a Phenolic thermosetting resin. The fiberglass reinforced Phenolic skins shall be permanently bonded to an approved end grain balsa core or foam through a compression molding process, co-curing the wet Phenolic resin impregnated skins directly against the core. The floor construction and floor panel material shall be submitted to the Engineer for review and approval. **[CDRL 4-005]**

The panels shall be comprised of pieces as large as possible and extend from the side wall to side wall. The ship-lap transverse joints shall be located over structural members. All exposed edges of the panels, including interior holes through, cutouts for ducts and conduits, and joints between panels, shall have a dense Phenolic syntactic composite edge machined smooth and free of sharp edges and burrs. The floor material shall be non-vermin supporting and shall not rot, corrode or absorb water. The passenger compartment floor shall be flat and level throughout and shall not exhibit visible buckles or waviness.

No transverse joints shall be used in the entrance ways.

4.3.2 Strength Requirements

The floor shall be suitably supported by the car framing to provide a structurally sound, and sealed installation which shall not deform permanently under passenger loads up to AW3. The floor deck shall not deflect more than 1/250 of the shortest span between supports, up to a maximum of 0.0625 inches, from a load equal to the sum of dead loads plus a uniformly arranged AW3 passenger load.

The installed floor deck shall be flat and level from end to end in each seating level without waviness or buckles. Floor joints shall not be visible or discernible under the floor covering. The floor structure shall be resistant to the effects of water, road salt, and cleaning fluids.

4.4 FLOOR COVERING

Samples of each floor covering with supporting technical data sheets and details of the floor covering installation system shall be submitted to the Engineer for approval. **[CDRL 4-006]** The floor covering, both rubber tile and carpeting shall be demonstrated by the Contractor to be replaceable either for local repair or complete removal. The interior arrangement of the floor covering shall be submitted to the Engineer for approval. **[CDRL 4-007]**

4.4.1 Rubber Tile

The floors of the vestibule area, stairways, restroom, and control cab, electrical and storage closets shall be rubber Norament® 825 C, square pastille, Article 1871, square tile flooring or approved equal. The color of the floor tiles shall be Purple Fog #1350. The floor tiles shall be a minimum of 0.118 inches thick and of an approved size. Coloring shall be uniform and shall be distributed completely through the material. The coefficient of friction of the floor tiles shall not be less than 0.60 when tested in accordance with ASTM D 2047.

At all door openings, the floor tiles shall connect to form a positively clamped, watertight seal with threshold plates or equivalent moldings. Where the floor tiles reach the walls of the car body, it shall follow the radiused cove to the bottom of the floor heat enclosure. The edge of the floor covering shall be mechanically retained. Nora® 310 PU two-part polyurethane adhesive system shall be used to bond floor tiles to floor panels. All seams between floor tiles shall be cold welded in accordance with the manufacturers recommend procedure.

4.4.2 Carpeting

The area under the seats and the aisle ways between the seats shall be covered with Mohawk Barathea Woven Interlock, pattern BTH/812, color Rainbow Rock or approved equal carpet material. The carpeting shall run longitudinally from bulkhead to bulkhead. No more than three strips shall be used to cover the width of the car. The carpet backing material shall provide water resistance.

The method for securing the carpet to the floor panels shall be consistent in all locations and shall facilitate easy removal for maintenance purposes without damage to the substrate or floor panels. The carpet securement method shall be approved by the Engineer. **[CDRL 4-008]** The carpet shall be arranged so that the aisle strips on all levels can be removed and replaced without disturbing any seats, interior components, parts or other furnishings.

4.4.3 Thresholds

All toilet room doors, body end door, and side door thresholds shall be cast aluminum with grit cast in, and where required, shall incorporate guides for sliding doors and drain holes to carry off water and accumulated debris. The aluminum casting alloy shall be Aluminum Association No. 443 or approved equal. Adhesive backed, non-skid “tape” shall not be permitted.

All thresholds shall have a permanent band of color(s) running the full width of the threshold which contrast from the adjacent floor by 70 percent as determined by the following formula:

Contrast	=	[(B1-B2)/B1] x 100
Where B1	=	Light Reflectance Value (LRV) of the lighter area, and
B2	=	Light Reflectance Value (LRV) of the darker area

Thresholds for sliding doors, which have door guides incorporated into the threshold, shall have renewable and adjustable plates to allow for minimizing the play in door leaves when fully closed.

4.4.4 Low Location Exit Path Marking

Each car shall be equipped with a passive illumination, low location exit path marking system that complies with the requirements of APTA SS-PS-004-99, "Standard for Low-Location Exit Path Marking." The layout of the markings shall be similar to that found on the existing SCRRA vehicles. The system shall be approved by the Engineer and demonstrated on the Pilot Cars. **[CDRL 4-009]**

4.5 INTERIOR LININGS AND FINISHINGS

The ceiling, side walls, and bulkhead walls shall be finished with integrally colored melamine, fiberglass reinforced plastic, or similar approved material and color, applied and fastened in a manner to permit ready removal for maintenance. Where fiberglass reinforced plastic is used, it shall be Tedlar covered using the in-mold process. For each of the interior finishes the Contractor shall submit a repair procedure for review and approval by the Engineer. The repair procedure shall be submitted as part of the preliminary design review package. **[CDRL 4-010]**

End walls, bulkheads, windscreens, and other partitions shall be solid core laminated melamine. Side wall window masks shall be Tedlar covered fiberglass. The Tedlar shall be applied using the in-mold process. The masks shall be retained by elastomeric glazing strips around the windows. Edge radii design of the window masks, as well as the installation procedures, shall prevent stress cracking.

The ceilings shall be lined with 0.125 inch thick balanced melamine panels or Tedlar covered fiberglass. Hinged access panels with limit chains and maintainer's key locks shall be provided for access to equipment mounted overhead, including air conditioning units, battery charger/LVPS, air tanks, and electrical junction boxes.

Supporting technical datasheets for liners, masks and associated trim pieces, bulkheads, end walls, windscreens, and other vehicle surfaces shall be provided by the Contractor. The supporting technical data sheets for each material shall be submitted to the Engineer for approval. **[CDRL 4-011]**

The side lining below the windows shall be of sufficient strength and adequately supported to resist damage by kicking. The side lining below emergency exit/access windows and adjacent seats shall have a provision for supporting removed emergency exit/access windows between the seat and the side wall. Covers for door pockets shall be suitably framed for rigidity and hinged for access to equipment in the door pockets, using the maintainer's key lock. The covers shall be interchangeable by size and/or location.

Edges of covers and removable panels shall be assigned to align with joints on adjacent panels to present an aesthetically pleasing appearances

4.6 STANCHIONS AND WINDSCREENS

All stanchions handrails and grab rails shall meet the requirements of ADA of 1990, 49 CFR 38, 49 CFR 231, 49 CFR 238, and APTA Standard for Attachment Strength of Interior Fittings for Passenger Rail Equipment APTA SS-C&S-006-98.

Circumferential brush finished, 120 grit, stainless-steel stanchions, including tubing, fasteners, and fittings shall be provided in the area of the side doors, stairwells, and in other areas of the car where passengers are likely to accumulate. Stanchions, of suitable strength, shall have an outside diameter of 1.25 inches.

Handrails shall be provided on each side of the stairway from the intermediate level to the upper level, and from the intermediate level to the lower level. Suitable handholds shall be installed on both sides of each side door opening to assist passengers when boarding or alighting from the car. Details of the design and assembly of stanchions, handholds, and handrails shall be submitted to the Engineer for review and approval. **[CDRL 4-012]**

Windscreens shall be provided at the lower level side by each side door opening, extending from approximately 6 inches above the floor to ceiling and projecting 27 inches into the car, and shall include integral stanchions. Windscreens shall be of reduced width at locations where full sized windscreens will interfere with wheelchair or bicycle movement.

All installations shall be free of rattles, squeaks, sharp edges, burns, scratches, pitting, and discoloration. Glass used as part of the windscreens and partitions shall be 0.375 inch thick tempered laminated safety glass and shall include an anti-graffiti/vandal film of optically clear, distortion – free layer of polyester film on both exterior surfaces. The polyester film shall be 3M product or approved equal. The film shall be installed such that it can be removed and replaced without removing the glass from the frame or glazing rubber. The film shall not be considered in determining the thickness of the panes. Glass used in lower level windscreens and partitions, and cab partition wall shall be clear tint and glass used in intermediate windscreens and partitions shall be grey tint with a 24 percent to 28 percent light transmission.

4.7 SEATS

4.7.1 General

It is SCRRA's desire to provide the maximum possible number of seats per vehicle, and each vehicle is required to have a minimum number of seats as per Section 2. The seating design shall be a family of seats capable of being arranged transversely with two-passenger face-to-face seating, two-passenger knee-to-back seating, bulkhead mount, and a flip-up seat. Seats, cushion inserts, and head-rests shall be interchangeable with like seats and cushions.

The seating envelope at face-to-face table and knee-to-back configurations shall conform to the general outline of Section 20, Dwg. No.: 03012005010. Final dimensions shall be supported by ergonomic analysis. Cushion contours shall be similar to those on SCRRA's existing fleet as shown in Section 20, Dwg. Nos.: 03012005000, 03012005001, 03012005002, 03012005003, and 03012005004. The seating configuration, ergonomic measurements, and all features shall include, but not limited to, headrests, crash-pads, center armrests and aisle grab handles

Seats in the cab car shall all be facing the B-end of the cab car, except for the Operator seat and work table locations. Seats in trailer cars shall be distributed such that half the seats are facing the B-end of the trailer car.

Details of the seats, seat arrangements and installation shall be submitted to the Engineer for review and approval. **[CDRL 4-013]** Each seat shall be designed to comply with 49 CFR 238 and APTA SS-C&S-016-99, Rev. 1. All recommended practices in APTA SS-C&S-016-99, Rev. 1 apply. There shall be two basic types of seat assemblies; those with a fixed back and bottom; and those with a fixed back and removable bottom. The Contractor shall identify the differences for each seat configuration and their locations in the vehicles. Each seat configuration shall be included in the design review process.

An engineering design and ergonomic analysis shall be performed by the Contractor in conjunction with the seat manufacturer on the proposed seat design arrangement and installation and shall be submitted for the Engineer's approval. **[CDRL 4-014]** The analysis shall take into account all aspects of the seat design, including as a minimum the materials used in the seat construction, human factor related dimensions, passenger ingress and egress, cushion contours, seat pitch, cushion comfort, seat attachment method, and maintenance. The analysis shall demonstrate the application of compartmentalization concept for each seat type and orientation used.

The seats shall reflect high standards of quality, comfort, and appearance. Resistance to wear and ease of cleaning shall be important considerations and shall be demonstrated during the design review process. Seat spaces shall be defined by contouring or bucketing of the seat bottom and back cushions design and shall also comply with Section 4.5 requirements for spacing between window masks and adjacent seats.

4.7.2 Seat Construction

For seats with a fixed back and bottom, the seat assemblies shall use two seat designs; the low back shall be used for installations adjacent to interior bulkhead walls, and shall not include provisions for handholds; and the high back shall be used in all other knee-to-back and knee-to-knee shall be constructed as a one piece composite part. The seat assemblies shall include an integrated headrest for the high back seats in knee to back configurations the headrest shall include a crash pad feature for the adjacent row of seats. The decorative color and finish shall be a Tedlar covered decorative film such as Schneller Inc. or equal on all exposed surfaces. A co-cured process within the mold shall be utilized to apply the Tedlar film. Direct adhesive applications will not be accepted.

The seat assembly shall provide seating for two (2) passengers. The seat knee-to-back assemblies shall include an armrest to separate the two (2) individual seats. The face-to-face seat assemblies used at work table locations shall have movable armrests that separate the two (2) individual seats, but can be moved out of the way to allow the window seat passenger to exit the work table location.

The seat cushion assemblies shall be designed to define two (2) individual passenger placements. The seat cushion assembly shall be readily removable from the seat without special tools. The seat back cushion shall be a construction of approved fire retardant foam such as Chestnut Ridge XL or approved equal. The seat bottom cushion shall be constructed of Magnifoam silicone foam over a fabric seat suspension such as Entransit or approved equal. The headrest area shall be covered with approved transit grade vinyl upholstery such as Uniroyal Naugahyde Purple Grey-No. 215117 or approved equal material, meeting the requirements of Sections 15.15 and 15.23. The remainder of the seat back and bottom cushion shall be covered with an approved transportation grade woven fabric such as Lantal 90/10 Product No. D20578, Style F072790052, Color M101443-03-09, or approved equal, meeting the requirements of Sections 15.15 and 15.23.

Alternative seat and seat cushion constructions shall be subject to the approved equal process. In addition, the Contractor shall provide sufficiently detailed information to prove that the construction for the proposed alternative(s) is equivalent to the specified construction in terms of strength, performance, comfort, maintainability and durability. Any alternative seat cushion construction shall meet the flammability, smoke emissions and toxicity requirements of Section 15.2.3.

For seats with a fixed back and movable bottom, two (2) types shall be provided; those with legs identified as fold-up seats and without legs identified as flip-up seats. These seat assemblies shall include provisions for the moveable bottom to remain in the last commanded position. These seat assemblies shall be located in the wheelchair parking stations and bicycle storage rack area and submitted for review and as approved by the Engineer. These seats shall not include armrests, but shall be compartmentalized as practicable. Seat assemblies mounted in longitudinal positions may not include headrests. The force required to move the seat bottoms shall be minimized, but in no case shall the force required to move the seat bottom exceed 10 pounds throughout the full range of motion.

4.7.3 Strength

Seat frame construction and attachments to the carbody shall be sufficient to withstand, without permanent deformation, the stresses to be expected in commuter rail operation. Each seat type shall be designed to comply with 49 CFR 238 and APTA SS-C&S-016-99. Each seat type, seat base assemblies and all respective attachments to the carbody or floor shall be tested to and meet the requirements of APTA SS-C&S-016-99, Rev. 1 Section 5.1.1, 5.1.2, 5.1.3 and 5.1.4. All seat configurations shall be dynamically tested in accordance with APTA SS-C&S-016-99, Rev. 1 Section 5.2. The test results shall be submitted to the Engineer for approval. **[CDRL 4-015]**

The seat construction and its attachments to the car body shall withstand, without permanent deformation, the loads to be expected in transit operation, but in no case less than the following:

- The seat design and installation shall withstand a longitudinal force (acting in either direction from front of the seat to back, and back of seat to front, and equally distributed along the back of the seat at an elevation of 3 inches below the top of the seat back) of 300 pounds per passenger (total 600 pounds) for two (2) passenger seat with deflections everywhere less than 0.75 inch with no failure. A permanent set of 0.125 inch maximum will be permitted under these conditions.
- The seat design and installation shall withstand a longitudinal force (acting in either direction from front of the seat to back, and back of seat to front, and equally distributed along thegrab handle) of 300 pounds applied at the aisle side grab handle for two (2) passenger seat with deflections everywhere less than 0.75 inch with no failure. A permanent set of 0.125 inch maximum will be permitted under these conditions.
- The seat design and installation shall withstand a downward vertical load applied uniformly along the front edge of each sitting position of 450 pounds (total 900 pounds) for two (2) passenger seat. A permanent set of 0.125 inch maximum will be permitted under these conditions.
- Each seat within the passenger car that includes the transverse seat attachment to the side structure, seat boxes where used and all crew seating shall be constructed to comply with all aspects of 49 CFR 238.233 Interior Fittings and Surfaces and APTA SS-C&S-016-99, Rev.1.

4.7.4 Work Tables

Work Tables shall be provided only at the face-to-face seats. Work Tables shall be designed in such a manner to provide an aesthetically pleasing, cleanable, stable work surface for writing, retaining computers or food. The edge treatment shall be a flat resilient material wider than the table and shall provide a marine edge to retain fluid spills. The Work Tables shall comply with all aspects of 49 CFR 238.233 and be tested in conjunction with the seating per APTA SS-C&S-016-99, Rev. 1. Energy absorption features shall be built into the Work Table and/or its attachments such that Human Injury Limits for 50th percentile male ATD are not exceeded during dynamic sled testing as per APTA SS-C&S-016-99, Rev. 1, Section 5.2.1 modified for testing seating with a Work Table installed. The design and mounting arrangement of the work tables shall be approved by the Engineer. **[CDRL 4-016]**

4.8 WINDOWS

4.8.1 General

Window glazing materials shall conform to the requirements of Section 15.13 and must comply with FRA standards outlined in 49 CFR 223, 238, and 239. All side and non-F end windows shall be FRA Type II material. The cab car windshields and cab end door windows shall be FRA Type I material.

The maximum solar energy transmittance shall not exceed 50 percent as measured by ASTM E-424. The window assembly shall be grey tint and a visible light transmittance of 28 percent +/- 4 percent. All passenger compartment windows shall be supplied with an antigraffiti/spall film of optically clear, distortion-free layer of polyester film on the interior facing surface. The polyester film shall be 3M product or approved equal. The film shall be installed such that it can be removed and replaced without removing the glass from the frame or glazing rubber. The film shall not be considered in determining the thickness of the panes and the light transmittance requirement.

The window assembly shall be capable of withstanding (with a safety factor of 2.5) the pressure caused by the combination of maximum wind speeds and train speed considering their relative direction created by trains passing in the opposite direction on adjacent tracks at a relative speed of 220 mph.

The Contractor shall ensure positive sealing of the windows against environmental conditions as well as machine car washing without the use of sealants. Corners shall be rounded to facilitate cleaning. Ready repair and ease of replacement from inside the car are mandatory.

4.8.2 Passenger Side Windows

Fixed passenger side windows shall be provided as shown on the general arrangement drawings. Passenger side windows shall be of an integral design and shall be coordinated with the seating and interior layout to provide as much passenger viewing as is practically possible. All passenger side windows shall be double glazed with a 0.375 inch dead air space. The outer pane shall be 0.250 inch tempered safety glass and the inner pane shall be 0.375 inch laminated safety glass or approved equivalent. The inner pane shall comply with the requirements for FRA type II material.

A single pane safety glass design may be proposed for the side windows if the Contractor can show that the construction's solar energy transmittance will be equal to or better than the specified double pane construction.

All glazing shall be installed using extruded seals approved by the Engineer. Clearances between edge of glazing and extrusion, and between extrusion and side skin or door skin shall be sufficient to prevent damage to glazing due to car body deflections. Proper tools shall be used when installing glazing to prevent damage to the window or seal. The use of a sealant to facilitate a watertight seal is prohibited. Exterior paint, if used, shall extend under the window seal extrusions to prevent unpainted metal from becoming visible due to the shifting of rubber during service or maintenance.

4.8.3 Emergency Exit/Access Windows

A total of sixteen (16) windows on each car shall be emergency exit windows and shall be identified and marked accordingly. The emergency exit windows shall be located as follows: four (4) on each side of the upper level, two (2) on each side of the lower level and one (1) on each side of each intermediate level. All emergency exit windows shall function as emergency access windows and shall be identified and marked in accordance with 49 CFR 223.9(d).

The design shall prevent the emergency exit window assembly and its installation parts from becoming loose through normal operation, action of the car washing system or similar functions.

Design and window removal functions shall be in accordance with relevant sections of the requirements of 49 CFR 223, 238, and 239.

The emergency exit windows should be a framed window that will retain a constant shape and size (in lieu of an all rubber assembly) to maintain a consistent pull force for the life of the glazing unit. The operating pull force from the inside shall be a maximum of 40 pounds force for one-handed operation or a maximum of 60 pounds force for a two-handed operation.

The emergency exit window system shall use pull handle(s) colored red and suitably designed for either one-hand or two-hand unbraced pull action or other approved means to release the window assembly from its installation. Each emergency exit window assembly shall incorporate two (2) handles appropriately sized and located, or other approved means, to permit easy removal of the window assembly from its installation. When the window assembly is removed from its installation, these handles shall be suitable to lift and move the window assembly to provide an unobstructed exit route. The emergency window clear opening shall be a minimum of 26.0 inches horizontally and 24.0 inches vertically.

The design of the window assembly, installation system and removal procedure shall be submitted to the Engineer for review and approval. **[CDRL 4-017]** The design shall comply with Section 4.5 requirements.

4.8.4 End Door Windows

Non-cab end door windows shall be single glazed using 0.375 inch FRA Type II clear safety glass. The windows shall be retained in the doors in endless neoprene glazing strips. The maximum solar energy transmittance shall not exceed 90 percent.

4.8.5 Cab Car Control Station Sliding Window

The side window on the cab side of the cab shall be a horizontal sliding or vertical drop type. This window shall act as an emergency window for the Operator. The emergency window clear opening shall be a minimum of 26.0 inches horizontally and 24.0 inches vertically If a horizontal sliding type is used, half of the window shall be fixed and half a sliding sash. The glazing materials shall meet the requirements of Section 15.13. The opening action of the sash shall be a manual operation. Opening force shall comply with 5th percentile female guidelines of MIL Standard 1472E Human Engineering Design Criteria for Military Systems, equipment and facilities. The opening portion shall be lockable in the closed position and will hold, but not necessarily latch, the sash in any position from closed to fully open. The window shall be effectively weather-stripped, free running, reinforced for hard usage and designed to eliminate rattling in any position. Application of Teflon or other expandable coatings shall not be permitted. In the open position, the window opening shall be large enough to enable the Operator to obtain a full view of the side of the train.

Under normal operating conditions in either direction of car travel, the windows shall be weatherproof when in the closed position. The windows shall be retained in an aluminum sash frame. The frame material shall be extruded aluminum and shall be black anodized to withstand the mechanical and weather elements as well as SCRRA’s cleaning chemicals. The frame shall confine the passage of water to the outermost portion of the car, collect it, and drain it to the outside of the car. In order to keep water from running down over operating personnel, sloping gutters shall be installed over sliding windows to redirect water.

The sliding window design installation and glass specifications shall be submitted to the Engineer for review and approval. **[CDRL 4-018]**

4.8.6 Cab Car Windshield

A1 The cab windshields shall meet FRA Type I requirements. The size and location of the Operator's windshield, in conjunction with the location of the Operator's seat, shall ensure that acceptable lines of sight and field of view exist **as required b**y Section 7.2.1. The Contractor shall provide a study of the Operator's field of view showing the vertical, horizontal and side viewing angles for both a 95th percentile male operator and a 5th percentile female operator. The line of sight and field of view shall be demonstrated during the cab mock-up review. A1

Windshields shall be electrically heated to prevent the formation of frost or moisture on the inside surface under all specified operating conditions. Windshield defrost or demisting requirements are in Section 8.2.6 and test requirements are in Section 17.5.5.5. The inside surface of each windshield shall have DuPont-type 307, or approved equal, spall shield.

The windshields shall be single glazed, clear safety glass. The maximum solar energy transmittance shall not exceed 70 percent.

4.9 DOORS

4.9.1 Side Doors

4.9.1.1 General

Sliding doors shall be supplied at two locations on each side of the car, at the lower floor. Each side door opening shall contain two sliding leaves which, when opened, shall withdraw into door pockets without scuffing against seals, insulation, or the door operator mechanism. The doors shall be double sheathed, of the same material as the carbody, construction with glass windows set in rubber glazing strips. Doors shall be free of dimples, warping, spot welding depressions or other deformities. The space between the door sheets shall be filled with a noise and vibration dampening material and thermal insulating glass fiber semi-rigid insulation with performance as per Section 4.2. Approved equal door leaf construction which meets all specification requirements (noise and vibration dampening, thermal insulation, strength, deflection, etc.) shall be submitted to the Engineer for approval.

The door leaves (side doors, end-of-car doors, toilet room door) shall be supported at the top by a tube style bearing door hanger arrangement that shall offer minimum friction to the sliding motion of the doors.

The windows shall be as described in Sections 4.8.4 and 15.13.

4.9.1.2 Door Strength

All side door panel skins, structure and mounting hardware shall be designed to provide sufficient strength and rigidity to withstand a concentrated load of 200 pounds applied perpendicularly to the plane of the door on a 16 square inch area (4 inches by 4 inches, 2 inches by 8 inches, etc.) with the long axis parallel to that of the door 2 inches from the door edge and centered within the height of the door. The allowable maximum deflection shall be limited to 0.375 inch under these conditions with the door simply supported at the top and bottom and there shall be no permanent deformation after the load has been removed. To avoid "oil canning" and warpage, the door design and construction shall take into account the differential expansion of the inner and outer skins at the doors under the extremes of the ambient and car internal temperatures.

4.9.1.3 Door Seals

All doors and edges shall be thoroughly sealed against air and moisture ingress when in the fully closed position. Each door shall be equipped with interlocking rubber bumpers on the leading edge, extending the full height of the door. When doors are closed, the two interlocking bumpers shall mate and form a weather tight joint. Seals shall be provided in the door opening to completely seal the door trailing edges.

4.9.2 End Doors

4.9.2.1 General

Manually opening and automatically closing sliding end doors shall be provided except for the A-end of the Cab Car, which shall have a hinged door that manually opens to the interior of the car. The doors shall be double sheathed construction, fitted with windows, and shall be supported by linear ball bearing hangers with bottom guiding as specified for the side sliding doors. The doors shall be sealed against weather and noise with thermal and acoustic performance as per Section 4.2. The door edge member at the latch side shall be in three pieces to facilitate latch removal. Due consideration shall be given to minimizing warpage as for the side doors. The door shall be free of all dimples, warping, spot welding depressions and other deformities. The design of the A-end cab car end door shall not include exposed rivets as a means of joining the door panel to the door frame.

The end doors shall automatically close. The closing device shall be concealed and adjustable but shall still be readily accessible for maintenance. The door is to be opened manually requiring a force no greater than 20 pounds. The mechanism shall contain provisions to adjust the force required to open the door. The opening force and closing speed shall be reasonably consistent through the full range of ambient temperatures given in Section 2.7.3. The Contractor may submit alternative designs of the door closing mechanism that do not require adjustment and provide the specified performance and functionality, for review and approval by the Engineer.

4.9.2.2 Strength

All end door panel skins, structure and mounting hardware shall be designed to provide sufficient strength and rigidity to withstand a concentrated load of 200 pounds applied perpendicularly to the plane of the door on a 16 square inch area, with the long axis parallel to that of the door 2 inches from the door edge and centered within the height of the door. The allowable maximum deflection shall be limited to 0.375 inch under these conditions with the door simply supported at the top and bottom and there shall be no permanent deformation after the load has been removed. To avoid "oil canning" and warpage, the door design and construction shall take into account the differential expansion of the inner and outer skins at the doors under the extremes of the ambient and car internal temperatures.

The A-end cab car door and its attachment points shall withstand, without door opening, an impact with a 50-pound object with a circular impact area of 1 square foot traveling at 80 mph. The door shall withstand a load of 14,000 pounds, minimum, applied over a circular area of 1 square foot, centered on the door below the window, without yielding and shall be as strong as the end sheathing under the windshield. The air load due to train motion is included in the weight of the impact object.

4.9.2.3 Door Hardware

A latch shall be provided to hold the door in the closed position. This latch shall be operable from either side of the door. Safety locks, operable by an approved crew key, shall be provided to preclude inadvertent opening of the end door by passengers when the car is located at the end of the train. A safety lock override is required for use in the event of an emergency.

The safety lock override shall consist of a release lever on each end door which permits opening of the door from inside the car whether it is locked or not.

A safety bar shall be provided at each end between the collision posts and approximately 42 inches above top of floor. When not in use, the bar shall swing downward and be secured by a spring clip on the web of the collision post. Refer to Section 3.9.2.

To prevent unauthorized entry from the outside while the car is in the train yard, a means shall be provided to secure the end doors from inside the car.

4.9.3 Cab Door

The cab door will be constructed of 0.5 inch thick solid melamine or approved equal. The cab door and its attachments shall be designed to provide sufficient strength and rigidity to withstand a concentrated load of 200 pounds applied perpendicularly to the plane of the door on a 16 square inch area anywhere on the surface of the door. The door shall remain latched under these conditions and there shall be no permanent deformation after the load is removed. A full-length hinge will be installed. The door will be fitted with:

- A clear, tempered, laminated safety glass window, 0.375 inches thick
- An opaque window roller blind
- A foot-operated door open holder
- A lock set which can be opened from the outside with a staff key, and from the inside by pushing in a crash pad
- A1 **A security lock set that can be opened with a security key as per Section 4.19** A1
- A louvered ventilation panel near the bottom of the door.

4.9.4 Toilet Room Door

The handicapped-accessible toilet door will be comprised of two sliding panels. Each panel will be constructed of 0.75 inch thick aluminum honeycomb construction. Each panel will be hung from the top on a linear ball bearing slide arrangement, similar to the end doors. A latch will be provided to hold door in the open position. The door will normally be held closed by a lock set, which can be locked and unlocked manually from the inside, and which can also be locked and unlocked from the outside with a staff key. The operating force for any portion of the Toilet Room, such as locking, door sliding or stopping, shall not exceed 5 pounds force.

4.10 EQUIPMENT LOCKERS

Equipment lockers shall be located in approved locations of all cars. The equipment locker shall be welded construction of type 304 or 430 stainless steel panels on the sides, back, door, floor, and ceiling. Alternative materials may be submitted to the Engineer for review and approval. The stainless steel shall be lined with a minimum 0.125 inch thick Haysite material or approved equal. All wire passages, joints, and seams shall be caulked with approved fire barrier putty.

As a minimum, the area above the intermediate ceiling and below the roof shall be designed to house the self contained heating, ventilation, and air conditioning system (if attic mounted), low voltage power supply and battery charger. The HVAC system shall be removable from the roof, through roof hatches, or directly from the roof, if a roof mounted unit is provided. The design of the HVAC system shall allow routine service and inspection activities to be performed using hinged panels accessible from inside the car.

4.11 ACCESSIBILITY PROVISIONS

Accessibility for passengers with disabilities shall be in compliance with ADA and 49 CFR 27, 37 and 38.

All cars shall provide space near the toilet room for wheelchairs. The design shall provide for companion seating and the layout shall, to the extent possible, avoid having the wheelchairs face the toilet room. There shall be space for four (4) wheelchairs on Cab cars and space for two (2) wheelchairs on Trailer cars. Each car shall also be equipped with a portable bridgeplate to negotiate passage from the car floor to the mini station platform, or vice versa. A portable folding bridgeplate shall be provided in the B-end of each car. The bridgeplate shall be stored in a holder and secured with an approved securement device. The holder shall be designed such that the bridgeplate can be readily deployed and stowed by one employee yet retain the bridgeplate with individually applied accelerations of 8g longitudinal, 4g lateral, and 4g vertical. Weight of portable bridge shall not exceed 30 pounds. Designs and stowing arrangement shall be subject to Engineer's review and approval. **[CDRL 4-019]**

4.12 TOILET ROOM AND WATER SYSTEM

4.12.1 Toilet Room

A toilet room with a lockable door shall be installed in each car. The required accessibility and accommodation provisions of the toilet room shall comply with Section 4.11. As a minimum, the following equipment shall be included in each toilet room:

A1 1. Stainless steel hopper **coated with a non-stick surface** enclosed in a fiberglass shroud that is the same color and finish as toilet room interior, with seat and cover that are black in color. **A1**

2. Vanity assembly which shall include:
   - Stainless steel wash basin.
   - Provisions shall be included for SCRRA to install a dispenser for liquid soap Celeste Industries Part No.: 4154 with a 2 inch diameter base or approved equal. As a minimum, these provisions shall include a properly sized and located mounting hole.
   - Tilted tempered glass mirror for wheelchair passengers.
   - Stainless steel paper towel dispenser.
   - Spring loaded faucet with a palm operated stem valve.
3. Waste container - with spring loaded cover - minimum size of 9 inches width by 4 inches depth by 24 inches length.
4. Disposable seat cover dispenser.
5. Two-roll type toilet paper holder or two (2) separate holders, one-roll type each.
6. Sanitary napkin waste container - with spring loaded cover - minimum size of 7 inches width by 3 inches depth by 9 inches length.
7. Flush-mounted retractable coat hook.
8. Tempered glass mirror for standing passengers.
9. Exhaust fan and grille.
10. Fluorescent ceiling light powered by the emergency lighting circuit.
11. Stainless steel wall mounted handholds around the toilet seat.
12. Illuminated toilet occupied status sign on the toilet room exterior wall.
13. Lockable cupboard in toilet compartment corridor wall for storing supplies.
14. PA speaker mounted behind a grille in the ceiling.
15. Red toilet flush push button.
16. HVAC system outlet.

Signage associated with the toilet room shall be as per Section 20, Dwg. No.: 0811200302 “SCRRA Trailer Car Interior Decals” or approved equal. Details of the design, integration, and installation of the complete toilet room/water system shall be approved by the Engineer. **[CDRL 4-020]**

4.12.2 Toilet Room Construction

The toilet room shall be modular in design to facilitate easy and complete removal. The module shall be completely self-contained, including interior and exterior walls, floor, ceiling, trim and sliding entrance door. Except for the door, the module shall be constructed of fiberglass-reinforced plastic (FRP). The module shall be constructed with as few components as possible. The floor and lower walls shall be manufactured as a one-piece pan extending at least 9 inches up the wall. The upper walls and ceiling shall be constructed of as few pieces as possible. A minimum 3 inch radius shall be provided in all corners to prevent accumulation of dirt and debris. The interior walls of the toilet room shall have a high gloss, gel coat finish measuring a minimum of 80 on a 60° gloss meter. The exterior walls (passenger compartment) shall be fabricated from a Tedlar covered composite laminate, or approved equal.

The module floor shall be designed to withstand the combined loading from a wheelchair and occupant weighing 600 pounds and an assistant weighing 250 pounds. The toilet room floor surface shall be within 0.25 inch of the same plane as the finished floor surface in the passenger compartment. The floor covering material shall conform to the requirements of Section 4.4.1. The floor material shall extend at least 9 inches up from the floor. The edge of the floor covering shall be sealed to be permanently waterproof.

Air, water, and drain line fittings shall be kept to a minimum. All fittings shall be hidden from passenger view, yet readily accessible for maintenance through access doors. All access panels shall use recessed or concealed hinges and shall be equipped with an SCRRA approved lock. Fittings and valves shall be easily identified and serviceable from the access doors. Fittings shall be readily separated with the proper tools. All fittings that pass through the module wall shall be sealed by a neoprene grommet or compression gasket. All fittings shall be heavy duty brass or stainless steel construction. All fittings used in the waste system shall be stainless steel. It shall be possible to remove the stainless steel hopper with minimum disassembly of the module. This shall be demonstrated during review of the mock-up.

A floor drain shall be provided, piped through the floor, and routed so that liquids are not discharged onto any part of the truck or other undercar equipment. The drain shall be capable of being opened and closed from outside of the vehicle near the Waste Dump Outlet on the Right Hand Side of the vehicle, and the drain outlet shall be vermin infestation proof. The drain shall be designed to be opened by an electric valve inside of the toilet room. The floor of the module shall be sloped so that the cleaning solution shall flow to the drain.

The floor heater guard shall be recessed into the wall to the extent practical and otherwise packaged to minimize the intrusion of the fender and grille into the toilet compartment.

4.12.3 Water and Waste System

Each car shall have a water supply and waste system. With the exception of the undercar water fill lines, and the toilet retention tank, all of the components associated with this system shall be located in a utility compartment behind the toilet compartment rear wall and shall be accessible through a hinged door. Illumination of the utility compartment shall be provided by a wall mounted service light.

Water raising shall be by compressed air. An approved pressure reducing valve shall be connected to the main reservoir and shall provide an output pressure of 15 psig which shall be used to pressurize the water system.

Grey water shall be discharged directly to the roadbed; however, the holding tank shall incorporate the appropriate fitting to permit the future installation for the grey water to drain into the holding tank. The tank shall be supplied with the appropriate plug installed in this fitting.

Toilet waste shall be gravity drained to a toilet retention tank mounted directly below the toilet hopper.

4.12.4 Water Tank

Water storage capacity shall be provided by one or more stainless steel tanks mounted in the B end vestibule area next to the partition bulkhead. Approved equal tank locations may be submitted by the Contractor for review and approval by the Engineer. The water storage tank(s) shall comply with the latest edition of the ASME "Unfired Pressure Vessel Code". The tank(s) shall be insulated and provided with antifreeze heaters.

The water system shall be designed for potable water and shall have a minimum usable onboard capacity of 60 US gallons. The onboard water shall be used for drinking, hand washing, and toilet flushing. To prevent drinking water contamination, an FDA approved backflow preventer shall be installed between the drinking water supply and the other parts of the water system.

4.12.5 Water Fill Arrangement

Wayside water fill nozzles with overflow outlets shall be installed on both sides of the car. The water filling system shall permit the wayside water supply pressure to overcome the car water raising pressure. A completely filled system shall be indicated by a steady flow of water from separate water flow outlets located adjacent to the water fill nozzles.

4.12.6 Piping

A properly sized network of copper lines shall be installed to connect the water tanks to the water filling equipment, wash basin, toilet and water cooler, and to provide a means for draining the system to the roadbed. Shut off valves with identification tags shall be provided at major equipment locations. A main drain valve shall be provided under the floor, accessible from below the car. Automatic thermostatic drain valves shall be installed. The drain valves shall automatically empty the water system when the utility compartment interior temperature falls below 34°F. Piping shall be installed in a manner that will prevent the formation of air or water pockets when the system is drained.

4.12.7 Water Cooler

A water cooler shall be located in the utility compartment. The water cooler shall be OASIS Corporation model RLFIS or approved equal. The unit shall provide 50°F drinking water with an Air Conditioning and Refrigeration Institute Standard Rating Condition 80°F inlet water temperature, and a 90°F ambient air temperature. The rated capacity of the unit under these conditions shall be 1 gallon per hour. The water cooler shall provide chilled water to a remotely located water fountain spigot mounted in the toilet compartment corridor wall. A cup dispenser shall be provided for dispensing a 100 count of 5 ounce pleated water cups. The water spigot shall be readily accessible to wheelchair passengers.

4.12.8 Waste System

A1 Waste sanitation shall be provided by a flushing arrangement. **Air assisted (vacuum) systems** A1
A1 **may be used such as Microphor Microflush LF-510/520 with a stainless steel hopper or** A1
A1 **Approved Equal**. When the toilet is flushed, a measured amount of gravity fed biocide solution A1
A1 shall be introduced into the toilet hopper flush water by a separate nozzle mounted in the toilet A1
A1 hopper. **The toilet hopper shall be coated with a non-stick surface**. Toilet flushing shall be A1
initiated by a pushbutton located on the side wall of the toilet room. The biocide storage tank shall be mounted above the ceiling and shall have a minimum usable capacity of 20 US gallons. Swagelok, or approved equal, stem and body fill nozzles shall be installed on both sides of the car.

The waste retention tank shall have a minimum usable capacity of 55 US gallons and shall be protected against freezing. It shall be possible to remove the retention tank without removal of any of the interior components of the toilet room module. The use of automatic drain valves is strictly prohibited. A 3-inch cam and groove waste tank drain fitting with quarter turn shut off valve and dust cap shall be mounted in an approved location on the Right Hand Side of the car. The waste retention tank shall be fitted with an internal water washing arrangement that shall use the yard water supply for tank cleaning. A cleanout plate shall be located on the tank to facilitate
A1 a thorough cleaning of the tank. **The tank shall have a non-stick surface on the interior, be** A1
A1 **sloped towards the waste tank drain and have rounded corners (no right angles).** A1

Alternative waste handling systems will be considered if the Contractor can demonstrate that the alternative system will be reliable, maintainable, and will fit within the maintenance practices of SCRRA.

4.12.9 Exhaust Fan

The exhaust fan to be furnished shall be an industrial grade, meeting NEMA requirements for industrial units. The exhaust fan shall be designed to withstand the condition encountered in transit service. It shall meet the ventilation requirements of Section 8.3.1.

4.13 STAIRS AND STEPS

Steps shall be designed to achieve low level loading at the platforms. The distance from the top of the rail to the top of the side door step shall be 18 inches under normal operating conditions. The design shall minimize the retention of snow and water on the side door steps.

All interior stairs shall have non-skid treads with a high contrast, molded-in, photo luminescent strip on the stair nosing. The stair tread and nosing shall be covered with a one piece, Norament® 925 B, rubber tile or approved equal flooring material. The stairs shall be designed to meet all structural strength and safety requirements. Handrails meeting the requirements of the

ADA shall be constructed of stainless-steel tubing and shall be located to assist passengers using the stairs. The interface between the stair tread and floor covering shall be smooth with no tripping hazards. The interface joint shall be sealed water-tight. Sharp corners shall be avoided to minimize dirt entrapment and facilitate cleaning. Embossed stainless steel kick plates shall be used on the stair risers to reduce wear.

Exterior side steps shall be of expanded metal treads with steel framework and assembly shall be of sufficient strength to withstand heavy passenger loads over the life expectancy of the car.

4.14 LOGO AND SIGNBOARD

Car numbers, logos, signboards, signage and other graphics shall be applied to the interior and exterior of the car. Car end designations shall be included near the car numbers. Logos, signboards, signage and other graphics shall be as per Section 20, Dwg. No.:0811200302 "SCRRA Trailer Car Interior Decals" and Dwg. No.: 0811200301 "SCRRA Trailer Car Exterior Decals," or approved equal. The car number sequence shall be provided by the Engineer. Drawings and samples with supporting data sheets for the car numbers, logos, signboards, signage and other graphics shall be submitted to the Engineer for approval.

4.15 LETTERING SIGNAGE AND NUMBERING

All signs shall be designed to a consistent graphic standard and shall be either rigid stainless steel plates secured with tamper-resistant fasteners, vinyl decals, or other as approved. At a minimum, the decals and signage shall meet all FRA regulations and APTA Standards. The size, location and material of all decals and signage shall be approved by the Engineer. **[CDRL 4-021]**

A Builder's name plate shall be located in an approved location. The car number shall be located on the car roof in size and location approved by the Engineer.

Car number and car end designations shall be applied over both end doors, in the lower vestibule, and in the upper passenger compartment at each end.

Approved identification of switches, circuit breakers, and fuses shall be provided in each electrical locker. Approved identification plates for all brake equipment valves shall be provided on the manifold.

A single digit number identifying each side door leaf shall be applied to the interior surface of each door leaf. The numbering scheme shall be as per Section 20, Dwg. No.: 0811200302 "SCRRA Trailer Car Interior Decals," or approved equal.

A number identifying each seat shall be applied to the upper horizontal surface of each seat back shell. The numbering scheme and location will be provided to the Contractor by the Engineer.

On the interior of one of the electrical locker doors, an aluminum plate shall be mounted showing the car number, identity, class of car, and date and place of manufacture. Record and log book holders shall be mounted inside the same door.

The cover of the emergency tool kit, first aid kit, and fire extinguisher cases shall be labeled with suitable access instructions.

Labels shall be provided for, but not be limited to, the following items:

- Overhead heaters.
- Air filters.
- Emergency brake valves (red lettering).
- DANGER DO NOT TOUCH (as appropriate - red lettering).
- DANGER 480 VOLTS (as appropriate - red lettering).
- HVAC temperature sensors.

The Contractor shall provide a Passenger Equipment Roof Emergency Access system that complies with the suggested requirements of APTA RP-C&S-001-98.

The Contractor shall provide a Low Location Exit Path Marking (LLEPM) system as required by APTA SS-PS-004-99. In designing the LLEPM system, the Contractor shall consider that the primary exit path shall be to the next car and not to the wayside.

Details of the design, arrangement, and installation of all signage, decals, graphics, Roof Emergency Access and LLEPM system shall be submitted to the Engineer for review and approval. **[CDRL 4-022]**

4.16 FIRE EXTINGUISHER

Four (4), 5-pound dry chemical fire extinguishers, (2A-10BC) or equivalent shall be furnished. Two (2) shall be flush-mounted on the lower level in a prominent position near the stairways, and two (2) shall be flush-mounted on the upper level in the end walls. The extinguishers shall be securely mounted on approved brackets in a manner that will prevent vibration and rattling. Access to fire extinguishers shall be provided with maintainer's key latches for maintenance. A breakable, clear plastic or polycarbonate window installed in a removable glazing section shall be provided for in-service access. Emergency access procedure shall be approved by the Engineer. Dry charge shall be as approved by the fire marshal in the area of intended use. **[CDRL 4-023]**

4.17 EMERGENCY TOOLS

Each car shall be provided with a set of railway standard emergency tools permanently marked "SCRRA" . Tools shall be: one (1) handsaw (metal cutting), one (1) axe, one (1) pry-bar, and one (1) 8-pound sledge hammer. The flush-mounted access door shall be fitted with a transparent plastic removable cover. A breakable clear plastic or a polycarbonate window installed in a removable glazing section shall be provided for in service access. Emergency access procedure shall be approved by the Engineer. **[CDRL 4-024]** Access to emergency tools cabinet to be provided with maintainer's key latches. An emergency flashlight with a charge indicator shall be provided and shall be mounted in the emergency tool compartment. The emergency flashlight shall be a DME Corporation P/N 207001214 or approved equal.

4.18 FIRST AID KIT

Each cab car shall be provided with provisions to store a first aid kit in the cab crew locker which shall comply with California Public Utilities Commission (CPUC) General Order No. 126 and 49 CFR 239.101. The cab car first aid kit is 10 inches by 10 inches by 2.5 inches. Each car shall be provided with provisions for a first aid kit in the passenger area which shall comply with California Public Utilities Commission (CPUC) General Order No. 12. The passenger area first aid kit is 8 inches by 5 inches by 2.5 inches. The first aid kit shall be contained in a recessed cabinet with a transparent plastic window located on lower level. Access to the first aid kit cabinet shall be provided with maintainer's key latches. A breakable, clear plastic or polycarbonate window installed in a removable glazing section shall be provided for in service access. Location of kits and Emergency access procedure shall be approved by the Engineer. **[CDRL 4-025]**

4.19 KEYS AND LOCKS

All keys shall be the same as provided for SCRRA existing fleet. The maintainer's key shall be James L. Howard P/N 2818EA or approved equal; the staff key shall be James L. Howard P/N 22389A or approved equal; and, the security key be Best Access Systems keyed to B101797-C503-RP3-626. The Contractor shall provide drawings identifying each key type and the location of its proposed use as identified in the Technical Specification. **[CDRL 4-026]**

Each cabinet or access door shall have one security lock that shall be opened with a security key. The locks shall comply with the following requirements:

1. Cabinet cylinders to be a Mortise Type cylinder, installed through the use of a hex nut.
2. Cylinders to be threaded the entire length of the body.
3. Cylinder to include a direct-drive cam, with cam dimensions being of various widths and lengths. (measured from tip of cam to center of rotation).
4. Provide locksets with 7 pin [BEST] interchangeable Patented core cylinders.
5. All mortise cylinders shall have a concealed internal set-screw to better secure the cylinder. The internal set-screw will be accessible only by removing the core from the cylinder body with a control key.

4.20 SAFETY APPLIANCES

Safety appliances shall be in accordance with current requirements of 49 CFR 231 and, where applicable, 49 CFR 38.

The exterior handhold arrangements of both ends of the car shall be identical. The following handholds shall be provided in accordance with 49 CFR 231.14 (passenger train cars without end platforms):

- One (1) vertical handhold above the sill step, on each side of the car.

- One (1) horizontal handhold on each end sill, on each side of the coupler, at the end of the car.
- One (1) horizontal handhold at the roof line, on each corner of the car. The handhold shall be equipped with a loop for securing a ladder.
- One (1) vertical handhold at each end door on the outside of the car.
- One (1) vertical handhold above each side-door step on each door post.

4.21 TRASH RECEPTACLES

A stainless steel waste receptacle with removable lid capable of containing a 30 gallon garbage bag shall be provided on each intermediate level at the top of the stairway from lower to intermediate levels. Approved equal locations, subject to equipment interior design and layout, may be submitted for review and approval by the Engineer.

4.22 BICYCLE STORAGE

Every car shall provide space and securing mechanisms for two bicycles oriented transversely, at the A end of the lower level of the car. The securing mechanisms, while securing two bicycles, shall be in compliance with 49 CFR 238.233 and shall be approved by the Engineer. **[CDRL 4-027]**Approved equal locations that maximize seating capacity and enhance passenger flow onto, off of, and through the car may be submitted to the Engineer for review and approval.

4.23 VESTIBULE CURTAINS

A full height vertical curtain of vinyl coated fabric material, Adams and Westlake Ltd. or equal, shall be provided, complete with an automatic-release handle. The curtain shall be mounted at the left side of each diaphragm with a matching hook on the right side as seen looking at the diaphragm from outside the car. The vestibule curtain installation system and location shall be the same as for the existing SCRRA fleet or approved equal, i.e. Adams and Westlake Ltd. P/N P103319 or approved equal.

4.24 EXTERIOR FINISH

All exterior surfaces of the carbody shall be unpainted stainless steel with a grit finish, unpainted aluminum with a grit finish or painted aluminum unless otherwise specified in this Specification. If corrugated, the visible metal surface of stainless steel shall have AISI No. 2-B finish where it is corrugated and a fine grit scratch finish, with grain horizontal (except door framing and collision posts which shall have a grain parallel to the longer dimension of each piece) where it is not corrugated. The visible metal surface of aluminum shall have a fine grit (50) scratch finish with grain horizontal. The exterior paint system for painted aluminum car shells shall be compatible with the paint system used for the existing SCRRA fleet (AKZO Nobel Coatings Inc. - Autocryl or approved equal) of multi-level rail passenger vehicles and shall, when used in Southern California meet the applicable California South Coast Air Quality and Management District requirements.

The color scheme shall be similar to the existing SCRRA color scheme except that unpainted stainless steel or aluminum surfaces shall be in place of white painted surfaces and Metrolink Periwinkle color banner type stripe decals shall be applied to each side of the carbody in place of painted Metrolink Periwinkle stripes. SCRRA and Contractor shall work jointly to develop the color scheme and configuration of the banner stripe decal as part of the exterior graphics package.

The Contractor shall provide and apply the exterior graphics package to the carbody. The exterior graphics package shall include all FRA and APTA required and recommended signage. Lettering, signage and all graphics, tags and other lettering shall be as per Section 20, Dwg. No.: 0811200301 "SCRRA Trailer Car Exterior Decals," or approved equal. Drawings and samples with supporting data sheets shall be submitted to the Engineer for approval. **[CDRL 4-028]**

End of Section

Contract Deliverables Requirement List

CDRL No.	Title	Car Type	Reference Paragraph
4-001	Test Results of Interior Materials Supplied Showing Conformance with Performance and Flammability Standards	All	4.1.1
4-002	Interior Materials' Design and Installation	All	4.1.1
4-003	Four (4) Interior and Three (3) Exterior Finalized Color Detail Renderings of Industrial Design	All	4.1.2
4-004	Mechanical Fastenings Used to Position Thermal Insulation	All	4.2.2
4-005	Floor Construction and Floor Panel Material	All	4.3.1
4-006	Sample of Each Floor Covering with Supporting Technical Data Sheets and Details of Floor Covering Installation System	All	4.4
4-007	Interior Arrangement of Floor Covering	All	4.4
4-008	Carpet Securement Method	All	4.4.2
4-009	Low Location Exit Path Marking	All	4.4.4
4-010	Repair Procedures for Interior Finishes	All	4.5
4-011	Interior Linings and Finishings Supporting Technical Data Sheets	All	4.5
4-012	Details of Handrails Design and Assembly	All	4.6
4-013	Details of Seats, Seat Arrangements, and Installation	All	4.7.1
4-014	Engineering Design and Ergonomic Analysis on Proposed Seat Design	All	4.7.1
4-015	Dynamic Test Results of All Seat Configurations	All	4.7.3
4-016	Design and Mounting Arrangement	All	4.7.4

CDRL No.	Title	Car Type	Reference Paragraph
	of Work Tables		
4-017	Design of Window Assembly, Installation System, and Removal Procedure	All	4.8.3
4-018	Sliding Window Design and Glass Specifications	All	4.8.5
4-019	Accessibility Designs and Stowing Arrangement of Bridgeplate	All	4.11
4-020	Design, Integration, and Installation of Complete Toilet Room/Water System	All	4.12.1
4-021	Size, Location, and Material of All Decals and Signage	All	4.15
4-022	Design, Arrangement, and Installation of All Signage, Decals, Graphics, Roof Emergency Access and LLEPM System	All	4.15
4-023	Fire Extinguisher Emergency Access Procedures	All	4.16
4-024	Emergency Tools Emergency Access Procedure	All	4.17
4-025	First Aid Kit Location of Kits and Emergency Access Procedures	All	4.18
4-026	Key Types and Locations	All	4.19
4-027	Bicycle Storage Space & Securing Mechanism	All	4.22
4-028	Drawings and Samples with Supporting Data Sheets for Color Scheme, Lettering, Signage, and All Graphics	All	4.24

SECTION 5

COUPLER, DRAFT GEAR, AND

TRAINLINE CONNECTIONS

SECTION 5

COUPLER, DRAFT GEAR, AND TRAINLINE CONNECTIONS

TABLE OF CONTENTS

SECTION 5

COUPLER, DRAFT GEAR, AND TRAINLINE CONNECTIONS

5.1 GENERAL

As a minimum, the couplers shall have sufficient lateral swing and the trainlines shall have sufficient clearance to allow the car to negotiate the track conditions described in Section 2, while coupled to another SCRRA car and/or locomotive.

Separate hoses and jumper cables shall be used for pneumatic and electrical connections. The coupler, draft gear, and trainline connections shall be compatible and interchangeable with those of the existing SCRRA multi-level commuter car fleet. If changes to connections are required, the Contractor shall submit a report to the Engineer identifying the differences and their impact on existing fleet. The Contractor shall comply with all of the requirements, and guidelines provided in APTA RP-M-003-98 to demonstrate through design, analysis and testing that the coupler, draft gear, yoke and coupler carrier conform to the requirements of this Specification. For each batch of couplers, coupler yokes, draft gear followers and pins, the Contractor shall provide certification that the materials used in the manufacture of the components and the assemblies have been manufactured, sampled, tested and inspected in accordance with, and comply with, the requirements of APTA RP-M-003-98. Each certification shall be signed by an authorized representative of the supplier and the Contractor.

Details of the design, arrangement, installation, and testing of coupler, draft gear, and trainline connections (electric and pneumatic) shall be submitted to the Engineer for review and approval. **[CDRL 5-001]**

5.2 REFERENCE DOCUMENTS

- APTA SS-C&S-034-99, Rev. 1 – Design and Construction of Passenger Railroad Rolling Stock.
- APTA RP-E-016-99 – Recommended Practice for 480 VAC Head End Power System.
- APTA RP-E-017-99 Recommended Practice for 27-Point Control and Communication Trainlines for Locomotives and Locomotive-Hauled Equipment.
- APTA RP-E-018-99 – Recommended Practice for 480 VAC Head End Power Jumper and Receptacle Hardware.
- APTA RP-E-019-99 – Recommended Practice for 27-Point Jumper and Receptacle Hardware for Locomotives and locomotive-Hauled Equipment.
- APTA RP-M-003-98 – Recommended Practice for Purchase and Acceptance of Type H – Tightlock Couplers.

5.3 COUPLER ASSEMBLIES

5.3.1 CEM Features

Except as provided for by Section 3.10.7, both ends of all cars shall be equipped with push–back, energy absorbing coupler assemblies. A higher capacity coupler shall be provided on the F-end of the cab car.

The coupler assembly shall include mechanical "H" type tight lock coupler, manual uncoupling mechanism, draft gear unit, anchor, energy absorption unit, and support and centering devices. The couplers shall be designed and manufactured to comply with all the requirements and guidelines of APTA RP-M-003-98 except as otherwise specified. Draft gear characteristics shall be compatible with units on the existing SCRRA commuter rail cars and locomotives. It shall be possible to couple the cars procured under this Contract to existing SCRRA cars and locomotives without the use of an adapter. The coupler assemblies shall be accessible for inspection, maintenance and trouble-shooting on the cars without requiring the removal of any components.

Coupler testing requirements specific to CEM are in Section 17.3.9 and Section 17.5.1.14.

The coupler assemblies shall be designed to permit lifting of the car using the coupler as point of lifting. The Contractor shall provided a detailed analysis to verify the coupler assembly subjected to these loads. **[Part of CDRL 5-001]**

The push-back energy absorbing coupler assemblies shall meet the requirements shown in Table 5-1, Push-Back, Energy Absorbing Coupler Requirements except that the difference between the actual coupler and PEAM initiation loads in the Contractor's design shall not be less than 200,000 pounds. Refer to Section 3.10.7.1 and Section 3.10.7.2 for PEAM requirements. For example, if the Contractor's design PEAM initiation load is 950,000 pounds, the coupler initiation load may not exceed 750,000 pounds. There shall be no permanent deformation of the coupler support structure prior to exhausting the minimum Push Back Stroke

Table 5-1

Push-Back, Energy Absorbing, Coupler Requirements

Application	Minimum Initiation Load, Pounds	Maximum Initiation Load, Pounds	Minimum Energy Absorption, Foot-Pounds	Minimum Push-Back Stroke, Inches
All, except Cab Car F-end	450,000	800,000*	300,000	9
Cab Car F-end	450,000	800,000*	500,000	20

* The difference between the actual coupler and PEAM initiation loads in the Contractor's design shall not be less than 200,000 pounds. Refer to Section 3.10.7.1 and Section 3.10.7.2.

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

A1 In impacts of **12** mph or less involving CEM cab cars and trailers equipped with push back energy **A1**
absorbing couplers, it is intended that the collision energy will be dissipated while the energy
absorption unit is within the approved push back range. In this case, damage to the end-of-car
A1 must be limited to components that are easily replaceable **such as the diaphragm, sprung** **A1**
A1 **buffer, walkover plates, etc**. Damage to the primary structure is unacceptable. Additionally, the **A1**
attachment of the coupler assembly shall remain intact, allowing loads to be applied through the
assembly to tow the train to the SCRRA facility.

Structural requirements, as related to the CEM feature of the coupling mechanism, are further detailed in Section 3.10.5.

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

Whether the coupler assembly, the coupler assembly in combination with another mechanism or another mechanism is used to provide the anti-climbing feature, the anti-climbing feature as required by 49 CFR 229.141(a) and 49 CFR 238.205 shall be maintained even when the push-back feature is exhausted. **[Part of CDRL 5-001]**

5.3.2 Coupler

Two (2) high tensile steel tightlock couplers, single rotary locklift operating type with “H” type tight lock heads and shanks, shall be provided on each car. The coupler shall withstand the loads and stresses specified in APTA RP-M-003-98. The material shall be to the requirements of Section 15.8.1. The couplers shall have sufficient lateral swing to allow the car to negotiate the track conditions, described in Section 2, while coupled to another SCRRA car and/or locomotive. The coupler height shall be adjusted to 34.5 inches from top of rail to centerline of coupler before leaving the Contractor’s plant. Coupler height shall be adjusted with the trucks leveled and adjusted in accordance with Section 11. No paint shall be applied to the coupler. The coupler design shall preclude couplers coming uncoupled on tracks due to debris strikes. The coupler assembly shall include a lift lock mechanism H15A, Columbus Steel BS-15 or approved equal. The Contractor shall submit an analysis, for approval by the Engineer, showing that the draft gear arrangement is capable, within reasonable margins of safety, of withstanding the loads encountered during conditions described in the Technical Specification. **[Part of CDRL 5-001]**

5.3.3 Uncoupling Lever

An uncoupling arrangement shall be provided at each end of the car. It shall be a standard APTA type No. 6 operating mechanism arranged for operation from the side of each car end that is on an observer’s left side when viewing the corresponding end of the car. The uncoupling arrangement shall be submitted to the Engineer for approval. **[CDRL 5-002]**

5.4 DRAFT GEAR AND YOKE

5.4.1 Draft Gear

Cushioned draft gears shall be National Castings Type MS-489-6A, ASF-Keystone P/N 46908 or approved equal, as provided on the existing SCRRA fleet, or approved equal as required by the Contractor's approved CEM design.

5.4.2 Draft Gear Pockets

Draft gear pockets shall be properly sized to accommodate the draft gear and yoke arrangement described.

5.4.3 Yoke

Two (2) high tensile steel, tight lock, quadruple shear coupler yokes shall be provided on each car for use with the draft gear and APTA "H" type short shank coupler. The yoke shall withstand the loads and stresses specified in APTA RP-M-003-98. The material shall be to the requirements of Section 15.8.1. Yokes shall be complete with bushings and yoke pin. No paint shall be applied to the yoke, bushing, or pin. The yoke shall be National Casting No. 46637, ASF-Keystone P/N 46908 or approved equal as provided on the existing SCRRA fleet, or approved equal as required by the Contractor's approved CEM design.

5.5 COUPLER CARRIER

Coupler carriers shall be of the spring loaded, floating type, or approved equal as required by the Contractor's approved CEM design, and shall meet the strength requirements of Section 5.5 of APTA SS-C&S-034-99. The coupler carrier shall be equipped with non-metallic wear plates and with non-metallic side and end pads and stops to prevent metal-to-metal contact except at the coupler shank interface which shall have a manganese steel wear plate as per Section 3.3.2.2(c). The arrangement shall permit adjustment to suit AAR and APTA Recommended Practices and Standards, whichever is applicable, for vertical and horizontal movement. These arrangements shall comply with the noise requirements of Section 2.5.2.

5.6 PNEUMATIC TRAINLINE CONNECTIONS

AAR approved, locking type angle cocks shall be provided for the Brake Pipe on both ends of the car. Locking type, self-vented, cut-out cocks shall be provided for the Main Reservoir Equalizing Pipe at both ends of the car so the handle is located to minimize debris strikes. Angle cocks at the ends of the cars shall be accessible and located in accordance with the latest AAR and APTA recommendations and the requirements of SCRRA. Dummy couplings and chain assemblies for air connections shall be provided at each end of the car.

The air hoses shall be located in such a manner to avoid fouling or kinking when cars are coupled on straight or curved track. The Contractor shall ensure that pipe and hose locations are consistent among all cars. Hose supports, approved by the Engineer, shall be applied to prevent coupled or uncoupled hose ends from dropping below 2.75 inches above top of rail. **[Part of CDRL 5-001]**

Brake pipe connections shall be provided in the same location as on existing SCRRA cars. Brake pipe hose shall be AAR standard.

Main reservoir air connections shall be located adjacent to the couplers for compatible interface with SCRRA's existing locomotives and passenger cars. Main reservoir hose shall be Aeroquip 1531-16 with LS-4 couplings, or approved equal.

5.7 ELECTRIC TRAINLINE CONNECTIONS

5.7.1 Trainline Requirements

Trainline receptacles and cables shall be mounted at both ends of the car in such a manner and location to permit one end of one car to be connected to either end of another car or locomotive. All receptacles shall be located above the uncoupling levers in a manner, orientation and location as provided for the existing SCRRA multi-level commuter cars. The receptacles shall be downward sloped. All wiring shall be adequately protected from damage. The trainline wiring shall be arranged such that a locomotive can control the operation of the train when coupled at either end of the train with the cars oriented in either direction in any location in the train, and the cars will operate properly regardless of location and individual orientation in the train.

Where individual conductors and multi-conductor cables enter trainline junction boxes watertight, strain relief fittings shall be used for each conductor.

5.7.2 Locomotive Control (MU) Trainline

A 27-conductor, Locomotive Control (MU) trainline system shall be provided through each car for remote control of the locomotive from a control cab car or another locomotive at the opposite end of the train.

The pin assignments shall be in accordance with Table 5-2, Locomotive Control (MU) Trainline Wire Assignment. Wires to pin numbers 8 and 9 shall be crossed over in the car wiring at the B-end of the car.

A yellow, 27-pin male receptacle assembly, Pyle-National P/N P-201452KCY or Clements CRA-27-MU-LC, or approved equal, shall be provided at both ends of each car and each side.

Two (2) locomotive control 27-pin jumpers shall be provided. The jumpers shall be yellow Pyle-National P/N P-201453KCY-80 or Clements CPA-2780-MU-LC or approved equal. Wires to pin numbers 8 and 9 shall be crossed over in the jumper.

Locomotive Control (MU) jumpers and receptacles shall be mounted in a location compatible with the existing SCRRA fleet as shown in Section 20. Final design and wire size shall be submitted to the Engineer for approval. **[CDRL 5-003]**

All unassigned carbody trainline wires from the 27-conductor Locomotive Control (MU) trainline system shall be connected through to the trainline receptacles.

Three (3) spare trainlines, in addition to the 27-conductor trainline system, shall be connected end-to-end of each car and shall be terminated at terminal blocks in the end-of-car junction boxes.

Table 5-2

Locomotive Control (MU) Trainline Wire Assignment

Pin Number Symbol		Symbol	Function
A-End	B-End		
1	1	TLM Blk	Load Meter
2	2	SG	Alarm
3	3	DV	Engine Speed DV
4	4	N	Control Negative
5	5	LAES	Loco Assigned (ES)
6	6	GF	Generator Field
7	7	CV	Engine Speed CV
8*	9*	FO	Forward
9*	8*	RE	Reverse
10	10	WS	Wheel Slip Indicator
11	11	TLM Wht	Load Meter
12	12	BV	Engine Speed BV
13	13	PC	Control Positive
14	14	ZSP	Zero Speed Bypass
15	15	AV	Engine Speed AV
16	16	ER	Engine Run
17	17	B	Dynamic Brake Setup
18	18	LASP	Loco Assigned (Caltrans)
19	19	LASP	Loco Assigned (Caltrans)
20	20	BW	Dynamic Brake Warning
21	21	BG	Dynamic Brake Start
22	22	LASP	Loco Assigned (CC)
23	23	SA	Manual Sanding
24	24	BC (PRC)	Dynamic Brake Excitation
25	25	ALEP	Aux. Light Positive
26	26	ALEN	Aux. Light Negative
27	27	SP	Not Assigned

***Note:** Wires to Pin numbers 8 and 9 are crossed over in the car wiring of the B-end of the car.

5.7.3 Door Control and Communication Trainline

A 27-conductor door control and communication trainline system shall be provided through each car. The trainline shall have the necessary pins and conductors for door control, communication, battery trainline, and brake control functions.

The pin assignments shall be in accordance with Table 5-2, Door Control and Communication Trainline. Wires to pin numbers 2 to 11; 17 to 27; and 18 to 26 shall be crossed over within the car wiring at the B-end of the car.

A red, 27-pin male receptacle assembly, Pyle-National P/N P-201452-ACKR or Clements P/N CRA-27-MU-CC or approved equal, shall be provided at both ends and each side of the car.

Two (2) door control and communication 27-pin jumpers shall be provided. The jumpers shall be of the same style and size as those used for the locomotive control (MU) trainline. They shall be red jumpers Pyle-National P/N P-201453-ACKR-80 or Clements CPA-27-MU-CC or approved equal. Wires to pin numbers 2 to 11; 17 to 27; and 18 to 26 shall be crossed over within the jumper.

Door control and communication jumpers and receptacles shall be mounted in a location compatible with the existing SCRRA fleet as shown in Section 20. Final design and wire size shall be submitted to the Engineer for approval. **[CDRL 5-004]**

All unassigned carbody trainline wires from the 27-conductor door control and communications trainline system shall be connected through to the trainline receptacles.

Three (3) spare trainlines, in addition to the 27-conductor trainline system, shall be connected from end-to-end of each car and shall be terminated at terminal blocks in the end-of-car junction boxes.

Table 5-3

Door Control and Communication Trainline

Pin Number Symbol		Symbol	Function
A-End	B-End		
1	1	TZS	Zero Speed
2 *	11 *	TPL	Pass Enable Left
3	3	TDH	Door Interlock
4	4	TN	Neg 36 VDC
5	5	TWD	Passenger Alarm
6	6	TLB	Buzzer Power
7	7	TRA Blk	Intercom, black
8	8	SP	Not Assigned

Pin Number Symbol		Symbol	Function
A-End	B-End		
9	9	TRA Blk	PA/IC Control, black
10	10	TRA Wht	PA/IC Control, white
11*	2*	TPR	Pass Enable Right
12	12	TRA	Intercom (Shield)
13	13	TRA Wht	Intercom, white
14	14	TDC	Door Closed Light
15	15	TRA Blk	PA System, black
16	16	TRA	PA (Shield)
17*	27*	TDD	Door Open (Left)
18*	26*	TDD	Door Closed (Left)
19	19	LATP	Pos 64V DC (Loco Assigned)
20	20	TRA Wht	PA System, white
21	21	TDB	Buzzer
22	22	TDO	Door Override
23	23	TBR	Brake Indicator
24	24	T	Layover Control +36V
25	25	SP	Not Assigned
26*	18*	TDE	Door Closed (Right)
27*	17*	TDE	Door Open (Right)
***Note**: Wires to Pin Number 2 and 11; 17 and 27; and, 18 and 26 are crossed over in the car wiring of the B-end of the car.			

5.7.4 Head End Power (HEP) Trainline

A 480 VAC Head End Power (HEP) trainline system shall be provided through each car. The pin assignments shall be in accordance with Table 5-4. A power control trainline as described below shall also be provided on each car to establish trainline completeness before connecting the power supply from the locomotive to the train.

Two (2) red 3/3 pole receptacles, Pyle-National P/N RPC17-XXX or Clements MRA-1-XXX molded type or approved equal, each having three (3) main power contacts and three (3) control contacts, shall be provided at each end of the car for a total of four (4) receptacles per car. The HEP trainline system shall be compatible with existing SCRRA commuter cars and locomotives. Final design and wire size shall be submitted to the Engineer for approval. **[CDRL 5-005]**

Two (2) fixed jumper assemblies, Pyle-National P/N RPC-11-XXX or Clements MPA-1-XXX molded type or approved equal, each consisting of three (3) 4/0 AWG (minimum) single conductor cables and one (1) 3-conductor 10 AWG cable with 3/3 pin plug, shall be provided at each end of the car for a total of four (4) jumpers per car. Three (3) 10 AWG conductors shall be terminated to the three control pins at each of the HEP connectors on the car. One (1) conductor shall run the length of the car from each HEP jumper and receptacle to form the continuity interlock circuit (loop circuit) that provides the trainline complete signal to the locomotive and wayside power station. The other two (2) 10 AWG conductors shall be terminated in two (2) control pins of the fixed HEP jumper cables and HEP receptacles on each car. These conductors shall be connected to car body ground to form a car-to-car carbody ground bond.

The jumper plugs shall have three (3) power pins and three (3) shorter control pins. When any jumper is disconnected, the shorter control pins shall break contact first, opening the trainline complete circuitry and, as a result, the output contactor of the HEP 480 VAC supply in the locomotive to prevent disconnecting the power pins under load.

Jumpers and receptacles shall be so designed and located to permit each jumper to be inserted into the adjoining receptacle on the next car or, if an end car, into the adjacent receptacle to complete the control circuit. If required, the loose ends of cables shall have a semi-permanent chain and clasp support arrangement. This device shall allow for replacement of the cables, including support chains and cords without the use of any special tools.

Trainline wires shall be 4/0 AWG (minimum) for power circuits and 10 AWG (minimum) for control circuits, except as noted, with Exane insulation.

Table 5-4

HEP Trainline Wire Assignments

Pin	Wire Size (AWG)	Signal/Power Source	Description	Function
1	4/0	Loco HEP	HEP Trainline Phase A	480 VAC head end power
2	4/0	Loco HEP	HEP Trainline Phase B	480 VAC head end power
3	4/0	Loco HEP	HEP Trainline Phase C	480 VAC head end power
1P (4)	10	Loco Pos	HEP Complete	HEP Complete
2P (5)	10	Ground	Ground Path	Grounded
3P (6)	10	Ground	Ground Path	Grounded

5.7.5 Labeling and Color Coding

HEP trainline, Door Control and Communication trainline and Locomotive Control trainline jumpers and receptacles shall be labeled to indicate their functions and shall also be color coded to assist employees in making up trains, as follows:

Table 5-5
Jumper and Receptacle Colors

Jumper and Receptacle	Color
Door Control and Communication Receptacles and Jumper Head	Red
Loco-control Receptacles and Jumper Heads	Yellow
HEP Receptacles and Jumper Heads	Red

5.7.6 Location of Jumpers

HEP trainline, Door/Communication trainline, and Locomotive Control trainline jumpers and receptacles shall be so designed and located to permit movement of the cars, coupled to one another or to a locomotive, over the curves and crossovers specified in Section 2 without damage to the jumper loops and heads. Jumpers and receptacles shall be located as near as possible to the underside of the end sill, but mounted above the uncoupling lever and not higher than 50 inches above the top of the rail. Jumper hangers or supports shall be provided to prevent damage.

5.7.7 Plug and Receptacle Design

Jumper plugs and receptacles shall be designed so that if cars are separated before jumpers are unplugged, no damage will result to jumper or receptacle. The method of achieving this shall be submitted to the Engineer for approval. **[Part of CDRL 5-001]** The design and location of all trainline connections shall provide compatibility with existing cars.

End of Section

Contract Deliverables Requirement List

CDRL No.	Title	Car Type	Reference Paragraph
5-001	Details of Design, Arrangement, Installation, and Testing of Coupler, Draft Gear, and Trainline Connections	All	5.1
5-002	Details of Uncoupling Lever Arrangement	All	5.3.2
5-003	Locomotive Control (MU) Trainline Design and Wire Size	All	5.7.2
5-004	Door Control and Communication Trainline Design and Wire Size	All	5.7.3
5-005	HEP Trainline System Design and Wire Size	All	5.7.4

SECTION 6

DOOR SYSTEM AND CONTROLS

SECTION 6

DOOR SYSTEM AND CONTROLS

TABLE OF CONTENTS

SECTION 6

DOOR SYSTEM AND CONTROLS

6.1 GENERAL REQUIREMENTS

Sliding, bi-parting doors, shall be supplied at two locations on each side of the car, at the lower level. The doors shall be double sheathed construction, with glass windows set in rubber glazing strips. The space between the sheets shall be filled with a noise and vibration dampening material. The threshold shall have integral grooves for a seal rubbing strip and for drainage. Anti-skid safety strips shall be provided. The design, operation, installation, arrangement, and associated signage shall comply with APTA SS-PS-002-98, Rev. 2, APTA SS-C&S-012-02 and 49 CFR 27, 37, 38, and 238. The entire vehicle door system shall meet the EMI/EMC requirements of Section 17.5.17.

At all speeds and operating scenarios, all doors and edges shall be sealed against dirt, air and moisture ingress when in the fully closed position. The doors shall be designed to be free of rattles and squeaks at all speeds. Properly sealed doors shall be demonstrated to provide positive interior air pressure and effective door sealing at all speeds.

No single point failure in the door system internal to the car shall cause:

- Any door to unlock or open,
- A door open command to be transmitted or responded to when train is in motion,
- A “door closed” indication to be transmitted when any door is unlocked or open,
- A “door closed” indication to be transmitted when an unlocked or opening command is stored anywhere in the system/train.

The door controls shall be interlocked with the train “Zero Speed” signal such that no door can be opened until the train has stopped. Failure mode of all apparatus shall be such that, in the event of a failure, doors remain closed. Door controls shall be protected against transient and spurious signals and shall be filtered in an approved manner to provide electric noise immunity.

Each side door opening shall contain two opposed sliding leaves which, when opened, shall withdraw into door pockets without scuffing against seals, insulation, or the door engine mechanisms.

Each door leaf shall be equipped with interlocking rubber bumpers on the leading edge, extending the full height of the door. When doors are closed, the two interlocking bumpers shall mate and form a weather tight joint. Seals shall be provided in the door opening to completely seal the door trailing edges. The seals and drain arrangement shall prevent water from entering the interior of the car from action of SCRRA car wash. The door leaves shall be supported at the top by a tube style bearing door hanger arrangement HAFCO Foundry & Machine Co., Inc., Part No. 99801 or approved equal, which shall offer minimum friction to the sliding motion of the doors. The door hanging arrangement shall be submitted for review and approval by the Engineer. **[CDRL 6-001]** The doors shall be guided at the bottom in a manner that properly retains the doors and prevents them from protruding into the passenger area in the event of an accident. If a nylon door guide is applied to the bottom of the door leaf, it shall be designed to not collect dirt and debris. Any wearing part of the door guide arrangement, including the interlocking rubber bumpers, door guides, etc., shall be easily replaceable without removing the door.

In order to keep water from running down over passengers, gutters, with a radius downward near either end, shall be installed over the exterior of the side door openings to direct water away from the door areas.

6.2 DOOR OPERATORS

Door operating mechanisms shall be provided to open and close the side doors and shall include positive over-center locking of the doors when they are in the closed position.

An arrangement shall be provided in the drive engine to each door, which shall permit the door to travel in the closing direction without injury to a passenger caught between a pair of doors. The door operator shall be similar to existing SCRRA vehicles or approved equal. Overhead operators shall not be permitted. The door drive arm shall be equipped with a spring mechanism and arranged to ensure that the closing force shall not exceed 30 pounds in mid-travel. The spring mechanism shall allow the door leaf to be pushed back not less than 3 inches and no more than 4 inches in case of entrapment between the edges of a closing door. The force required to move the door leaf back towards its door pocket shall not exceed 30 pounds.

A direct acting, differential force, pneumatic door operator, or equal, shall operate each leaf of each door. The operating compressed air from the main reservoir system shall have the necessary pressure regulator valve and a shut off valve readily accessible inside the car body in one of the door pockets. Moisture traps and/or filters shall be provided as required in the door operator compressed air system to prevent ingress of dirt or moisture in door engines. Materials used in the door operators or air system shall not be affected by either moisture or methyl hydrate which may be present in the air system.

The motion of the doors shall approximate simple, harmonic motion and shall, thereby, provide cushioning in both opening and closing. The speed of door movement shall be such that from the moment of actuating the appropriate door control button until the completion of the operation, the following times shall be obtained:

Opening: 1.6 to 2.0 seconds (from initial movement to fully open)

Closing: 2.0 to 2.6 seconds (from initial movement to fully closed)

These times shall be independently adjustable. The method of adjusting times shall be submitted for review and approval. **[CDRL 6-002]**

All limit switches and/or proximity sensors shall be precision units that are positively and precisely located so that they may be replaced without the need for mechanism readjustment. All mechanism, limit switch, and proximity sensor adjustments shall be by positive means such as interlocking serrated flat clamped surfaces or axial adjustment of threaded items with locking nuts, locking tabs, or similar securement that cannot drift or loosen. Reliance only on friction between clamped surfaces is not acceptable.

Adjustments shall be provided on door engine mounts and mechanisms to eliminate scuffing of either face of the door panels. Door Operator mechanical adjustments shall be by secure means, threaded studs with lock nuts or serrated clamped plates. Items, such as wiring, that are located in the door pockets shall be installed to prevent fouling of the door mechanisms. The door controls shall be trainlined to permit remote operation from control stations in each car. Door control stations shall be located adjacent to each of the side doors at the B-end on each car.

6.3 DOOR CONTROLS AND SIGNAL SYSTEM

6.3.1 Door Controls

Remote operation of door opening and door closing shall be provided by two panels, one on each side, at the lower level B-end side doors on all cars. Reference crew communication station figure in Section 20 for door control panel layout. These controls shall be trainlined and shall control the doors on each side of the train, in all the cars in a train of up to ten (10) cars. Switches and pushbuttons used for these controls shall be of heavy-duty, industrial, momentary contact type, suitable for the application. Samples of all switches and pushbuttons selected shall be submitted to the Engineer for review and approval. **[CDRL 6-003]**

Features of the door control panels located at the B-end lower level of each car shall be as follows:

- Keyed lock to secure door control panel.
- Setup switch with ON/OFF positions to activate/deactivate door control panel.
- Red pushbutton switch to open passenger side doors adjacent to and all doors on the train towards the B-end of the car from the activated door control panel.
- Red pushbutton switch to open passenger side door at A-end of car and all doors on the train towards the A-end of the car from the activated door control panel.
- Blue Crew Open pushbutton switch to open one leaf of the passenger side doors adjacent to the activated door control panel.
- Green pushbutton switch to close passenger side doors adjacent to and all doors on the train towards the B-end of the car from of the activated door control panel.
- Green pushbutton switch to close passenger side doors at A-end of car and all doors on the train toward the A-end of car from the activated door control.
- Black conductor’s signal pushbutton.
- Separate public address and intercom system buzzer pushbutton.
- White intercom system buzzer pushbutton.

At the B-end only, on both sides of each car, located on the vertical grab handle adjacent to the door control panel, a pushbutton switch to hold open the single door leaf nearest to the activated control station for the use by the train crew only. This CREW HOLD OPEN pushbutton switch shall be enabled only when the adjacent door panel is activated.

Two green-lens lamps complete with LED indicators on the panel will indicate that all doors on the train are closed when illuminated. The green lamps shall be identified as “Door Closed”.

The following operating functions shall be provided:

1. A door position interlock circuit that includes a passenger release relay circuit. The car door interlock relay logic shall not assume the doors are closed until the passenger release relay is de-energized.

2. Opening of the side door at the B-end, each side, from both the interior and the exterior of the car using a crew key shall be possible. Crew key operation of the door leaf shall only be possible if the zero speed trainline signal is present and shall open the door interlock circuit when activated. The outside crew switch shall have a hinged, spring-loaded, weatherproof cover.

3. If an emergency release is activated, either from interior or exterior of the car, the corresponding door shall open under power. Should power not be available, then the operation of the device shall unlock the door operating mechanism enabling the door to be pushed open manually. The minimum clear opening under either condition, with power or without power, shall be 30 inches horizontally and 74 inches vertically. The device shall not allow the doors to be re-closed under power until it has been manually reset. It shall be possible to activate this device by pulling the door release mechanism located behind breakable covers both on the interior or exterior of the car. See Section 6.2.

4. Operation of the master control drum switch shall “short circuit,” connect to battery negative, the open trainline for the opposite side of the train to prevent simultaneous actuation of doors on both sides of the train.

5. With a key inserted and the master control train switch actuated, the door open trainlines on the selected side of the train shall be short circuited, connected to battery negative, until the open pushbutton control switches are actuated.

6. Suitable safeguards shall be integrated with the door controls to prevent the doors from opening while the train is in motion (zero speed system - #7 below) and to prevent the train from moving (locomotive traction achieved) if any side door on the train is open (door interlock system - #8 below).

7. Unless the zero speed system is activated or bypassed, it shall not be possible to open any side door from any door control station or any staff switch. The zero speed system shall only be activated when its trainline wire is energized at 36 +/-4 VDC, if zero speed is detected on the locomotive. Should the train move at a speed above the threshold of the zero speed detector on the locomotive, the zero speed trainline shall be de-energized and all open doors shall close. A “Zero Speed Bypass” switch and indicator shall be provided in each cab car for use by the operator in the event of a zero speed system malfunction. This switch and indicator is on SCRRA locomotives.

8. Unless the door interlock system is activated or bypassed, it shall not be possible for the locomotive Generator Field Circuit to be closed and the train to move. The door interlock system shall only be activated when all side doors on each car in the train are closed (or individual doors bypassed by its cutout switch) energizing each car interlock system and, in turn, energizing the 72 VDC door interlock trainline to the locomotive. A sealable “Door Interlock Bypass” switch and indicator shall be provided in each cab car for use by the operator in the event of a door interlock system malfunction which cannot be corrected by use of the individual cutout switches. This switch and indicator is on SCRRA locomotives.

9. Suitable cutout switches for each door leaf to isolate the doors and controls from the trainlines. The cutout switches shall disconnect the pneumatic solenoid valves from the control circuits and shall bypass the door leaf position detection switches so as to cause the car door interlock relay to indicate a doors closed condition. The switches shall be located in the door pockets near the door operator and shall be clearly labeled as to their function and switch positions.

10. Suitable door leaf position interlock switches on each door leaf which shall detect when each door is fully closed. The switch shall close when the door edges, as the doors are closing, are within 0.50 inch (plus 0.25 inch, minus zero) of each other measured at the height of the switch actuator. The switch shall open when the edges of the doors are greater than 0.50 inch apart as the door leaves are moving in the opening direction. The switch will be actuated by the door leaf or an attachment to it, not by any part of the actuating mechanism. All switches shall be connected in series and all switches must be closed or bypassed by the cutout switch in order to energize the car door interlock relay.

11. The door operators shall be so arranged that the door leaves open when the air solenoid valves are electrically energized. Each door operator shall have a two-position air shutoff valve. Valve position: open shall be normal with closed as a vented off position to isolate the operator from the air supply and vent air from the operator. This will allow the door to be manually moved to and locked in the closed position as an emergency in service measure. The trainline signal buzzer shall be mounted on the rear face of the control panel.

12. All door control relays, including the zero speed and the door interlock relays, shall be mounted on one common panel and all wiring shall be brought to terminal blocks with screw terminals that will accept ring tongue lugs. All relays shall be fully enclosed in dust tight enclosures with screw or Fast On terminals.

13. The locomotive traction (Generator Field Circuit) will be interlocked with the door circuit so that traction cannot be achieved unless continuity within the door interlock system is reached (doors are closed or failed door system is bypassed).

14. Provisions shall be made for opening the single door leaf nearest each door control station (crew door) regardless of the status of the zero speed trainline and door interlock loop circuit.

If adjacent to an activated door control station, the activation of the CREW OPEN pushbutton shall cause the door to open and remain in that position until closed by a trainline door close signal or by loss of the zero speed signal. The grab handle mounted CREW HOLD OPEN switch, when depressed, shall delay the closing of the crew door even when all train doors have been commanded to close by the trainline signals. The crew door is held open only while the CREW HOLD OPEN switch is depressed and will irrevocably close if the CREW HOLD OPEN is released even briefly.

Control of crew doors shall be accomplished by using the CREW OPEN pushbutton located on each door control station and the CREW HOLD OPEN switch located on the vertical grab handle adjacent to each door control station.

6.3.2 Door Control Relay Panel

All door control relays shall be mounted in an approved location in the intermediate level electrical locker. Door control, power, and signal circuits for each side of the car shall be separate and distinct from those for the other side of the car. There shall be no shared components, except for the "door closed" light in the Operator's compartment and the door indicator light in each vestibule. The door system shall be designed such that, when operating in a consist which includes existing SCRRA vehicles and/or North San Diego County Transit District (NCTD) Vehicles, all doors on each side of the train can be operated from any vehicle in the train, regardless of the location and orientation of any vehicle in the consist.

Details of the door controls shall be submitted to the Engineer for approval. **[CDRL 6-004]**

6.4 AUDIBLE DOOR ALARM AND WARNING LIGHT

Audible and visual warnings shall be provided at each doorway. The warnings shall be activated upon initiation of the door close command, and shall continue until the doors are closed and locked. The operational frequencies for the audible and visual warnings shall be independently adjustable. Each warning signal shall operate on a 50 percent duty cycle, with a minimum adjustable cycle period of from 0.5 to 1.2 seconds. The audible output shall also be adjustable to the desired loudness with a minimum range of 68 to 80 dBA and audible to passengers inside and outside the car. The visual warning shall be provided by white, LED-illuminated fixtures visible to passengers inside and outside the car. The warning lights shall initially be set to flash approximately once per second. The details of the location, design, operation and testing of the audible door alarm and warning lights shall be submitted to the Engineer for review and approval. **[CDRL 6-005]**

6.5 EMPLOYEE ACCESS

Employees shall be able to open the B-end side doors from the interior or exterior of the car by means of key switches located on the exterior of the car adjacent to the door and in the interior of the car at the door control stations. The switches shall be actuated by the staff key. Design and location of the key switches shall be subject to review and approval by the Engineer. **[CDRL 6-006]**

Access panels, hinged and with locks operated by maintainer keys, shall be provided in the door pockets and above the doors to permit access for maintenance and adjustment of the operating parts.

6.6 PASSENGER EMERGENCY RELEASE

Passenger emergency operating devices shall be provided for each doorway, on interior and exterior of the car, that complies with requirements of APTA SS-C&S-012-02 and 49 CFR 238 and 239. The door shall provide a minimum clear opening of 30 inches horizontally by 74 inches vertically when opened with passenger emergency release. This may be achieved by opening one door leaf, if the minimum clear opening is achieved, or both door leaves adjacent to the passenger emergency release. When the device is actuated, door leaf(ves) shall open under power if the compressed air and car electrical systems are functioning. If the systems are not functioning, continued pulling on the emergency cable shall unlock the door and move it sufficiently so that the door leaf(ves) can be pushed open manually. The operating devices shall be covered by a transparent, breakable cover. Interior and exterior devices shall be located at appropriate heights to be reached by passengers or rescue personnel.

6.7 DOOR POSITION INDICATOR LIGHTS

A bi-directional, exterior door status indicator shall be provided on each side of each car. The indicator shall be visible in daylight and nighttime conditions and shall be illuminated on both sides of the car with a red aspect under all conditions except when the door is fully closed. The design and location of the door status indicators shall be approved by the Engineer. **[CDRL 6-007]**

The warning lights of Section 6.4 shall serve to indicate individual door leaf status as an aid in trouble shooting. Persistence of the flashing shall indicate a door that has not fully closed and locked. Flash patterns distinctly different from the 50 percent on-off warning may be utilized to indicate other local door malfunctions.

6.8 DOOR SIGNAL SYSTEM

A suitable trainlined electric buzzer, intercom signal system shall be available between any activated door control position and an appropriately equipped locomotive or cab car. The signal shall also be audible at all door control positions throughout the train if the master control drum switch is actuated at a control station. The electric buzzer signal system shall have a distinctively different tone from the private communication signal buzzer utilized between any car and locomotive. It shall operate from the low voltage DC system.

The signal system shall comply with applicable radio interference regulations.

End of Section

Contract Deliverables Requirement List

CDRL No.	Title	Car Type	Reference Paragraph
6-001	Bearing Tube Style Door Hanger	All	6.1
6-002	Adjustment of Door Opening and Closing Times	All	6.2
6-003	Samples of Control Switches and Pushbuttons	All	6.3.1
6-004	Details of Door Controls	All	6.3.2
6-005	Location, Design, Operation and Testing of Audible Door Alarm and Warning Lights	All	6.4
6-006	Design and Locations of Interior and Exterior Key Switches	All	6.5
6-007	Design and Location of Door Status Indicators	All	6.7

SECTION 7

CAB AND CAB CONTROLS

SECTION 7

CAB AND CAB CONTROLS

TABLE OF CONTENTS

SECTION 7

CAB AND CAB CONTROLS

7.1 GENERAL REQUIREMENTS

A full-width cab shall be located in the F-end of the car. The cab shall include all the necessary controls and devices needed to operate the train, including throttle, brake valve, headlight switches, communication equipment, indicators, alarms, and any other train operational controls found in the locomotive cab. Details of the design, arrangement, equipment, and installation of cab area shall be submitted to the Engineer for review and approval. **[CDRL 7-001]** This submittal package shall include an ergonomic analysis and report that addresses the ergonomic and human factors' engineering aspects of the cab arrangement, field of view, operation of controls, and other Operator/control interfaces.

7.2 CAB ARRANGEMENT

7.2.1 General Arrangement

The cab shall be separated from the passenger compartment by a wall with a lockable, hinged door. The cab door shall provide 180 degrees hinging. When the car is not in use as a train control unit, the door shall enclose the control area and free the seat on the Left Hand Side of the cab area for passenger use.

The cab shall contain all controls and apparatus necessary for operating the train from the cab car with the locomotive in the trailing (pushing) or leading (pulling) position or elsewhere in the train. The compartment shall have an Operator's control console on the right side of the car. All controls and panels shall be sufficiently compact to enable the Operator freedom to move about the cab with minimal restriction. The Operator's control panel, switches, and displays shall be organized in a logical manner using ergonomic design principals. The interior of the cab shall meet all FRA requirements, AAR clean cab recommendations, as well as all current APTA Standards and Recommended Practices. The arrangement of the cab interior control console and operating controls shall be of proven design in service similar to that expected of SCRRA system. Details of the design, arrangement of the cab, and the controls shall be submitted to the Engineer for review and approval. **[Part of CDRL 7-001]**

The interior of the cab shall present a clean, pleasing appearance and shall be free of sharp edges and protrusions. The cab shall be designed so that all devices and equipment are integrated (built-in and flush-mounted) into the console, walls, or ceiling. The design shall group controls and instruments for logical function and ease of use, maintenance and servicing.

The cab layout shall maximize the use of available space and shall employ sound human factors and industrial design principles in its development. The cab shall be designed to ensure ease of egress for quick exit by an Operator in an emergency situation. Seat placement shall consider the Operator's relationship to the console and the windshield. The Operator's space and equipment shall be properly designed to ensure safe and optimal Operator performance and a maximum field of view for Operators in the range of 5th percentile female to the 95th percentile male of general population. Obstructions to the field of view shall be minimized. The

A1 field of view shall be such that an Operator, from a seated position, can see a track level object as A1
A1 close as **18** feet away and a **36 foot high** overhead track signal as close as 55 feet away. A1

An equipment locker, behind the cab, shall be designed to house intercar jumper cables, dummy receptacle plugs, the radio and radio power supply, an event recorder, the ATS control module, and any other apparatus that may be logically located there. There shall be space in the locker for a stretcher and the Operator's personal effects.

The Contractor shall work with SCRRA to ensure that the type, location and arrangements of all train controls, warning lights and related indicator panels are as similar as possible as related components in the SCRRA locomotives and existing cab cars with full-width cabs. Any deviations shall be identified by the Contractor and submitted to the Engineer, in a report identifying the reason for the deviation, for review and approval. A mock-up of the cab shall be provided by the Contractor, per Section 1.6.2 to assure proper fit for the apparatus.

7.2.2 Cab Construction

The cab partition, cab side linings and ceilings shall be constructed in accordance with the requirements in Section 4.5. The cab structure design shall meet the CEM requirements of Section 3.10 and maintain the Protected Operator Cab Space defined in Section 3.10.8. The cab door shall be constructed of the same material as the cab partition and shall match its color and pattern. The door shall be equipped with a staff key operated lock. See Section 4.9.3 for door requirements. The floor covering in the Operator's area shall be the same as that used in the entranceways. See Section 4.4.1 for flooring requirements.

7.2.3 Console Arrangement

A desk-type console (Console Desk) shall be installed on the Right Hand Side of the cab below the windshield. Refer to Section 7.8 for details. Primary console features, used for train operation, shall be positioned to be accessible and functional from the Operator's seated position with all primary operating controls and displays mounted within the Console Desk. Normal operation shall not require awkward or unnatural positioning, extension, or excessive movement by the Operator.

Secondary controls, switches, and features, not used for train operation, shall be placed on panels more remote but accessible to the Operator. Electrical and control enclosures shall be designed to preclude the intrusion of water and dust. To the extent possible, indicator lights shall be grouped together in a panel with a single push-to-test button.

7.2.4 Console Construction

The control console and display panels shall be user friendly and easily removable for component replacement; with maintenance, servicing, and operational requirements as major considerations in their design, construction, and installation. The display portion of the console shall be easily viewed within the Operator's normal line of sight. The Console Desk surface shall be sloped downward toward the Operator. The Console Desk shall be designed so that liquid spilled on the surface will not damage or interfere with operation of components, apparatus, or wiring. Its finish shall be easily cleaned with a soap and water solution.

The control panel and display panels shall be hinged for access to all controls, switches, and indicators for maintenance and servicing. The panels shall have a means to be held in the raised or open position. The console surfaces shall incorporate a sound-absorbent material.

The Console Desk surface shall be hooded to block direct sunlight and shall be constructed of a stain, burn and corrosion-resistant, integrally colored, non-glare material. The console cabinet shall match adjacent cab lining materials.

All controls shall mount to hinged panels fastened to the console cabinet. Controls shall not mount directly to the console cabinet. All mounting panels shall be fastened to the console cabinet with approved threaded fasteners on permanently mounted spacers.

The console shall not obstruct or interfere with the Operator’s ability to open and use the cab side window to inspect the train.

7.2.5 Cab Interior

Each cab shall be equipped with the following accessories:

- Foot Rest: A foot rest shall be provided it with location and shape consistent with human engineering criteria.

- Sun Visor: A sun visor shall be installed at the Operator’s windshield. It shall be padded, fully adjustable in all directions, usable at both the windshield and the sliding side sash areas, and shall store unobtrusively and securely when not in use. It shall not interfere with access to the controls or viewing of the gauges or indicators. Two (2) sun visors may be used: one (1) for the windshield and one (1) for the sliding side sash.

- Coat Hooks: A folding coat hook shall be flush-mounted on the cab interior side wall behind the sliding side sash window. Two coat hooks shall be installed in the locker behind the cab.

- Form Holder: Two (2) standard cab form holders (full length forms) shall be mounted on the inside rear cab wall.

- Train Order Clip: A train order clip shall be mounted within easy reach of seated Operator.

- Paper Towel Dispenser: A paper towel dispenser shall be installed within reach of the Operator.

- Lighting: All brake gauges shall be illuminated by dimmable lights. An overhead cab light fixture shall be provided. It shall be of the same type as that used to illuminate the end door passageway and shall have an independent control switch. All lighting shall be protected by circuit breakers.

- Train Monitoring System: The cab car equipment shall include an Event Recorder (ER) which shall record train operating parameters continuously, and a Train Monitoring System (TMS) which shall monitor the Operator's vigilance. Train operating parameters, with real time date stamping, received from trainline signals or pressure transducers on the brake system shall be continuously recorded in digital form by the ER. For analysis of train operation or in the event of an accident, it shall be possible to download the recorded data to a lap top computer. Refer to Section 14 for ER and TMS requirements.

- Heating and Air Conditioning: The cab area shall be equipped with its own heating system or shall contain suitable ducting for heating and air conditioning supplied by the main system of the car. Control shall be as described in Section 8.5.1.2.d, Section 8.6.1.2 and Section 8.6.2.2. The cab area shall also be equipped with separate temperature controls. Refer to Section 8 for cab HVAC requirements.

7.3 BRAKE CONTROLS

Cab air brake equipment shall be Wabco schedule 26-C or approved equal.

A Wabco Type 26B-1 brake valve or Knorr Brake Corporation equivalent shall be mounted in the Console Desk within easy reach of the seated Operator, and shall incorporate a means to cut out the valve so that train braking can be controlled from the locomotive. The valve shall have a removable handle, which operates through six (6) positions identical to the operation of existing SCRRA cab cars. The handle, when not used, shall be stored securely on the console. A separate emergency brake valve, B-3B manufactured by WABCO, Knorr Brake Corporation or equivalent, shall be located in the cab area which, when activated, shall cause an emergency brake application irrespective of the brake valve position. Exhaust air from the brake valves shall be piped to the atmosphere through the floor.

7.4 AIR GAUGES

Two (2) duplex air gauges, at least 3.5 inches in diameter, shall be provided in each Operator's cab. The gauges shall have an internally illuminated black dial. The two (2) gauges shall be graduated from 0-200 psig. One (1) gauge shall indicate main reservoir and equalizing reservoir pressures, and the other gauge shall indicate brake cylinder and brake pipe pressures. Gauge-hand identification shall be shown on the gauge panel not on the gauge face. The air gauges shall be interchangeable. The air gauges shall be equipped with Prime Manufacturing Company, or approved equal, gauge test fittings and be arranged for testing in place. Alternative configurations compatible with the cab design may be submitted for consideration as options to the base configuration.

7.5 TRACTION CONTROL

A master controller with throttle and dynamic brake control and reverser shall be mounted in the cab console, within easy reach of the seated Operators. It shall incorporate a means to cut out the control functions so that train can be controlled from the locomotive. The controller shall be compatible with SCRRA locomotive control and train line functions.

All necessary locomotive control switches including, but not limited to, the engine run/stop, generator field, attendant call, alarm, etc., shall be provided on the Cab Console Desk and Side Panel. The cab console shall also include a remote locomotive load meter to read traction motor current in both motoring and dynamic braking.

7.6 SPEED INDICATOR

A Bach-Simpson, or approved equal, speed indicator system shall be installed in a position that shall be easily visible by the seated Operator. Speed indicator range shall be 0-120 mph.

The speed indicator shall include LEDs in the lower left of the display to indicate the overspeed level selected. If the upper amber LED labeled “OUT” is lit, the overspeed penalty sequence shall initiate at a speed of 83 mph. If the lower red LED labeled “IN” is lit, the overspeed sequence shall initiate at a speed of 93 mph. The overspeed setting shall be adjustable. Below the “OUT” and “IN” labels shall be an “ATS” label. When the actual speed is above the overspeed setting, a red LED indicator on the lower right side of the speed indicator display, head labeled “PENALTY,” shall be illuminated. The LEDs shall be easily visible by the Operator in the normal seated position. See Section 14.4 for additional details.

7.7 EVENT RECORDER DOWNLOAD PORT

The Event Recorder download port shall be located in the cab. This device shall be compatible with existing SCRRA and Bach Simpson event recorder as per Section 14.

7.8 OPERATING CONTROLS, SWITCHES, INDICATING, AND OTHER DEVICES

The cab shall have three (3) distinct panels for control devices arranged as follows:

- A desk-type console (Console Desk) for the brake valve, master controller, and other devices required for continuous availability to the Operator.
- A vertical panel (Side Panel) to the left side of the Console Desk for communication equipment and locomotive control switches.
- A horizontal panel (Overhead Panel) above the windshield for less critical switches and control devices.

In addition, there shall be a circuit breaker panel in the wall behind the Operator’s seat. Floor mounted foot pedals shall also be provided as specified herein. It may also be necessary to utilize the space below the console for cut-out valves and other devices not requiring close and proximity to and continuous use by the Operator.

The cab mock-up and/or drawings shall clearly show types, location, and arrangement of all controls, switches, indicators, warning lights, and other cab devices for SCRRA review, comment, and approval. Where possible, pilot lights shall be incorporated in switches.

7.8.1 Console Desk and Side Panel Controls

The following controls shall be located on the Console Desk or Side Panel:

a) Master controller,
b) Brake valve,
c) Horn, two (2) electric momentary pushbutton switches,
d) Bell push-on/push-off two-segment switch,
e) Sanding pushbutton switch with indicator lamp,
f) Headlight and auxiliary light off/dim/bright/bright + auxiliary rotary switch,
g) Windshield heater switch with indicator lamp,
h) Windshield wiper switch,
i) Console illumination dimmer switch,
j) Cab light switch,
k) Communication unit radio, PA, and intercom,
l) Communication handset,
m) Cab heater off/low/medium/high switch,
n) ATS acknowledgment switch,
o) Air gauges,
p) Speed indicator,
q) Engine run pushbutton switch,
r) Engine stop pushbutton switch,
s) Locomotive generator field off/on switch,
t) Cab set up off/on switch,
u) Locomotive load meter,
v) Zero speed override switch (sealed) with indicator,
w) Fuel pump on/off switch,
x) Auxiliary light flash mode on/off/automatic rotary switch,
y) Left side cab light switch.

7.8.2 Console Desk and Side Panel Indicator Lights and Audible Alarm

The following indicator lights shall be located on the Console Desk, or on the Side Panel within view of the seated Operator:

a) TMS reset,
b) Doors closed,
c) Locomotive wheel slip,
d) Conductor's Communicating Buzzer
e) Headlight failure left/right,
f) Auxiliary light failure left/right,
g) ATS warning
h) Penalty brake/acknowledge demand.

7.8.3 Overhead Panel Controls and Indicators Lights

The following controls and indicators shall be located on the panel above the windshield:

a) Right marker light control switch with indicator,
b) Left marker light control switch with indicator,
c) Door interlock bypass switch (sealed),
d) Door interlock bypass indicator,
e) Number board light switch,
f) TMS audible/visual alarm panel,
g) Brake applied indicator,
h) Dynamic brake warning indicator,
i) Locomotive PCS indicator,
j) Locomotive main engine fault indicator,
k) HEP alarm cut-out switch (sealed),
l) ATS in/out switch (sealed),
m) Cab car battery charger failure indicator.
n.) Zero speed bypass switch (sealed) with indicator,
o.) Zero speed bypass indicator.

7.8.4 Floor Mounted Controls

A foot activated TMS Reset switch shall be mounted on the floor under the console. The reset switch shall be waterproof and suitably robust for the intended service. The placement of the switch shall accommodate the 95th percentile male and 5th percentile female Operator. The location and operation of the switch shall be demonstrated in the cab mock-up and detailed in the Preliminary Design Review Package. **[Part of CDRL 7-001]**

7.9 AUDIBLE WARNINGS

The cab console shall enclose the vigilance and ATS audible alarms and controls as described in Section 14. The conductor's communicating buzzer, engine fault alarm and other normal train operation alarms shall also be located in approved positions in the cab.

7.10 COMMUNICATION EQUIPMENT

The communication equipment shall be located within easy reach of the Operator on the Side Panel. Components, which do not require the Operator's attention and intervention, shall be mounted in the equipment locker and shall be accessible for maintenance. A VHF antenna shall be mounted on the roof car within SCRRA clearance requirements. Radio, PA, and Intercom are specified in Section 13.

7.11 CIRCUIT BREAKER PANEL

A panel containing all the circuit breakers for the equipment particular to cab shall be located on the rear cab wall and shall be accessible to the Operator. The panel shall have a latched hinged cover. The main circuit breaker panel at the B-end of the car shall include a **"**Communications" circuit breaker that shall feed the PA and intercommunications circuit breaker and VHF radio circuit breaker located in the cab rear wall circuit breaker panel and a "Main Low Voltage DC Cab Services" circuit breaker that shall feed remaining circuit breakers in the cab rear wall circuit breaker panel.

7.12 HORN

A two-chime, pneumatic air horn shall be mounted underfloor on the Left Hand Side at the front of the cab car. The horn shall be Nathan P/N WH30167-13K24 or approved equal. The horn shall be compatible and directly interchangeable with the horn used on the existing SCRRA multi-level commuter rail cars. The horn assembly and underfloor mounted apparatus shall be protected from road debris and car wash. A horn cut out cock shall be provided in an approved location in the cab. The sound intensity of the horn shall be in full accordance with FRA requirements. Two (2) switches shall be provided to control the horn; one (1) switch for manual operation and one (1) switch for the horn sequence control utilizing the event recorder. The two (2) switches shall be mounted together on the console per Section 7.8.1. The Contractor shall submit details of the audible warning system design, installation, and operation to the Engineer for review and approval. **[CDRL 7-002]**

7.13 WINDSHIELD WIPER

Pneumatically operated windshield wipers, with a pantograph style operating arms, shall be located above each windshield and arranged to sweep not less than 70 percent of the area of the windshield. The center of the sweeping area on a vertical plane shall be located at the center of the Operator's viewing area, assuming a 95th percentile Operator. They shall have their park position located toward the center of the car. The drive mechanism shall be accessible from inside the car. Controls of the wiper shall be as specified in Section 7.8.1

7.14 EXTERIOR BELL

An electronic bell, shall be located alongside the horn. The bell shall be Graham-White Manufacturing Company 373 Series E Bell, Model No. 373-010; Transtronic Inc., Part No. 020-00892-00 or approved equal. Bell control shall be as specified in 7.8.1. **[Part of CDRL 7-002]**

7.15 REAR VIEW MIRROR

An adjustable rear view mirror shall be installed at the leading edge of the sliding cab side window. The location and adjustment shall permit use by a seated Operator. An identical adjustable rear view mirror, viewable from the Operator's seat, shall be similarly installed on the opposite side of the cab. **[Part of CDRL 7-001]**

7.16 OPERATOR'S CAB SEAT

A heavy duty, upholstered, adjustable operator's seat shall be installed in the cab of each cab car. The seat shall be fastened to the cab floor in a manner approved by the Engineer. The seat shall be designed to provide satisfactory comfort, proper access to all operating apparatus, and good visibility. The armrests, back panels (if used), seat cushions, upholstery materials, and any other combustible materials used in the operator's seat shall meet the requirements of Section 15.23. The operator's seat shall comply in all respects with the requirement of 49 CFR 229, 238, and APTA SS-C&S-011-99 except as noted below.

The cab seat shall be designed to accommodate operator sizes from the 5th percentile female through the 95th percentile male, as defined in Human Scale. The seat dimensions shall comply with APTA SS-C&S-011-98 Table 1 – Seat Dimensions except that Bottom Cushion Length shall be fixed in length, Bottom Cushion Angle shall be adjustable from 7 degrees to 12 degrees, and Back Cushion Angle shall be adjustable from 0 degrees to 15 degrees.

The cab seat shall be designed and tested to demonstrate compliance with the static load tests, dynamic load tests, cushion durability tests, and life cycle tests as defined in APTA SS-C&S-011-99.

Instructions for operating the seat shall be submitted to the Engineer during the design review for approval and shall be included on a stainless steel plate affixed to a wall surface in an approved location. The instructional information shall also be included in the Operator's and other manuals defined in this Specification. Details of design, construction, and installation of the cab seat shall be submitted to the Engineer for review and approval. **[CDRL 7-003]**

End of Section

Contract Deliverables Requirement List

CDRL No.	Title	Car Type	Reference Paragraph
7-001	Cab Arrangement/Equipment Layout	CAB	7.1
7-002	Audible Warning System Details	CAB	7.12
7-003	Operator Seat Details of Design, Installation, Integration and Performance	CAB	7.16

SECTION 8

HEATING, VENTILATING, AND AIR CONDITIONING

SECTION 8

HEATING, VENTILATING, AND AIR CONDITIONING

TABLE OF CONTENTS

SECTION 8

HEATING, VENTILATING, AND AIR CONDITIONING

8.1 GENERAL REQUIREMENTS AND FEATURES

The HVAC System includes all of the heating apparatus, ductwork, ventilation, cooling systems, and their controls. The local climatic conditions must be considered in order to properly size the systems, and the placement of all parts for these systems must be considered for ease of maintenance and reliability.

8.1.1 Location and Arrangement of the HVAC Units

The cars shall be supplied with an integrated heating, ventilating, cooling, and reheating system (HVAC) to meet the requirements identified in this Section. For the purposes of HVAC control, the car interior shall be divided into two (2) independent zones. Zone 1 shall be the A-end intermediate level, lower level right side, and upper level right side. Zone 2 shall be the B-end intermediate level, lower level left side, and upper level left side. The HVAC unit installed in the A-end equipment bay above the intermediate level passenger area shall provide the temperature control, cooling, and overhead heat capacity for Zone 1, and the unit installed in the B-end equipment bay shall provide control, cooling, and overhead heat for Zone 2. The control of the floor heat shall be generally as described above, except that zones shall be equally distributed on the right and left sides and throughout the upper and lower levels to avoid a one cold side or one cold level condition in the case of a single unit control failure. The Contractor may submit approved equal zone arrangements that provide efficient distribution of the conditioned air and optimize the sizing of the duct work to the Engineer for review and approval. These approved equal zone arrangements shall be service proven for commuter rail application and shall demonstrate compliance with the design and performance requirements specified. All system components shall be service-proven and supported by design and test data adequate to demonstrate compliance with the specified requirements. Details of the system capacity and performance calculation, design, arrangement, installation, and operation of the HVAC system shall be submitted to the Engineer for review and approval. **[CDRL 8-001]**

Each vehicle shall have two (2) independent, self-contained, modular, HVAC units. The units shall be identical and interchangeable among all cars in this Contract and between ends. The unit shall include an evaporator, fresh air (if necessary) and supply air fans, compressor, condenser and associated fans, electric heating elements, control unit, thermostat assemblies and filter assemblies. An approved equal arrangement is for the fresh air fan, filter and ductwork to be separate from the HVAC unit provided all requirements are satisfied and the arrangement provides full accessibility for maintenance, troubleshooting and repair without interference or disassembly of other systems. A fully-hermetic HVAC unit without full accessibility for maintenance, troubleshooting and repair on the car will not be considered an approved equal. The unit's frame and housing shall be constructed of stainless steel except as approved by SCRRA. The units shall be capable of being removed and replaced with the use of an overhead crane with a capacity of 2½ tons. Separation of the unit from the car shall be facilitated by the use of efficient disconnection of mechanical and electrical means and removal of mounting attachments. The units shall be removable without the disassembling of refrigerant piping.

Taper guide pins shall be provided for ease of precisely locating the unit. The taper pins shall be mounted to the carbody. The units shall be furnished with provisions for lifting. The Contractor shall minimize the distance required to lift the unit. If a lifting jig is required to safely remove the unit, four (4) such jigs and their associated manufacturing drawings shall be provided to SCRRA. Time required to remove and replace the HVAC unit on the car shall not exceed 2 hours for two (2) workers.

All electrical connections to the units, with the exception of the grounding strap, shall be by means of quick disconnects, in accordance with Section 15.21.13 for each voltage level.

The units shall be secured to the car structure using a maximum of eight (8) threaded fasteners. The mounting system shall be such that the air-conditioning unit shall be safely retained to the vehicle even in the event of failure of up to 25 percent of the fasteners. The HVAC unit and its controls shall comply with the requirements of APTA SS-C&S-034, Rev. 1 (Section 5.7) for equipment attachment. **[Part of CDRL 8-001]** A ground strap shall be provided between the unit frame and the carbody.

Table 8-1
Design Criteria

Ambient Temperature (Summer)	101^{o}F Dry Bulb (DB),70^{o} F Wet Bulb (WB)
Ambient Temperature (Winter)	22^{o}F Dry Bulb
Passenger Load	225 (not less than 450 Btu/hr per person with 55% SHR)
Interior Design Conditions	75^{o}F DB and 55% RH (Cooling) 70^{o}F DB (Heating)
Fresh Air	1600 cfm (Minimum)
Total Air Flow	Sufficient to meet the internal temperature, humidity, and car pressurization requirements of this Specification (5400 cfm minimum)
Carbody Heat Transmission	In accordance with the Contractor’s carbody and insulation design to meet the requirements of this Specification
Lighting Load	Total wattage of interior lights considering ballast efficiency
Solar Load	In accordance with ASHRAE data and calculation methods
Miscellaneous Equipment	In accordance with Contractor's design data and shall include, but is not limited to, blowers and equipment

8.1.2 Refrigerant

The air-conditioning system shall be capable of cooling and dehumidifying the car with direct-expansion, electromechanical vapor-cycle equipment using R407c or other approved refrigerant. The Contractor shall provide the acceptable charging procedures for the system charged with the blended refrigerants. **[CDRL 8-002]**

8.1.3 Maintenance Access

Equipment design and installation shall provide full accessibility for maintenance, troubleshooting, and repair without interference with other systems.

Air filters and return air thermostats shall be accessible via the return air plenum.

The following components shall be a part of the unit and shall be easily accessible for servicing and replacement either through a hinged grille, which provides access to the return air plenum from the inside of the vehicle, or through an approved interior access door located in the intermediate level ceiling:

- All electric and pressure controls,
- Contactors and circuit breakers,
- Refrigerant gauge ports,
- Liquid line sight glass,
- Diagnostic test plug for the PTU,
- System fault and status LEDs, and
- Crankcase oil sight glass (if applicable).

All other components shall be easily accessible for servicing and replacement from within the equipment bay or from the car roof.

8.1.4 Operating Parameters

The cooling system shall be able to start and operate without damage at any time of the year when exterior temperature is above 45°F. The system design shall allow full cooling operation without the influence of modulation control with the ambient temperature up to maximum anticipated conditions at the condenser and fresh air intakes. The Contractor shall submit, for review and approval by the Engineer, the design performance and capacity calculations for the system as part of the Preliminary Design Package. **[CDRL 8-003]**

The HVAC system shall be designed and constructed to operate under the shock and vibration conditions specified in Section 2.5.2.4. The HVAC system shall not impose vibrations greater than those specified in Section 2.5.2.4 to the carbody in any mode of operation. Interior and exterior sound levels shall meet the requirements of Section 2.5.2.2 and 2.5.2.3.

8.1.5 Interior Temperatures

A comfort control system shall be designed to automatically provide the specified control of car interior temperatures with any ambient temperature from 22°F to 110°F at the specified wet bulb conditions, with or without variable internal heat loads such as passengers, motors, lights and solar gain, at nominal applied voltages. The cooling system shall also remain in operation, at reduced capacity, if necessary, with ambient temperatures, as defined in Section 2.7.3 and Section 17.5.5, at the condenser and fresh air intake and design internal and solar loads.

The average temperature throughout the passenger area shall be maintained at the following temperatures for the respective ambient temperatures:

Table 8-2
Temperature Conditions

Exterior Ambient	Interior Ambient
Less than 60°F	67°F – 70°F
60°F to 101°F	72°F – 76°F
101°F to 110°F	Not higher than 25°F below the ambient dry bulb
Above 110°F	As the system will provide

The interior relative humidity shall not exceed 60 percent at any time when the HVAC system is operating in the cooling mode.

The temperature in the cab (of cab cars only), with the side window closed and the operating compartment heater turned to “OFF”, shall conform to the requirements for interior car temperature when air conditioning is in use.

When the car interior temperatures are within the ranges specified, the air temperature differential between the car interior and the air leaving the diffuser at the slot outlets shall not be greater than 25°F.

The following variations in interior car temperatures are the maximum that shall be allowed throughout the entire car. The criteria apply to the upper, lower, and intermediate levels of the car, simultaneously:

- At any given time, the temperature variations between different levels of the car should not be more than 4°F.
- At any given time, except during pull-down and warm-up, among all points in the same horizontal plane from one end of the car to the other should not be more than 4°F.

- At any given time, except during pull-down and warm-up, between any point approximately 48 inches above the floor and the corresponding point six (6) inches above the floor in a vertical plane should not be more than 4°F.
- At any given point in the car, and in the entrance ways, and at least 12 inches from the ceiling and 6 inches from the floor and walls over a period of time should not be more than 5°F.
- The average car temperature shall recover within 2°F of the required interior car conditions within 2 minutes maximum following a 30 second door opening. It shall be demonstrated that this requirement can be met during 1 hour of continuous door cycling of 30 seconds open and 2.5 minutes closed at design conditions in both air conditioning and heating modes, at the climate room test specified in Section 17.5.5.

8.1.6 Safety Requirements

If a roof mounted HVAC unit is provided, the top of the unit shall serve as a walkway for maintenance personnel to travel from one end of the car to the other. The designated walkway shall be at least 24 inches wide and shall be clearly marked, with etched and black paint filled stainless steel labels. The walkway area shall have a non-skid surface and shall meet the same load requirements as the roof structure.

8.1.7 CFD Model and Analysis

Within one hundred-eighty (180) days of NTP, the Contractor shall submit to the Engineer a Computational Fluid Dynamics (CFD) model and analysis of the air distribution system during cooling and heating operation. **[CDRL8-004]**

The model shall include, at a minimum, accurate representations of the following:

- All carbody ductwork
- Diffusers
- Return air grills
- Exhaust grills
- Interior furnishings
- HVAC unit components in the fresh, return, mixed, and conditioned air streams.

All internal and external loads may be modeled as sensible heat sources only, and the evaporator coil may be modeled as a sensible heat sink.

The analysis results shall demonstrate that the proposed air distribution system is capable of meeting the diffuser discharge velocity, interior air velocity, and temperature uniformity requirements of this specification. Should the analysis fail to demonstrate compliance to these requirements, the design of the air distribution system shall be modified and the analysis shall be repeated.

8.2 HEATING

8.2.1 Heating arrangement

The cars shall be electrically heated by a thermostatically controlled system, using a combination of the overhead heat from the heater elements, supplied as part of the unitized HVAC system, and the floor level sidewall heaters evenly distributed throughout the car.

8.2.2 Heating Capacity

The overhead heater coils shall have sufficient capacity to heat the total input of fresh air from 22°F to 67°F at 480 VAC.

The floor heat shall have sufficient capacity to heat the car interior from 22ºF to 67ºF with the ventilating fans and overhead heat inoperative and without benefit of solar or passenger loads. The required capacity shall be available at 480 VAC.

8.2.3 Overhead Heat

Overhead heaters shall be supplied within the evaporator compartment to provide tempering for fresh air intake and for reheat to maintain humidity control under partial cooling operation of the air-conditioning apparatus. The heater coils shall be located downstream from the cooling coils. The heater elements shall be of the low thermal inertia, with terminations and insulated supports as approved by SCRRA. **[CDRL 8-005]** Approved equal configurations shall be submitted to SCRRA for review and approval. The heaters shall be powered from the nominal 480 VAC supply and shall be staged to provide Low, Medium, and High power operation.

The heater unit shall be designed to allow easy removal and replacement by means of a maximum of ten (10) captive fasteners. Alternately, individual heater coils shall be capable of being replaced without removing the heater from the HVAC unit. There shall be no exposed, uninsulated, or unprotected high voltage components, wiring, or terminal connections in the heater area, except the heater element coils.

8.2.4 Protective Devices

The overhead heater elements installed in each HVAC unit shall be protected by circuit breakers. Each stage of overhead heat shall be switched independently by a suitable electro-mechanical or solid-state contactor.

Three (3) stages of overhead heater protection shall be provided. They shall include an airflow switch, overheat thermostat and back-up protection.

8.2.4.1 Air Flow Switch

An airflow switch, differential pressure switch, or evaporator blower current monitoring device shall be employed to detect and prove airflow through the evaporator section. The proof of airflow method, device, and application shall be approved by SCRRA. The overhead heaters shall not be allowed to be energized if proof of airflow has not been established. Loss of airflow, while the heaters are energized, shall cause the heaters to be immediately de-energized.

8.2.4.2 Overheat Thermostat

An automatic reset overheat thermostat shall be installed in a location to reliably and accurately sense the temperature in the area of the heater coils. The overheat thermostat shall be wired directly in series with the coil of the overhead heat contactor and shall also provide feedback to the control logic. The setpoint shall be selected such that the overhead heaters may cycle indefinitely on overhead thermostat control with no damage caused to any HVAC system components. The setpoint shall also prevent nuisance trips from any condition that may be expected to arise during normal operation, including operation over the allowed range of input voltage and air filter maximum recommended pressure drop.

8.2.4.3 Back-up Protection

Back-up protection shall be provided to positively remove power to the overhead heater elements in the event of a control failure or failure of the overheat thermostat. The back-up protection may be a fusible link or may, with the approval of SCRRA, be a thermostatic sensor wired to a shunt-trip circuit in the overhead heat circuit breaker. The setpoint shall be selected such that no damage shall occur to any HVAC component by temperatures reached before or after the back-up protection device actuates. The setting of the back-up device shall be coordinated such that it will not actuate under any conditions which may be achieved with normally operating controls and functional overheat thermostat.

8.2.5 Floor Heaters

The floor heating shall be zoned. Zone 1 shall be the A-end intermediate level, lower level right side, and upper level right side. Zone 2 shall be the B-end intermediate level, lower level left side, and upper level left side. The total floor heat capacity in each zone shall be divided into stages of approximately 1/3 and 2/3 of total capacity, allowing for HIGH, MEDIUM, and LOW power operation.

In the cab cars, floor heaters of the Zone 1 shall be extended to the cab.

Floor heating shall be provided using electric strip heaters, powered from the 480 VAC HEP supply, mounted behind stainless steel heater guards along the side walls at the floor. The heaters shall be uniformly distributed.

The electric floor heater elements shall be of the strip-heater type. The maximum allowable watt density shall not exceed 125 W per linear foot of element when operated at 480 VAC. The heater strip mounting design shall allow freedom for thermal expansion and contraction of the heater strip, as well as provide full electrical insulation between the heating element sheath and the carbody. The heater elements shall be mounted on approved insulators attached to the carbody. The heater elements shall not be mounted to the heater guard. No more than three (3) types of heater elements shall be permitted.

Each heater circuit shall have its own breaker and ground fault protection. Each circuit shall have current input to and output from the floor heaters monitored by the differential relay, which energizes for a predetermined difference between the two. When this relay energizes, both the positive and negative feeds to the effected floor heater circuit shall be interrupted

The ground fault type circuit shall remain latched in the disconnected mode until manually reset by means of a momentary reset button located in the HVAC control box or other approved location. The fault trip must not be affected by control power loss or fluctuation. A tripped ground fault circuit shall be annunciated by means of an LED indicator on the ground fault detection device in the HVAC control box and transmit to the fault monitoring network, if the latter is provided. The sensor device shall be designed such that it is not necessary to disconnect heater power leads to remove and replace the ground fault detection unit. A separable sensing coil or other approved method shall be provided to accomplish this requirement.

Approved equal methods of ground fault detection and protection may be submitted for review by the Engineer.

The heater elements shall be series wound internally. Electrical connections to the floor heater elements shall be so arranged that electrically live points cannot be reached with a long thin object such as a knife or screwdriver blade inserted through the holes in the heater guard face and section.

Air shall enter the heater guard through slots at the bottom, pass over the strip heaters, and rise by convection. Holes or slots shall be provided at the top of the heater guard vertical face so that the heated air will exit through the top of the vertical face of the heater guard. The holes or slots shall be small enough to promote convective heat flow while preventing litter accumulation.

All surfaces of the floor heater enclosures accessible to passengers shall be insulated, if required, to limit the surface temperature to the lowest practical value and in no case higher than 125ºF.

Floor heater guards shall be of at least 0.060 inch thick stainless steel. The heater guard front panels shall be constructed so that sections may be removed for replacement of heating strips without dismantling seats. The top of heater guard shall be sloped at least 15 degrees to prevent collection of dirt. Stainless steel screens shall be provided on the inside of the heater guard to prevent paper and debris from entering the heater area.

8.2.6 Windshield Defroster/Demister

Defrosting or defogging of the Operator's and opposite windshield shall be by means of an electrically heated windshield. The windshield element shall be designed to clear the entire window of frost or fog. The time required to defrost and defog the window shall not exceed 15 minutes at 0ºF ambient and a car interior temperature at layover condition.

8.2.7 Layover Heat

Layover heat shall be supplied by the sidewall heat or overhead heat or a combination of both and shall maintain a minimum interior temperature of 45ºF +/- 5ºF. During layover heating, the evaporator fans shall operate and the fresh air fan motors shall be shut off.

8.3 VENTILATION

8.3.1 Air Quantities

The evaporator blowers shall operate to ventilate the car whenever the HVAC system is energized. The minimum fresh air supply to the car shall not be less than 1600 cubic feet per minute (cfm).

As a minimum, the following fan design parameters shall be submitted for review and approval by the Engineer. **[CDRL 8-006]**

- Type, dimensions, model number, and manufacturer of the fan wheel and housing,
- Head-flow and power-flow curves for the selected fan wheel in the selected housing,
- Manufacturer's maximum allowable fan wheel speed, and
- Fan wheel balance requirements.

The system design shall ensure that a minimum interior pressurization of 0.10 inches of water is obtained in a stationary car with all doors and windows closed and all equipment operating under normal conditions. Positive interior pressure must be maintained at all car speeds regardless of the car's position in a consist or the direction of travel.

On cab cars only, the cab door shall be provided with a grille. It shall permit the conditioned air supplied to the cab to return to the passenger compartment.

Air shall be exhausted from the toilet room by a low noise, centrifugal-type fan arranged for direct drive operation on 120 VAC motors. The motor shall be fully enclosed and provided with lubricated-for-life, sealed ball bearings. This powered exhaust shall be in addition to the normal static exhaust grilles in the passenger compartment. A minimum of 100 cfm shall be exhausted from the toilet compartment. To ensure a positive air flow from the car interior into the toilet room, the HVAC system shall maintain a differential pressure of not less then 0.05 inches of water at all times. This pressure differential shall be maintained with side-doors opened and the train at rest and with the doors closed while traveling at any speed in either direction.

Ventilation of the car shall be accomplished by centrifugal fans supplied as part of each unit. Ventilation shall be available at all times, in accordance with design criteria of Section 8.1.1, when the units are operating, including conditions when heating and/or air-conditioning functions have failed. The ventilation system shall maintain a positive static pressure at all car operating speeds.

Fresh air shall be drawn into each air conditioning unit through a screened, weather-protected air intake grill and shall be filtered and then delivered to an integral mixing plenum. The design shall preclude wind-driven rain or snow from accumulating and leaking into the vehicle interior. The duct work shall be arranged to drain to the exterior of the car and to ensure no moisture traps or collection points exist.

Recirculated air shall pass through the return air grill and return air filters to the plenum where it shall mix with the filtered fresh air. The mixed air shall then pass through the evaporator coil, overhead heater coils, and evaporator blower. Mixing efficiency of fresh and return air shall ensure that the mixed air entering the coil is at a uniform temperature. Air flow velocity shall be uniform across the entire face of the filters and evaporator coils.

Temperature sensors shall be positioned and protected (if required) to ensure they sense the correct unbiased temperature of the fresh, recirculated, or supply duct air, as appropriate.

The ventilation system shall be designed and integrated into the vehicle to ensure that it does not contribute to the lethality of a fire. For this purpose, each car shall have smoke detectors installed in the unoccupied compartment as defined by 49 CFR 238.103, and, if required, in other areas of the car. The detectors shall be powered from the low voltage power system, and shall be rugged, reliable, and vandal proof. The detectors shall not be sensitive enough to detect cigarette smoke, but shall detect smoke in such a concentration, which can be considered a threat to passengers. When an unsafe condition is detected, the ventilation system on the car shall shut down and activate a trainline audio-visual alarm in each cab. Activation of the alarm shall be recorded in the car level and train level diagnostic systems, if the latter is provided. Indicators that are activated with the alarm, and are visible on the exterior and in the interior, shall indicate to the crew and rescue personnel the affected car. The alarm in the cab shall remain on until acknowledged, and the alarm in the affected car shall remain on until reset. The design shall include a press-to-test switch. The reset and press-to-test switches shall be in an approved location that is accessible to the crew and maintenance personnel and not visible to the passengers. Details of the design, operation, installation, and testing of the alarm feature shall be submitted to the Engineer for review and approval. **[CDRL 8-007]**

A motor-blower assembly shall be supplied as an integral part of each unit. It shall blow or draw the air from the mixing plenum through the evaporator and overhead heater assembly and force it into the supply-air ducts from where it shall be discharged into the passenger and cab areas.

The motor-blower assembly shall be balanced in accordance with IEEE Standard 11. Imbalances shall be less than 0.001 inch peak-to-peak displacements in any direction at the motor end bells when mounted in the unit. The motor-blower assembly shall be isolated such that motor and fan vibration and noise transmitted to the car structure shall be below the limits specified in Section 2.5.2.

The blower motor shall be of a permanently lubricated roller bearing TENV design. It shall operate from the 480 VAC HEP supply.

Motors and blowers shall be easily removable for repair, cleaning, or replacement either individually or as an assembly. Motors and blowers shall also be accessible for routine inspection and maintenance. Blower wheels shall be direct mounted and keyed to the motor shaft. Anti-seize compound shall be applied to prevent the blower wheels seizing to the shaft. Routine blower assembly inspection shall not be required more often than once every ninety-two (92) days. The design of the blower wheels and their enclosures shall meet the pressure and volume requirements while producing minimal noise.

An odor/fume controllant with sufficient capacity for thirty (30) days continuous operation, shall be provided in the air-mixing box of the plenum in both ends of the car. The unit shall be mounted in an approved stainless steel holder above the ceiling near the inlet of the evaporator units and shall not interfere with replacement of either the fresh air or return air filters. Access to the controllant shall be easily accessible through the return air grilles. The controllant holder shall be installed in a secure rattle free manner and shall permit the controllant container to be easily removable without the use of tools.

The final balancing settings for the entire air distribution system shall be determined at the climate room test.

8.3.2 Air Filters

Fresh and recirculated air shall be filtered by disposable type, 2 inch thick, pleated media filters of the cardboard frame type in a commercially-available standard size. Face velocity shall not exceed the manufacturer’s recommendation. The use of Camfil FARR 30/30 filters, part no. 4988004 currently used by SCRRA for maintaining the existing fleet is preferred.

Initial clean filter pressure drop shall be a maximum of 0.12 inches of water. Filter performance shall be a maximum pressure drop of 0.5 inches of water, at a constant velocity of 300 fpm/min. Filter efficiency shall be:

Test Standard	Requirement
ASHRAE 52.1	Average dust spot efficiency 25%
ASHRAE 52.1	Arrestance 90%
ASHRAE 52.2	MERV 7

The filters and filter holders shall be sealed at their edges to prevent filter by-pass. Support of the filter elements shall be provided to prevent blowout of the filter elements under clogged filter conditions. Filters shall be readily accessible for replacement from inside the vehicle through the re-circulated air opening.

Air filters shall meet the requirements of UL Standard 900, Class 2, and the requirements of Section 15.14.

8.4 COOLING

8.4.1 Required Capacity

The air-conditioning system shall be capable of cooling and dehumidifying the car with direct-expansion, electromechanical vapor-cycle equipment using R407c or other approved refrigerant. The unit capacity shall be such as to satisfy the requirements of Section 8.1.1.

8.4.2 Design/Operating Parameters

Every pressure-containing component of the equipment, except piping, shall be listed as having been pressure tested and approved by a nationally recognized testing laboratory. Alternatively, each component shall be designed, constructed, and assembled to have an ultimate strength sufficient to withstand 5 times the design working pressure. All such components shall be factory tested to at least 1.5 times the design working pressure for which it is rated.

The refrigerant system controls shall include an automatic pump-down cycle. Pump-down shall be initiated by closing the liquid line solenoid valve after an "OFF" signal has been received. System refrigerant shall be transferred to the condenser until the compressor suction pressure drops to an approved value. Pump-down shall not be initiated if the system shut down is initiated by a protective safety device such as: excessive pressure, temperature, or current protective devices or switched "OFF" via the circuit breaker.

Proof of airflow shall be required to initiate or maintain compressor operation. A pump down shall be immediately initiated if a loss of airflow is detected while the compressor is operating.

Refrigerant piping shall be sized in accordance with recommendations contained in the latest edition of ASHRAE Fundamentals.

The HVAC equipment manufacturer shall evacuate and dehydrate the system to 50 microns pressure or less. This vacuum must be maintained for a minimum of 2 hours with the vacuum pump running. After 2 hours, the vacuum pump shall be isolated from the system. The system pressure shall not rise above 300 microns in a 2-hour period after vacuum pump isolation.

8.4.3 Components Requirements

8.4.3.1 Evaporator Section

The evaporator coil fin assembly shall be housed in a rigid stainless steel frame. The tubes shall be supported at each end and in the center of the coil. The tube support sheets shall be constructed of stainless steel with die-formed support collars for each tube. The evaporator coil shall be of copper fin and copper tube construction with nominal fin thickness of 0.008 inch for flat or wavy fins and with a maximum of ten (10) fins per inch. The tubes shall be expanded to positively retain the fins in position and provide positive thermal contact.

The evaporator coil circuitry shall be split into two (2) separate circuits, using an interlaced circuit arrangement, with each half of the coil being fed by its own liquid line solenoid valve and thermal expansion valve. Solenoid valves and thermal expansion valves shall be identical for each coil circuit.

The design of the evaporator unit shall provide a space of not less than 3 inches between the evaporator coil and the heater elements to enable the cleaning of the coil by either back blowing or washing. The unit's design shall also prevent any air bypass through the drain pan or around the heat exchanger of the evaporator and heater elements. The coil face area shall be sufficiently large to prevent condensate carryover into the fan plenum or main air duct. In any event, the average coil face velocity shall not exceed 450 ft/min.

The Contractor may submit an approved equal design for a coil with coated aluminum fin construction for review and approval by the Engineer. The approved equal proposal must include service history of the proposed coating material in similar severe duty applications and any expected benefits from a cost, reliability, weight saving, efficiency, or other factors offering a benefit to SCRRA.

Other components, which shall be included as part of the evaporator portion, are as follows:

a) A liquid line solenoid valve for each circuit of the two (2) stage evaporator coils. The solenoid valves shall be of a compact design with pilot-operated disc construction. Solenoid valves shall have an operating differential rating of 300 psi minimum.

b) Thermal expansion valves (TXVs) for each evaporator coil circuit. They shall have external equalizers, and field-replaceable working parts. The TXVs shall be located to provide easy access for maintenance and servicing. The TXVs superheat shall be set as required to maintain superheat through the entire range of operating conditions and the adjustment screw or cap shall be sealed.

c) An easily removable and serviceable brass-bodied liquid line "Y" strainer provided with 80 or 100 mesh size. For a unitized HVAC system, the requirements for a separate "Y" strainer may be waived if the filter-drier unit is equipped with an appropriate mechanical particle screen (mesh) and with the approval of the Engineer.

d) A liquid line sight glass and moisture indicator between the strainer and tee for the each coil circuit. The liquid line sight glass and moisture indicator shall be located such than it is visible to an individual standing in the vehicle floor. It shall allow observation of the refrigerant flow state. Their location and access shall be subject to approval by SCRRA. **[CDRL 8-008]**

e) Two (2) air pressure taps for measuring evaporator coil air pressure drop. The pressure opening diameter in the side wall shall comply with Figure 2 of ASHRAE Standard 51.

8.4.3.2 Condensate Drain System

A condensate drain pan shall be provided beneath the evaporator coil, coil headers, thermal expansion valves, and coil "U"-bends in order to collect condensation. The drain pan shall be made of stainless steel with stainless steel fittings. The drain pan and fittings shall be designed so that water cannot spill over into the ceiling area under any operating conditions, including the worst case combination of negative evaporator section pressure, grade, super elevation, acceleration (positive or negative), and car roll. The drain pan shall be mounted in such a way to permit inspection and cleaning of evaporator coils.

Condensate drain lines shall be sloped for positive drainage to the underside of the car and shall not be routed through electrical or electronic cabinets and shall not discharge on car structure, wheels, or brake equipment. An elastomeric flapper valve shall be attached to the drain line termination underneath the car. Drain lines shall be arranged to eliminate any potential water traps. The condensate drain lines, coil housing, and pan shall be insulated to prevent condensation formation.

Connection between the HVAC unit's drain pan and the carbody condensate drain lines shall be made with a heavy gauge flexible tubing, meeting the smoke and flammability requirements of Section 15.23. Clear access to the connections shall be provided from the interior of the car or equipment bay to allow for unit removal.

8.4.3.3 Compressor/Condenser Section

The compressor-condenser portion of the self contained unit shall meet the following requirements of this section:

8.4.3.3.1 Refrigerant Compressor

The refrigerant compressor shall be a heavy duty, semi-hermetic reciprocating, and multi-cylinder transportation type compressor. The compressor shall utilize screened forced-fed lubrication. The oil pump shall function for either direction of rotation. Unloading shall be in two (2) stages and shall provide three (3) capacity steps (approximately 33 percent, 66 percent, and 100 percent). Unloading shall be accomplished with electrically operated suction cut-off unloaders. The compressor crankcase body shall be fitted with removable crankcase heater and crankcase oil sight glass. The crankcase heater shall be powered by the low voltage DC power supply. The compressor shall be provided with oil drain valve and an oil charging port. The compressor shall use separate compression and oil rings unless approved by the Engineer.

The Contractor may propose an approved equal refrigerant compressor unit, such as a scroll compressor(s), that provides enhanced interior comfort and increased system reliability. The approved equal refrigerant compressor unit shall be service proven for commuter rail application and shall demonstrate compliance with the design and performance requirements specified. Details of the approved equal refrigerant compressor unit and its integration into the HVAC system shall be submitted for review and approval by the Engineer.

The compressor(s) shall be resiliently mounted within the HVAC unit. A flexible copper strap shall be provided to electrically ground the compressor to the unit frame.

The HVAC compressor(s) shall be powered from the 480 VAC HEP supply.

8.4.3.3.2 Condenser Coil Assembly

The condenser coil(s) shall be housed in a stainless steel frame with suitable fan shrouding and protective screening. The coil(s) shall be of a copper tube and copper fin construction with minimal fin thickness of 0.008 inch for flat fins. Maximum number of fins shall be eight (8) per inch. The tubes shall be expanded to positively retain the fins in position and provide positive thermal contact. The tube support sheets shall be constructed of stainless steel with die formed support collars for each tube. A center tube support sheet shall be provided if the total tube length is greater than 36 inches. The coil shall utilize copper tubes of sufficient wall thickness to withstand system pressure. The coil shall be designed with adequate capacity to provide a maximum condensing temperature no greater than 30 degrees F above the condenser cooling air temperature under conditions of full-rated load. The coils shall also be designed to ensure that the air-conditioning system can operate under extreme ambient conditions without the risk of creating abnormal system pressures.

The Contractor may submit an alternate design for a coil with coated aluminum fin construction for review and approval by the Engineer. The alternate proposal must include service history of the proposed coating material in similar severe duty applications and any expected benefits from a cost, reliability, weight saving, efficiency, or other factors offering a benefit to SCRRA.

The condenser coil shall be proof tested by the manufacturer at 1.5 times the maximum pressure or 600 psig, whichever is greater. As an alternative, the first coil may be burst tested to demonstrate a positive margin of safety and all other coils proof tested to 425 psig.

8.4.3.3.3 Condenser Fan and Motor

The condenser fan(s) shall be driven directly by 3-phase, 480 VAC motor(s), powered from the 480 VAC HEP supply. The motors shall be fully enclosed and rated for wash down applications with permanently lubricated rolling element bearings and have sufficient capacity to drive the condenser fan under all load conditions. A flexible copper strap shall be provided to electrically bond the condenser fan motor frame to the HVAC unit structure. Motor installation, with its shaft vertically up, shall require the application of a slinger on the motor shaft to prevent moisture penetration to the inside of the motor.

The fan(s) shall be a multi-blade axial fan(s) and the blades shall have airfoil profiles or approved equal to ensure optimum fan efficiency and minimum noise generation. Connection of the fan hub to the motor shaft shall be by a tapered bushing type hub with a key. To facilitate removal of the condenser fan, the condenser fan motor shaft shall be of a corrosion-resistant material, or it shall be treated to prevent corrosion and seizing of the fan hub on the shaft.

8.4.3.3.4 Condenser Airflow

Condenser cooling air shall enter the unit through the condenser air intake grill on the side of the car or on the roof, pass through a section of stainless steel duct (if applicable), and enter the coil.

Hot air, discharging from the condenser coils, shall pass through the condenser fan(s), a stainless steel duct (if applicable), and shall be discharged through the roof (or unit) mounted discharge grill. The grill shall be designed so that condenser airflow is not affected by the direction or speed of car motion.

If applicable, connections between the intake and discharge ducts and the intake or discharge grill and between the ducts and HVAC unit shall be through neoprene coated fiberglass fabric isolators. The use of tools shall not be required to disconnect the condenser air ductwork from the HVAC unit.

The entire condenser system air-side shall be sealed such that water or snow entering the condenser section cannot enter the car interior and equipment bay (if applicable) under any operating or non-operating condition.

The condenser section shall be provided with drains, separate from the condensate drains, discharging under the car. The drainpipes shall be fitted with elastomeric flapper valves.

8.4.3.3.5 Other Condensing Section Components

1. A serviceable, "catch-all" type filter-drier assembly as manufactured by Sporlan, or approved equal, shall be provided in the liquid line. The filter-dryer capacity of water, refrigerant flow, filtering area, and acid removal shall be specified based on ARI Standard 710. The filter drier shall have rust proof shutoff valves on each side to isolate it for servicing. An access fitting shall be provided on one (1) valve to allow recovery and evacuation of the filter-drier section.
2. A discharge-line check valve.
3. A fusible plug as recommended by UL 1995.
4. Service valves in the compressor suction and discharge line connections to provide for isolation and replacement of the compressor(s). The service valves shall also be provided with service access ports, at least one (1) of which must allow access to the compressor when the associated valve is front-seated (closed).
5. All service valve caps shall have a metal-to-metal seal. Service valve and sight glass caps shall be safety chained to the unit to retain them with the valve or sight glass when removed.

8.4.3.4 Piping Design and Installation

The refrigerant piping design, installation, and piping materials within the unit shall meet the requirements of Section 15.10. The length of pipe between joints shall be the maximum length that can be installed without damaging the pipe or equipment so as to limit the number of joints required. The piping installation shall be such, however, that it shall be possible to replace any length of pipe using ordinary methods and without having to remove any other equipment.

All pipe insulation shall meet the flammability and smoke emission requirements of Section 15.23.

Vibration eliminators shall be provided where any refrigerant line attaches to a resiliently mounted assembly, including the compressor suction and discharge lines. The vibration eliminators shall be provided with neoprene covering over the flexible bronze wire braid to provide resistance to abrasion and prevent condensation from freezing behind the ferrules. Suction lines shall be designed and constructed without horizontal traps and sized for a maximum pressure drop of 3 psi. The liquid line shall be sized to prevent flashing due to pressure drop. All refrigerant lines shall be adequately supported to prevent vibration, chafing, fatigue, and stress of joints. All capillary tubes shall be arranged so as to prevent any metal-to-metal rubbing caused by vibration.

8.4.3.5 Electrical Compartment

The electrical compartment shall be an integral part of the unit. It shall be accessible for system maintenance and servicing through the return air grill or ceiling access panel.

The electrical control compartment shall contain the following components:

- Relays, contactors, solid-state power controllers, and individual component isolation circuit breakers.
- Electrical controls.
- Diagnostic test plug for attachment of the PTE.
- Power and control wire terminals.
- Main and control power disconnect switches.
- Static temperature control unit.
- Fault and status indication panel.
- Contactors for floor heat control may be installed in the HVAC unit electrical compartment or may be installed in a separate enclosure.
- ON/OFF Control Switch, described in Section 8.5.1.

Refrigerant suction lines shall be wrapped with a fire retardant, closed-cell foam insulation. All insulation and adhesives shall meet flammability, toxicity, and smoke emission requirements of Section 15.23. All piping insulation corners shall be mitered and sealed with a sealant recommended by the manufacturer of the insulation.

The evaporator section shall be insulated to prevent condensation formation on the outside of the HVAC unit.

8.4.4 Refrigeration Controls

The refrigeration control compartment shall be accessible from the return air plenum or from an access panel in the intermediate level ceiling as approved by the Engineer. If the access panel is located in the intermediate level ceiling, it shall be aesthetically compatible with the interior of the car and having no exposed hardware. The Contractor may submit, for review and approval by the Engineer, alternative locations for the refrigeration control compartment that provides equivalent access for maintenance, repair and trouble-shooting. Provision for access shall be detailed with design drawings and demonstrated as part of a Maintainability Demonstration. The refrigeration control compartment shall contain the following devices:

- Low-Pressure Cutoff Switch,
- High-Pressure Cutoff Switch,
- Modulation-Pressure Switch or Transducer
- Unloading Control Transducer,
- Gage and,
- Service Port.

8.4.4.1 Low-Pressure Cutoff Switch

A low-pressure, cutoff switch shall be provided to monitor compressor suction pressure to protect the compressor and other system components from potentially damaging low system pressure operation. The switch shall directly deactivate the control circuit to the compressor motor when the pressure drops below the safe limit. The switch shall automatically reset and energize the compressor motor when the pressure rises; suitable hysteresis shall be provided in the system to prevent short term system cycling at the cut/out pressure.

8.4.4.2 High-Pressure Cutoff Switch

A high-pressure, cutoff switch shall be provided to monitor the compressor discharge to protect the system from excessively high system pressures. The switch shall immediately de-energize the compressor when the discharge pressure reaches high limit pressure, approximately 400 psig. The switch shall be wired directly into the compressor contactor control circuit. The switch shall automatically reset and energize the compressor motor when the pressure drops to an acceptable safe limit, approximately 340 psig. The circuit shall be arranged such that condenser fan operation is not interrupted by the high-pressure, cutoff control. A time delay of 15 seconds (minimum) shall expire prior to the restart of the compressor following achievement of the reset pressure. The high-pressure, cut/off switch shall be provided with an external pulsation snubber.

8.4.4.3 Modulation Pressure Switch or Transducer

A modulation pressure switch shall be provided to monitor discharge line pressure and maintain system operation by reducing the air conditioning system capacity when conditions cause discharge pressures to approach the cutoff point. The control shall force the system into modulated cooling when the discharge pressure exceeds an approved value. The control shall automatically reset when the pressure drops to restore full cooling operation. A transducer monitoring the discharge line pressure is an approved equal for this function.

8.4.4.4 Unloading Control Transducer

An unloading control transducer shall be provided to monitor the compressor suction line and control the compressor capacity. The compressor capacity shall be reduced to match compressor capacity to the existing load and to prevent the saturated suction temperature from falling to an unacceptably low level. Other suction pressure based control functions, including compressor shut down after pump down, may also be controlled from this transducer. A suction line pressure switch or switches are an approved equal for this function. An approved equal method of capacity control may be proposed by the Contractor for review and approval by the Engineer

8.4.4.5 Pressure Switch and Transducer Construction and Mounting

All pressure switches shall be snap-acting with stainless steel wetted parts. The fluid side of the switch shall be hermetically sealed.

Transducers shall have stainless steel wetted parts and shall be hermetically sealed.

Pressure switches or transducers shall be connected to the system using flare type connections. The system side of the connection shall be equipped with a check valve to allow switch replacement without the need to recover the entire refrigerant charge from the system.

8.4.4.6 Gauge and Service Ports

High and low side gauge and service ports shall be provided. Each port shall be fitted with a self-sealing, Schraeder type valve, with chain-retained, metal-to-metal seal caps. Each line shall be equipped with a diaphragm type manual isolation valve. The manual valves and gauge connections shall be color coded red for high side and blue for low side.

8.5 TEMPERATURE CONTROLS

8.5.1 Control Arrangement

The control of the HVAC system shall be designed to automatically maintain the car interior temperature (including the cab on cab cars), at the specified conditions, with or without variable internal heat loads such as passengers, motors, lights, and solar gain. All control components and circuits shall operate from the nominal 120 VAC supply, except for the logic unit which shall operate from the 72 VDC power supply. The sensitivity and accuracy of the controls shall permit the requirements of Section 8.1 to be met. Temperature control of each zone shall be independent.

The final selection of temperature control arrangement shall be approved by SCRRA and shall be verified at the system qualification and vehicle climate room tests. **[CDRL 8-009]**

Local control of the heating and air conditioning shall be fully automatic when the HVAC control system is energized and HEP is available. An ON/OFF switch shall be provided on the outside of the electrical compartment or where approved by the Engineer. With the switch in the “ON” position, the HVAC unit shall operate normally under the control of automatic temperature controller. When turned to the "OFF" position, the switch shall override the commands from the temperature controller and initiate a normal pump-down and shut down cycle.

Cut-out of any HVAC system, on individual cars, shall be accomplished by isolating 72 VDC control power to the control(s) by switching off the HVAC Control Breaker for the desired unit. With the HVAC switch Control Breaker in the "ON" position, the HVAC system shall operate automatically in response to thermostat readings and control algorithm.

The HVAC system shall sense air dry bulb temperatures, as required, with thermistor sensors. Thermistors shall be encapsulated in a protective stainless steel tube. Temperature sensors shall be mounted to insure that they are not unduly influenced by local sources of heat, such as motors or resistors; that they are easily accessible for maintenance and replacement; that they are protected from damage during routine maintenance and servicing, such as replacing filters; and that they are not unduly influenced by fresh air. Sensor accuracy shall be required to comply with the requirements of this Specification.

The static temperature controls shall control the heating, ventilating, and air-conditioning contactors directly through power switching transistors provided as part of the unit without the use of pilot relays.

The static temperature control electronics shall be selected in strict conformance with the specified requirements and shall be packaged in a single, rugged, totally enclosed sheet metal enclosure. If required heat dissipation shall be accomplished by the use of external cooling fins arranged to avoid the collection of dirt. The unit enclosure shall be arranged for quick removal and replacement with no more than four (4) captive fasteners. Electrical connections, including portable test unit connections, shall be by means of 1/4 turn Litton-Veam or equivalent environmentally sealed connectors.

Operation of the HVAC System shall be fully automatic at all times when low voltage DC and 480/120 VAC power is available. The system shall function to maintain the required interior conditions listed in Section 8.1.1 for each zone.

8.5.1.1 Cooling Control

Each control system shall control the operation and unloading of the refrigerant compressor and the staging of the overhead heat (reheat) in response to the sensed return air temperature (including the rate of temperature change), refrigerant pressures, ambient temperature, and other factors as necessary to maintain the interior conditions listed in Section 8.1. The control logic shall preclude rapid cycling of any device.

When the cooling demand has been satisfied, the system shall perform a pump-down of the refrigerant circuit. The pump-down cycle shall end when the suction pressure reaches an approved value.

Compressors shall start in their maximum unloaded condition. Compressor starts shall be arranged such that only one (1) compressor per car attempts to start at any given time.

8.5.1.2 Heating Control

The overhead heat shall be controlled such that, the power offsets the fresh air ventilation heating load, except during pull-up, when the overhead heat shall operate at full power. The floor heaters shall be cycled as required to offset all other losses and maintain the interior conditions within the requirements of Section 8.1 for each zone. The size of each stage shall be arranged and controlled to minimize the cycling of the heat control contactors.

The control unit shall be powered by the 72 VDC system. The unit shall be designed and constructed to properly interface and control the HVAC system and to communicate with any monitoring and diagnostic systems.

8.5.1.2 (a) Overhead Heat

A duct temperature sensor shall be provided for use in controlling the overhead heat. Each control system shall cycle the overhead heater between HIGH, MEDIUM, and LOW power as required to maintain the delivered air temperature, as measured by the duct sensor at, or no more than 8°F above, the return air temperature.

In order to reduce cold car pull-up time, the overhead heat shall operate at HIGH power when the return air sensor reading is 10°F or more below the required interior temperature.

8.5.1.2 (b) Floor Heat

Each control system shall cycle the floor heaters between HIGH, MEDIUM, and LOW power as required to maintain the required interior temperature. Control schemes, which utilize the rate of change of the interior temperature as well as the actual value, are encouraged.

8.5.1.2 (c) Protective Heaters

Refrigerant compressor crankcases shall be provided with crankcase heaters, however, other car systems and components may require protective heaters, including, but not necessarily limited to: door threshold heaters, toilet and potable water systems, brake valves, and reservoir drain valves. The Contractor may utilize temperature information from the HVAC system sensors for these devices, or they may contain integral thermostats. The Contractor shall provide details of the protective heater control for approval by the Engineer. **[CDRL 8-010]**

8.5.1.2 (d) Cab Heat

Cab heat control shall be via a manual four (4)-position switch (Off, Low, Medium, High) mounted on the console. The fan shall operate in all heat positions. The fan shall be driven by a fully enclosed, lubricated for life, sealed ball bearing, and heavy-duty 120 VAC motor. The cab heat control switch shall be energized only in an active cab.

8.5.1.2 (e) Door Pocket Heaters

Anti freeze protection, activated at an outside temperature of 46°F, shall be provided for the door thresholds, and a convection heater for the door pocket area shall be provided. All heaters shall be of a modular design, potted, self-regulating, and easily replaceable. No interior furnishings, such as seats, floor heaters, windscreens, etc., shall require removal for replacement of heaters. It shall be demonstrated that qualified personnel can remove and replace the heaters in no more than 30 minutes. Details of the design, installation, and removal tasks shall be submitted to the Engineer for review and approval. **[CDRL 8-011]**

8.5.2 PTU and Diagnostic Requirements

The unit shall include an RS-422 serial interface for servicing the unit and for software and event information downloads to a laptop computer. The interface shall be readily accessible without removing any components. The Contractor shall supply, 30 days prior to the delivery of the first car, the software required to access and service the unit.

8.6 DUCTING

8.6.1 Air Ducts

Air distribution ducts for levels shall run the length of the level in the corner at the intersection between the sidewall and ceiling. The internal cross sectional area of the ducts shall taper, as required, to maintain a constant static pressure differential across the diffusers. The Contractor may submit, for review and approval by the Engineer, an alternative ducting arrangement for the upper and lower levels that provides the specified performance and functionality.

The material selection for the ductwork shall be approved by Engineer. **[CDRL 8-012]** Considerations shall include, but are not limited to, thermal insulation performance as required to prevent condensation on the exterior of the duct under all conditions, acoustic insulation such that the interior noise requirements of Section 2.5.2.2 are met, weight, appearance, and ability to repair. The air velocity within the ductwork is not specifically limited but shall be such that in combination with the acoustic insulation, shape, and diffuser design, the interior noise and vibration requirements of Section 2.5.2 are met.

Air ducts for the intermediate levels shall be located inside the equipment bays. The Contractor may submit alternative intermediate ductwork arrangements for review and approval by the Engineer, provided such arrangements satisfy the specified requirements including, but not limited to noise limit and temperature distribution requirements.

8.6.1.2 Auxiliary and Cab Distribution Ducts

On cab cars, the ductwork for the cab end intermediate level shall be extended to supply the cab diffusers described in Section 8.6.2.2.

8.6.2 Diffusers, Grilles and Outlets

8.6.2.1 Passenger Compartment Diffusers

A continuous linear slot diffuser shall run the length of the air ducts on all levels. The diffuser shall be installed in the vertical side of each duct nearest the car centerline. Diffusers shall be anodized aluminum, in a color in accordance with the interior design requirements.

Diffusers shall be easily adjustable on the climate room test car only. All other cars shall have non-adjustable diffusers with the same settings as approved in the climate room test report. If the car design requires diffusers to be adjusted on a car-by-car basis to ensure compliance with the performance and functional requirements, the Contractor may submit an alternative diffuser design that shall be adjustable for temperature distribution testing purposes and shall be fixed and sealed after adjustment, for review and approval by the Engineer.

The diffuser design shall preclude a cylinder 2 inches long and 0.25 inch in diameter (such as a screw driver) from entering the duct.

The mixing efficiency of the diffusers shall be such that an equal mass of room air is entrained and mixed with the discharge air at a distance of 6 inches from the face of the diffusers. The maximum velocity of discharged air shall not be greater than 150 fpm at 6 inches from the diffusers. Maximum air velocity throughout the car interior shall not exceed 100 fpm at 60 inches above the floor and 50 fpm at 48 inches above the floor.

8.6.2.2 Cab Diffusers

Air shall be discharged into the operating compartment through an approved adjustable diffuser. The Operator shall be able to manually control airflow to the cab from full flow to no flow and control the direction of air discharge. Final design and layout shall be part of the cab design review as described in Section 7.2.1.

Operator's cab diffusers shall not be subject to velocity limitations, however, all interior noise requirements must be met with the cab diffuser set at any flow rate.

8.7 RETURN AIR GRILL

A return air grill or grills shall be provided in approved locations for each HVAC unit. The return air grill shall be of sturdy and rattle-free construction and shall have a core and satin-finished frame of anodized aluminum, hinged on one of the short sides and provided with approved captive fasteners and two (2) safety catches on the other short side. The return air grill shall be designed to pass the required quantity of air with sound levels such that the requirements of Section 2.5.2.2 are met anywhere 1 foot from the grill.

The grill design shall not allow a direct line of sight from the car interior to the mixed air plenum and shall preclude the introduction of small objects, such as cigarettes, from entering the plenum.

8.8 FRESH AIR INTAKE AND WATER ELIMINATORS

Fresh air shall be delivered to the HVAC unit as described in Section 8.3. Fresh air shall not be drawn from the ductwork supplying the condenser coil(s). Suitable acoustic insulation shall be provided to prevent condenser fan noise from entering the car interior through the fresh air system. Water eliminating baffles or louvers shall be provided to prevent water, which enters the fresh air intakes, from being drawn into the unit. Eliminators shall be fabricated from stainless steel. Cleaning and servicing of the water eliminators shall not be required more often than once a year with no significant reduction in the system performance. Fresh air filters shall not be considered part of the water elimination design.

End of Section

Contract Deliverables Requirement List

CDRL No.	Title	Car Type	Reference Paragraph
8-001	HVAC System Design, Installation, and Operation	All	8.1.1
8-002	HVAC System Charging Procedure	All	8.1.2
8-003	Design Performance and Capacity Calculations	All	8.1.4
8-004	CFD Model and Analysis	All	8.1.7
8-005	Overhead Heating Elements and Installation	All	8.2.3
8-006	Ventilation Design Parameters	All	8.3.1
8-007	Design, Installation, Operation, and Testing of the Smoke Alarm	All	8.3.1
8-008	Location and Access to Liquid Line Sight Glass	All	8.4.3.1
8-009	Temperature Control Arrangement	All	8.5.1
8-010	Protective Heater Control	All	8.5.1.2
8-011	Design, Installation, and Removal of the Door Pocket Heaters	All	8.5.1.2
8-012	Duct Material	All	8.6.1

SECTION 9

LIGHTING

SECTION 9

LIGHTING

TABLE OF CONTENTS

9.1 GENERAL REQUIREMENTS

Vehicle lighting designs shall incorporate an approved arrangement of incandescent, LED and fluorescent lighting fixtures. The lighting shall operate from the 120 VAC and 72 VDC power supplies. The lighting shall be as uniform as practical throughout the car. All fluorescent lamps shall be soft white and the same color.

The vehicle lighting shall include the following:

- Passenger area and toilet room fluorescent fixtures,
- Cab lights (cab car only),
- Headlights (cab car only),
- Auxiliary lights (cab car only),
- Marker lights (cab car only),
- Car number sign lights (cab car only),
- Emergency lights (both battery-powered and self-contained),
- Platform lights,
- Stairway lights,
- Air gauge lights (cab car only),
- Exterior indicator lights.

The lighting system design and illumination requirements shall meet the Federal Regulations including 49 CFR 27, 37, 38, 221, 229, 238, and 239, AAR and APTA Standards and Recommended Practices for lighting. Where a conflict exists, the most restrictive condition shall apply. The Contractor shall follow all of the guidelines and requirements provided in APTA RP-E-012-99, "Recommended Practice for Normal Lighting System Design of Passenger Cars," and APTA SS-E-013-99, "Standard for Emergency Lighting System Design for Passenger Cars" to demonstrate through design, analysis, and testing that the lighting conforms to the requirements of the Specification.

The lighting system shall neither produce an objectionable glare nor decrease light intensity below requirements due to the accumulation of dirt on fixtures. Fixtures shall permit easy access for cleaning and renewal of lamps and shall not rattle or generate any noise during normal operation of the car. Cleaning, maintenance, and parts replacement shall be accomplished without disassembly of interior panels.

The general lighting in the passenger seating areas shall be integrated into the ceiling for an aesthetically pleasing appearance. Sockets, wiring, hardware, etc., shall not be visible to passengers when seated or standing. Exposed hardware shall not be permitted unless approved by the Engineer. Light fixtures shall provide light at the reading plane, to the specified intensity, while also illuminating adjacent ceiling panels to assist in diffusing light and enhancing the overall brightness level of the interior of the car. The details of the lighting design, arrangement, and installation shall be submitted to the Engineer for review and approval. **[CDRL 9-001]**

9.1.1 Power Sources

Platform lights, stairway lights, exterior indicator lights, marker lights, car number lights, cab lights, headlights, and air gauge lights shall operate from the battery circuit and, if required, through pulse-modulation circuits. Lights shall not be wired in series. All other lights shall operate from the 120 VAC power supply. The system providing power for emergency lights shall be capable of operation in accordance with the requirements of 49 CFR 238.115 for a back-up power system. The entire vehicle lighting system shall meet the EMI/EMC requirements of Section 17.5.17 and be part of the EMCP of Section 2.5.4.

9.1.2 Intensity

The intensity of illumination shall be in accordance with the requirements of 49 CFR 238, APTA RP-E-012-99 and APTA SS-E-013-99. Lighting shall be uniform throughout the reading plane in the passenger seating area of the car and shall provide adequate illumination of surfaces such as aisles, doors and advertising cards. The illumination shall be directed downward to minimize glare. The intensity of illumination with nominal voltage available at the fluorescent lamps shall satisfy the following criteria:

Location	**Method of Measurement**	**Intensity**
Passenger Seats	At an elevation of 33 inches above the floor and on the upper surface of a 45 degree reading plane	30 foot candles (All seats except those in the vestibule which shall be 10 foot candles)
Passenger Aisles	At the floor	5 foot candles
Entrances and Exits	At the floor within 20 inches from the door, inside the car	5 foot candles
Stairways	At center of tread	5 foot candles

9.1.3 Fixture Construction

Fluorescent fixtures shall be designed to accommodate T8, soft white, fluorescent lamps rated for minimum service life of 20,000 hours. Fluorescent fixture sockets shall be of an approved heavy-duty spring type with a circular configuration and edge wipe contacts and shall be designed to provide support to the end of the lamp. Supplementary support for the lamping, shall be provided by installation of two (2) spring-metal clamps (one at each end of each lamp), or an approved equal configuration, attached to the underside of the reflector. Sockets shall not be visible when viewing the fixture from seated positions. Easily accessible AMP MATE-N-LOK connectors, or approved equal, shall be provided on lighting fixtures for connection of wiring so that the fixture may be electrically isolated for maintenance. The back of the fixture may be an aluminum extrusion. Continuous wire-ways, separate from the fixture or an arrangement of thin wall steel conduit and junction boxes, shall be provided to route wiring to each fixture. The access panel to the fixture shall be made with a concealed hinged extrusion and a closing screw extrusion. No wire splice shall be permitted in conduits or fittings connected to the lighting fixtures. The lighting fixtures shall be integrated into the interior arrangement. The fixtures shall be arranged to be compatible with the color, pattern, and texture of the interior materials for an aesthetically pleasing appearance. All fixtures shall have polycarbonate diffusers/lenses, uniform in color, and shall be arranged for re-lamping from the front. Fixtures shall be free from rattles and resistant to dust and moisture. Fixtures shall include suitably designed solid neoprene rubber seals between the lens and fixture.

Sockets, wiring, and hardware shall not be visible with the fixture installed in the car. The light fixtures may be fitted with endcaps to accomplish this requirement.

9.2 INTERIOR LIGHTING

9.2.1 Fixture Arrangement

The lighting fixtures in the main passenger areas shall be ceiling mounted in two (2) parallel rows extending throughout the lower, upper, and intermediate levels to provide evenly distributed light. Approved equal arrangements may be submitted to the Engineer for review and approval. The light fixture arrangements are subject to the approval of the Engineer. **[Part of CDRL 9-001]**

The fixtures shall be divided electrically into three (3) circuits. The fixtures on each of the three (3) circuits shall be connected in a manner to produce uniform distribution of light throughout the car when only one (1) or two (2) circuits are activated. Adjacent fixtures shall not be on the same circuit.

Lighting ballasts shall comply with requirements of UL 595 and ANSI-C82. A rapid-start, fluorescent lighting circuit, using two-lamp, high power factor, Certified Ballast Manufacturer's Association Ballasts with individual thermal protection or approved equivalent, shall be used. The over-temperature feature shall remove the power when over-temperature is reached and automatically reset when the temperature drops to acceptable levels. The over-temperature setting of the ballast shall not exceed the maximum temperature ratings of the components. The rating of ballast internal components shall not exceed UL limits. The ballasts shall have an operating frequency of 25 kHz or greater. Ballast reliability shall be 500,000 hours MTBF minimum. The ballasts shall also include reverse polarity and high and low voltage protection.

A shutdown circuit shall be provided for the protection of Operating and Maintenance personnel to prevent shock hazard when relamping and to prevent arcing at poor connections. The ballast shall automatically sense these conditions, turn off the power circuits, and remove 120 VAC from the lamp circuits.

Ballast electromagnetic emissions shall not exceed the levels specified in Section 17.5.17 and shall not interfere in the operating frequencies of the car communication system and crew radios.

Programmable electronic ballasts may be proposed to perform the functions of this Section. Such proposal shall include technical information and test data detailing how the proposed ballast complies with the requirements of this Section. The proposal shall also include experience and reliability data based on rail vehicle applications.

The design and reliability data for all fixtures shall be submitted to the Engineer for approval during design review process. **[CDRL 9-002]**

9.2.2 Stairway Lighting

Compact fluorescent fixtures shall be recessed in the stairway walls and directed downward to illuminate the stair tread. The fixtures shall be powered from the 72 VDC supply or from a combination of 72 VDC and 120 VAC supplies to provide the required illumination for normal and emergency service. The fixtures shall be proven for railway service.

9.2.3 Toilet Room Lighting

The toilet room shall use fluorescent fixtures of the same style as those in the main passenger area and shall include an emergency light. The fixtures shall be powered from the 72 VDC supply or from a combination of 72 VDC and 120 VAC supplies to provide the required illumination for normal and emergency service. The fluorescent lamp shall be rated at 20,000 hours. The fixtures shall be proven for railway service.

9.2.4 Emergency Lights

Each car shall be provided with emergency lights in four (4) passenger areas (both intermediate levels, upper level and lower level), in the vestibules, in the stairways in the end of car diaphragm area, and in the toilet room. Emergency lighting shall be evenly distributed throughout the car interior and include the car door areas and stairways. The emergency lights shall be powered from the car battery system upon loss of HEP trainline power. The emergency lights shall be powered from a long-life, DC inverter with status and test capability. The emergency lighting system shall comply with the minimum performance requirements of APTA SS-E-013-99 and 49 CFR 238 and 239. Additional protection shall be provided to the emergency lights and ballasts when the battery voltage drops below fifty (50) volts and the car remains in operating mode.

When the battery voltage drops below fifty (50) volts after less than 90 minutes, the emergency lighting shall extinguish and self-contained emergency lights shall be energized for the missing time to achieve the 90 minutes. The self-contained emergency light units shall consist of a 74

VDC current limited/ trickle charger with a nickel cadmium battery pack, and an internal battery operated emergency ballast for lighting during periods of total loss of AC and DC power on the car. The emergency light unit shall have sufficient capacity to provide a minimum of two (2) hours of operation from its own battery. The operation of the emergency light unit shall be coordinated with the load-shedding system to ensure a smooth change over of the lighting circuits without the loss of illumination. The emergency light unit shall be automatically recharged after the 74 VDC power is restored. The emergency light package shall be as furnished by Trans-Lite No. RS-4783-4 in a fixture RS-5538 or approved equal. The unit shall have an easily accessible self test feature which annunciates the condition and operation of the battery and light. One momentary activated switch shall be provided to reset the 90 minute timer. The switch shall be installed in the electrical locker.

Emergency lights shall be controlled by solid-state sensing devices or relays and shall be so designed that when the normal carbody lighting power is interrupted, the emergency lights shall be transferred to the car battery system. The car battery system shall provide power for emergency lighting until voltage falls to 50 VDC. The battery system shall have sufficient capacity to operate all emergency lights for at least 90 minutes as specified in 49 CFR 238.115.

The quantity and location of the emergency lights, emergency lighting arrangement, and operation shall be submitted to the Engineer for review and approval and demonstrated on the first of each car type. **[CDRL 9-003]**

9.2.5 Cab Console and Ceiling Lights

The lights for the cab area shall be designed and arranged to comply with the requirements of 49 CFR 229.127. A cab console light shall be provided with a dimmer control. It shall provide lights for the console and for reading train orders, timetables, etc. without reflecting from the windshield. Cab ceiling lights shall be provided.

9.2.6 Air Gauge Lights

Gauge lights, integral with the air gauges, shall be supplied as part of the pneumatic system and be powered from the 72 VDC low voltage power supply through the headlight switch. All gauge lights shall be provided with dimming capability. A single rotary interval switch shall be provided for dimming the cab console gauges. If required, voltage dropping resistors, to match the lamp voltage with the car voltage, shall be provided.

9.3 EXTERIOR LIGHTING

9.3.1 Headlights

A dual headlight shall be installed at the F-end of each cab car. It shall be installed above the end-of-car door opening, on the centerline of the car. It shall be designed to be aimed and relamped from the interior of the car. The procedure for access to and aiming of the lamp from the car interior shall be submitted to the Engineer during car design review. **[CDRL 9-004]**

The headlight shall consist of two (2) sealed beam lamps, each 200 W, 30 VDC, PAR 56 lamp, or approved equal. The lamps shall be mechanically adjustable with a locking device to permit proper horizontal and vertical alignment to comply with the requirements of 49 CFR 229.125. The headlight fixture cover glass, if required, shall be Pyrex or approved equal. Voltage-dropping resistors shall be provided to obtain 30 VDC at the headlight in the bright mode and 17 VDC in the dim mode when 72 VDC is supplied. The lamps shall be connected in series using zener diodes or approved equal apparatus to ensure that one lamp remains lit if the other fails.

9.3.2 Auxiliary Lights

Two (2) external, white auxiliary lights, complying with 49 CFR 229.125, shall be mounted on the lower end sheet on the F-end of each cab car (one light on each side). The auxiliary lights shall be aimed so the beams cross at a point 400 feet from the car at 50 +/-2 inches above top of rail. The auxiliary lights shall be recessed. The housing shall be of rugged corrosion resistant construction, approved by the Engineer and suitable for railroad use. The auxiliary lights shall be powered by the 120 VAC system through AC/DC converters and shall operate continuously when energized. Loss of 120 VAC converter power shall switch to power supply from locomotive trainline circuit formed by auxiliary light positive (pin 25) and auxiliary light negative (pin 26). The auxiliary light flash mode shall be controlled from the cab by a three (3) position selector switch to select “ON,” “OFF,” or “Automatic” modes. The auxiliary light shall be activated and flash in the “ON” position. The auxiliary lights shall stop flashing when the switch is turned to the “OFF” position. The auxiliary lights shall be activated and flash for 20 seconds whenever the horn is blown or the bell operated when in the “Automatic” position. The flashing rate shall be adjustable from 40 to 180 flashes per minute and shall be initially set to flash alternately at 60 flashes per minute. The power supply shall operate on 72 VDC and shall be capable of operating without damage within the voltage range specified in Section 2. The auxiliary light shall be designed to be lamped from the exterior of the car.

9.3.3 Marker Lights

Two (2) red marker lights shall be installed on the F-end sheets the of cab cars. Marker lights shall comply with requirements of 49 CFR 221 and shall be designed to be relamped from the exterior. The procedure for relamping shall be submitted to the Engineer for review and approval. **[CDRL 9-005]**

The marker light fixture shall use a clear bulk long life LED array rated at 100,000 hours at 40-95 volts. The light fixture shall be appropriately keyed to ensure the LED array is properly installed. The housing shall be red in color similar to Trans-Lite FM-6227, or approved equal. The marker light assembly shall be constructed of the same metal as the car structure, or have a gasket between the housing and mounting surface if made from a material different from the car body. Sealed beam lamps are not acceptable.

9.3.4 Car Number Signs

Two (2) illuminated car number signs shall be provided on the front of each cab car. One (1) shall be located on each side at an approved location. The signs shall allow for a four (4) digit number, 8 inches high, with a typeface of Helvetica Medium. The signs shall have a white translucent background with black numbers. They shall be located for access from the interior of the car for ease of servicing. The method for accessing the lights shall be submitted to the Engineer for review and approval as part of the design review package. **[Part of CDRL 9-001]** Each sign shall provide uniform illumination and shall be powered from the car battery with an electronic DC ballast at a frequency of at least 30 kHz. The ballast shall be Trans-Lite P/N AH-4781, Luminator P/N 108344-001, or approved equal.

9.3.5 Platform Lights

When the doors are open on SCRRA's existing vehicles, adequate platform lighting is provided from the interior lighting. The new vehicle's interior lighting and door arrangement shall be designed to provide lighting levels on the platform as per 49 CFR 38. If this cannot be achieved, the Contractor shall provide separate lights to meet the requirements of 49 CFR 38. Platform lights, if required, shall operate from the 72 VDC circuit.

9.3.6 Status Lights

A single side status light fixture shall be provided on each side of each car in a location submitted to the Engineer for review and approval. **[CDRL 9-006]** The design and location of the fixtures shall assure visibility of the fixture and aspects in sunlight and darkness by employees at track level, at door control stations or in control cabs.

Each fixture shall contain three (3) indicators and shall show the following:

1. Red Color: DOOR OPEN
   (Displayed only on car(s) with an open door).
2. Amber color: BRAKES APPLIED
   (Activated when the brake cylinder pressure is greater than 10 psi).
3. White Color: EMERGENCY BRAKE APPLIED/DOOR CONTROL STATION ACTIVATION
   (Displayed on any car where the passenger/conductor emergency brake actuator has been activated and/or the door control station is activated).

Access to the fixture for easy lamp replacement and cleaning shall be by a convenient, removable panel accessible from the car interior. Lenses and housings shall be watertight.

9.3.7 Portable Marker Light

A receptacle and mounting device for a portable marker light shall be provided at the A and B-ends of trailer cars and the B-end only of cab cars. One portable marker light shall be provided with each car. The marker light and luminosity shall comply with 49 CFR 221 requirements for marking devices. The light mounting arrangement and storage shall be subject to the approval by the Engineer. **[CDRL 9-007]**

9.3.8 End Door Lights

A fluorescent light fixture shall be installed overhead at each end door. The fixture shall be arranged and located to illuminate the inter-car passageway and floor area. The light fixture shall be powered from the 72 VDC system and shall be part of the emergency lighting system as described in Section 9.2.4.

The light fixture shall be watertight and service proven for commuter rail vehicle application. It shall also comply with general lighting requirements in Section 9.1.2.

9.4 LIGHT CONTROL

All lighting shall be protected by circuit breakers. The main passenger area lighting and platform lighting shall be controlled by circuit breakers located in the circuit breaker locker. The emergency lights shall be automatically controlled by a solid-state sensing device or a relay, as described in Section 9.2.4.

The car number sign lights, cab lights, auxiliary lights, headlights and marker lights shall be controlled by switches on the Operator's switch panel as described in Section 7.8. A switch with dimmer control shall be provided for controlling the cab console lights. The light control system, arrangement and switch location shall be subject to the approval of the Engineer. **[CDRL 9-008]**

End of Section

Contract Deliverables Requirement List

CDRL No.	Title	Car Type	Reference Paragraph
9-001	Details of Lighting Design, Arrangement, and Installation	All	9.1
9-002	Design and Reliability of Fixtures	All	9.2.1
9-003	Emergency Lighting Arrangement, Quantity, and Location	All	9.2.4
9-004	Headlight Access and Aiming Procedure	Cab	9.3.1
9-005	Marker Relamping Procedure	Cab	9.3.3
9-006	Location of Side Status Light Fixture	All	9.3.6
9-007	Portable Marker Light Mounting and Storage Arrangements	All	9.3.7
9-008	Lighting Control Arrangement and Switch Locations	All	9.4

SECTION 10

AUXILIARY POWER SUPPLIES AND ELECTRICAL APPARATUS

SECTION 10

AUXILIARY POWER SUPPLIES AND ELECTRICAL APPARATUS

TABLE OF CONTENTS

SECTION 10

AUXILIARY POWER SUPPLIES AND ELECTRICAL APPARATUS

10.1 GENERAL REQUIREMENTS AND FEATURES

The electrical power for the car system shall be derived from the Head End Power (HEP) or from Wayside power during layover periods. The Head End Power will be supplied from the locomotive by means of a 480 VAC AC, 3-phase, 60 Hz trainline. The trainline source shall be interlocked with the locomotive control by a loop circuit which shall not allow the disconnecting of a power receptacle under load. All systems shall meet 49 CFR 238 and 239 requirements and APTA RP-E-016-99, latest revision. All systems shall be isolated from ground on the positive and negative sides in a floating system. The design shall meet IEEE Standard 1476-2000 for Passenger Train Auxiliary Interfaces and IEEE Standard 1478-2001 for Environmental Conditions for Transit Rail Car Electronic Equipment. Design and concept development shall mitigate interference in the communication frequency band. Details of the design, arrangement, and installation of the low voltage power supply and battery charger shall be submitted to the Engineer for review and approval. **[CDRL 10-001]**

10.2 VOLTAGES

Four (4) voltage classes shall be used to distribute the electrical load requirements in the car.

10.2.1 Head End Power Distribution (HEP) 480 VAC

A 480 VAC, 60 Hz, 3-phase system shall provide the main electrical power from the trainline. Two (2) independent runs of three (3) 646MCM Cables shall form the three (3) power trainlines in order to allow power to be supplied from two (2) independent, non-parallel generating systems. Three (3) AWG #10 conductors shall be terminated to the three (3) control pins at each of the eight (8) 480 VAC connectors on the car. One (1) AWG #10 conductor shall be terminated in one (1) control pin of the 480 VAC fixed jumper cables and four (4) 480 VAC receptacles on each car. The designated conductor shall run the length of the car from each 480 VAC jumper and receptacles to form a continuous interlock circuit (trainline complete). The loop circuit provides the trainline complete signal to locomotive or wayside station. Two (2) AWG #10 conductors shall be terminated in two (2) control pins of the four (4) fixed jumper cables and four (4) 480 VAC receptacles on each car. The conductor shall be connected to carbody ground to form car-to-car ground continuity.

The trainline power shall be used to run the motors of the air-conditioning compressors, condenser and evaporator fans. It shall also furnish energy for floor and overhead heat. The load on the trainline system shall be properly distributed so as not to cause phase unbalance. A power consumption analysis and load distribution shall be provided to the Engineer for review and approval. **[CDRL 10-002]**

10.2.2 120 VAC Distribution

A 120 VAC, 60 Hz, single-phase power shall be derived from one (1), 3-phase 480/120 VAC transformer or two (2), single-phase transformers from the 480 VAC system. The 120 VAC system will provide the auxiliary and lighting load. The load will include fluorescent ballasts, fresh air fans, water cooler and convenience and maintenance outlets. The load shall be divided evenly among the phases.

10.2.3 72 VDC Distribution

A 72 VDC regulated, filtered output derived from the 480 VAC power supply shall be provided for various controls, battery charging, and emergency loads. Protective circuits are to be provided for over voltage and under voltage conditions. All 72 VDC devices shall be designed to be capable to operate within the range of 40 VDC to 85 VDC. This range is required to maintain compatibility with the SCRRA existing fleet.

10.2.4 36 VDC Distribution

A 36 VDC, 10 ampere, ungrounded, short circuit protected, power supply shall be provided to retain compatibility with existing SCRRA 36 VDC cars. The 36 VDC shall be derived from the 72 VDC system through a DC to DC converter. DC to DC converters are to be service proven under similar operating conditions.

10.3 BATTERIES

The Contractor shall comply with the requirements of and follow the guidelines provided in IEEE Standard 1536-2002 for Rail Transit Vehicle Battery Physical Interface and IEEE Recommended Practice 1568-2003 for Electrical Sizing of Nickel-Cadmium Batteries for Rail passenger Vehicles and APTA RP-E-007-98, Recommended Practice for Storage Batteries and Battery Compartments.

10.3.1 Requirements

Batteries shall be pocket or sintered plate or fiber, 48 cell, nickel cadmium (SAFT, Hoeppke or approved equal) of adequate Ampere-hour capacity to meet the required operating load. The battery capacity shall be sufficient to enable all low voltage DC circuits to operate for at least 3 hours over the specified ambient conditions described in Section 2.7.3 without the charger being turned on, with the battery fully charged at the start of the discharge cycle. After 3 hours, the battery voltage at the battery terminals shall not have fallen below 50 VDC. The battery, when discharged to 50 VDC measured at the battery terminals, shall charge within 2 hours to a level that will meet 49 CFR 238.11 requirements. The battery construction, identification, test methods, and connectors shall comply with 49 CFR 238.225 requirements. In emergency operation, the batteries must provide the loads specified in Section 10.6.

Details of battery capacity calculations, temperature de-rating, aging factor and load requirements are to be furnished to the Engineer for review and approval. **[CDRL 10-003]**

10.3.2 Battery Container

The battery shall be mounted in a weatherproof container with the battery raised to clear the bottom floor. The container shall be designed to be removable without the use of special tools. The container shall be properly corrosion resistant. The battery shall be mounted on a roll-out tray accessible from the exterior of the car. Consideration should be given for proper identification of tray connections to prevent accidental reversal of polarity. The design of the container shall be similar in construction and functionality as the battery boxes provided on the existing SCRRA cars. Proper ventilation shall be provided to prevent the accumulation of gasses using EN 50272.2.2001c standard or equal. Details of the battery container, ventilation, and battery specification shall be submitted to the Engineer for review and approval. **[CDRL 10-004]**

10.4 LOW VOLTAGE POWER SUPPLY (LVPS) AND BATTERY CHARGING SYSTEM

10.4.1 Requirements

The Contractor shall comply with the requirements of and follow the guidelines provided in IEEE Standard 1476-2000 for Passenger Train Auxiliary Power System Interfaces. The LVPS and battery charging unit shall be functionally separate systems with separate current limit and circuit breaker protection. The modules for the LVPS and battery charger shall be interchangeable. The battery charging unit shall have a dual charging rate to optimize the charging time to a specified level. The maximum charging current must be limited to the capacity of the LVPS/BC unit and the temperature limits of the battery cells. The capacity of the charger shall reflect the ability to charge a totally discharged battery within 2 hours to a level that will meet 49 CFR 238.115 requirements. The battery shall have sufficient capacity to provide the emergency loads specified in Section 10.6.

Details of the LVPS/Battery Charger system shall be submitted to the Engineer for review and approval. **[CDRL 10-005]** The details shall include LVPS/Battery Charger system technical data including:

1. Operating characteristics of auxiliary system power supply components;
2. Low-voltage power supply/battery charger operating characteristics;
3. Temperatures selected for overtemperature protection compensation and display;
4. Battery discharge curves and charging requirements; and
5. Tabulation of all low voltage DC loads, giving:
   - Maximum and average current,
   - Circuit breaker ratings, and
   - Continuous or intermittent load.

The unit shall be suitably weatherproofed and protected from shock and vibration by shock mounting of the enclosure or the internal components. The unit shall be solid-state, full-wave, best-available technology, with transient protection and surge suppression necessary to produce reliable performance in the commuter rail transit environment.

The LVPS/Battery Charger shall be capable of operation with a nominal input of 480 VAC, 3-phase with a tolerance of +/- 10 percent with an input frequency of 57-63 Hz, 3-phase. The input power factor, including all frequency harmonics of the current, should exceed 0.9 at the rated load. The output voltage shall have a ripple not to exceed 2.0 V peak-to-peak (0.7 V rms) under all operating conditions.

An optional separate LVPS and BC System may be proposed as equal. The merit of such system must be presented to the Engineer for evaluation.

- The LVPS/BC shall be a low voltage power supply derived from the 480 VAC HEP power system. The output is to be isolated from the input and properly regulated at 72 +/- 1 VDC for all operating loads. The input loads shall be balanced and distributed between the phases. Open phase protection shall be provided and indicated on the car monitoring system.
- Overtemperature protection and removal of charging current with indication of its occurrence, both at the LED display as well as on the remote display unit. The overtemperature protection shall be independent of the temperature compensation circuitry so as to provide independent operation of the circuit.
- The LVPS shall respond properly to load changes without flickering of lights and/or affecting other vehicle systems and components under all load conditions.
- Current limit protection shall be provided and shall be time limited to differentiate load characteristics from system faults.
- Self-test features shall be included to insure operation of the charging system as well as the operation of the protective circuitry.
- The LVPS/BC shall operate in the range of 46 VDC to 80 VDC. A load transfer shall occur when the limits specified in Section 10.4.2 are reached. The overvoltage and undervoltage circuits shall be activated when the high limit of 535 VAC and low limit of 425 VAC, from Section 10.2.1 HEP nominal voltage of 480 VAC +/-10 percent, are reached.
- Overvoltage and undervoltage activation will be announced in the car from the LVPS/BC monitoring and diagnostic system. Reverse polarity protection shall be included. The operation of the reverse polarity features shall not require the replacement of any components.
- The LVPS shall meet EMI specification requirements, Section 17.5.17, as well as FCC requirements Part 15, Subpart B, Class A, for emissions.

- Automatic change over to battery backup shall occur in case of a 480 VAC power failure or LVPS failure. The non-essential loads will be dropped during the change over.

10.4.2 Load Shedding

A load shedding contactor shall be provided to protect the battery from complete discharge in a short time. The contactor shall open when the battery voltage level drops within adjusted range between 46 and 50 VDC. An external indicator is to be included showing the contactor drop out. When the voltage level is at the lowest voltage recommended by the battery manufacturer for safe operation, an additional load drop-out shall occur. In this case only emergency load (radio and PA) will remain connected.

10.4.3 Sectionalized Construction

The design of the LVPS/BC system must be modular, permitting the replacement of sections within car (no roof opening access). Modular design should be based on functional units. Modules performing the same or similar function should be interchangeable. Redundancy in the LVPS and BC functions is required. Details of the modular design shall be submitted to the Engineer for review and approval. **[CDRL 10-006]**

10.4.4 Ground Isolation

Isolation from ground on both positive and negative sides shall be provided. Ground detection circuits shall be opto-isolated, or equal, from the carbody. The minimum setting for ground detection shall be adjustable from 5 to 10 milliampere. The setting should be locked at 6 milliampere.

10.4.5 Input and Output Protection

All fuses or circuit breakers protecting internal LVPS/BC circuitry shall be easily accessible for change-out or reset. The fuse nomenclature should differentiate between the car fuses used externally and the internal fuses of the power supply. Circuit breaker protection is preferred.

10.4.6 Integration with Car Monitoring and Diagnostic System

The Contractor shall design the car operational and data collection system including a data port and signal compatibility to provide meaningful operational data. The details for the car operational and data collection system shall be submitted to the Engineer for review and approval. **[CDRL 10-007]** An RS-422 port shall be provided for transmission of data at an agreed upon location. The status of abnormal operation of the LVPS/BC system shall be transmitted to the car monitoring system using the RS-422 port. Such condition shall include high or low output, ground fault, current limit and overtemperature occurrence.

10.4.7 LED Status Indication

The LED status display must be designed to facilitate the diagnostic procedure to detect the defective modular unit. The display should show the status in the operating mode as well as the status of protective features. The LED location should be selected to enable identification of defective modules. Green LED's should indicate normal operation; red LED's should indicate faults or operational problems; dual colored LED's may be proposed. As a minimum, the LED's shall be provided for the following events:

a) Current limit,

b) High voltage input,

c) Low voltage input,

d) Phase missing,

e) Overtemperature, and

f) High voltage output, presence of input voltage, open fuses or breakers.

10.5 BATTERY CHARGER

The battery charger shall include the following features:

1. Overtemperature protection and cut-out by means of properly positioned overtemperature sensors at the battery connections shall be provided to reduce or eliminate the battery charging current.
2. Interchangeability with existing fleet shall be provided on an assembly level. Functional assemblies should be physically interchangeable with the existing LVPS/BC units used by SCRRA in that the assemblies shall be dimensionally suitable to fit into the existing space, and should be compatible with the existing wiring. They shall equal or exceed the rating of the present units in both the LVPS and battery charging function.
3. Temperature compensation shall be provided for ambient temperature variations in accordance with the battery manufacturer's recommendation.
4. Current limit protection shall be provided to start a dead battery with a high charging current. The current limit should be in effect for a predetermined time allowing the charging system to detect a lower current requirement and a voltage rise. The output should return to the normal operating condition.
5. In addition to the charging requirement specified in Section 10.4.1, the unit is to be capable of charging a fully discharged battery in one 8-hour shift to a level that will meet the requirements specified in Section 10.3.1.

6. The remote display unit shall include the status of the battery charge, based on the charge and discharge current measured at the input to the battery. It should also include indication of the LED status indicators. The unit must retain the status of the battery charge in its non-volatile memory, without the use of the main battery power. The battery status condition must be retained when the car battery is disconnected from the charging system for long periods of time.

10.6 EMERGENCY OPERATION

The LVPS/BC unit should revert to emergency mode when there is a loss of 480 VAC power. The change-over shall be properly coordinated so as not to cause any cycling of loads or circuit breaker operation. The following loads are to be provided for 3 hours in emergency operation:

- Emergency Lighting (continuous),
- Door Controls and ADA audio/visual system (cycle doors on one side of the car open for 40 seconds every 5 minutes),
- PA and Intercom Systems (operate PA for 20 seconds every 5 minutes from hand held radio),
- Temperature Controls (continuous),
- Conductor Signal (operate for 5 seconds every 5 minutes),
- Wheel Slide Controller (cycle self test every 5 minutes),
- Destination Sign (continuous),
- Air Brake and Door Indicting Lights (continuous),
- Headlight and Marker Lights (Cab Car only - continuous),
- Radio (Cab Car only - operate for 20 seconds every 5 minutes),
- Speed Indicator (Cab Car only - continuous),
- Console Indicators (Cab Car only - continuous),
- Event Recorder (Cab Car only - continuous),
- Alertness Control (Cab Car only - continuous),
- Automatic Train Stop (Cab Car only - continuous), and
- Locomotive Controls (Cab Car only - continuous).

10.7 TRANSFORMERS AND 120 VOLT AUXILIARY LOAD

10.7.1 120 VAC Transformer

a) One (1), 3-phase 480/120 VAC, 60 Hz transformer of adequate capacity or two (2), single-phase 480/120 VAC delta connected transformers shall be provided for auxiliary loads. The total capacity of the transformers shall not be less than 18 kVA or larger than required to meet SCRRA operating conditions. The transformer load shall be distributed between phases.

b) The transformers shall be encapsulated industrial units, with proper shielding to reduce electrical noise. Copper windings are preferred.

10.7.2 120 VAC Auxiliary Load Convenience and Maintenance Outlets

All outlets shall be provided with a spring loaded cover to prevent accidental contact.

a) UL listed, twist-lock duplex maintenance electrical outlets located in the interior of the car. These outlets shall have spring loaded covers. The outlets shall be located at either end of each level and one in each intermediate level; for a total of six (6) receptacles. One switched incandescent light fixture and u-ground maintenance outlet shall be provided in the area of each HVAC unit.

b) UL listed standard duplex convenience outlets located in the interior of the car, four (4) on each level, shall be provided for laptop computer users. On levels with tables, the outlets shall be located at table locations. A spring loaded cover shall be included with each outlet to prevent unintentional contact. The outlets shall be on a separate circuit breaker and shall be protected by UL approved Ground Fault Interrupters (GFI) from power grounds. These outlets are not intended for vacuum cleaners or similar equipment; therefore, signs shall be installed indicating that these outlets are for laptop computers only.

c) UL listed, twist-lock duplex convenience electrical outlets shall be located at the B-end upper stairway wall and at the A-end of the lower floor. These outlets shall have spring loaded covers. These convenience outlets are intended for use by Maintenance Personnel for cleaning, servicing, and for general trouble shooting of the car.

d) UL listed twist-lock outlets shall be heavy duty outlets suitable for use by Maintenance Personnel for cleaning, servicing, and for general trouble shooting of the car and the car systems.

e) Grounded neutral outlets shall be provided for specific circuits in compatibility with the circuits of the present SCRRA cars.

The location of the outlets shall be submitted for review and approval by the Engineer. **[CDRL 10-008]**

10.8 SWITCH AND BREAKER PANELS

10.8.1 Switches

Switches are to be heavy duty, dustproof, industrial type, toggle action, trip free, shock resistant, properly sized and rated for the rail transit environment. They shall be mounted vertically, “ON” in the up position, and shall clearly indicate whether “ON” or “OFF”. Switches shall be provided with a keying feature so that after installation, the body of the switch is 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 of the manufacturer. All control switches which are subject to water splash, such as any switches mounted near windows or doors, or mounted on the Train Operator’s control console, shall be environmentally sealed.

Toggle and pushbutton switches shall be per MIL-S-3950, MIL-S-8805, MIL-S-83371, or the industrial equal. The design and selection of all switches shall be subject to review and approval.

10.8.2 Circuit Breakers – General

All circuit breakers shall be of rugged construction and fully suitable for the rail transit service environment. The design and selection of all circuit breakers shall be subject to review and approval. All circuit breakers of the same rating shall be of the same manufacturer and model throughout the vehicle.

a) The “ON,” “OFF,” and “Tripped” positions of all low voltage circuit breakers as applicable shall be permanently marked on the handle or the case of the circuit. The circuit breaker, when tripped, shall assume a distinct position between “ON” and “OFF” positions to permit visual determination of the fact that it has been tripped.

b) All circuit breakers shall be mounted in the vertical direction with the “ON” in the “UP” position. Circuit breakers shall be individually replaceable without disconnecting or removing any bus bars other than removing the mounting fasteners.

c) Electrical connections to circuit breakers shall either be threaded to accept machine screws or use threaded studs. Wires to circuit breakers shall use ring terminals. Circuit breaker terminals shall not be used as junction points.

d) The continuous current rating of thermal-magnetic trip circuit breakers shall be selected in accordance with ANSI C37.16 for the load and service specified.

e) High Voltage Breakers: The 480 VAC breakers shall be rated, at a minimum, for 600 VAC service and shall be mounted in the interior of the car for ease of troubleshooting and maintenance in an appropriate enclosure approved by the Engineer. The location and access shall provide adequate clearance as defined in NFPA - 70 for performing these tasks. The enclosure shall display the high voltage caution signs. The circuit breaker shall not be visible with the access panel of the enclosure in the closed position. The 480 VAC circuit breakers shall be Heinemann type GH3 or approved equal.

f) Low Voltage Breaker: The low voltage breakers shall be Heinemann type AM/R with center trip position or equal for the 120/240 VAC and 72 VDC rating, as required. All breakers used in the DC circuits must have the proper DC rating. They must operate under the specified environmental conditions without nuisance trips.

g) Circuit Breaker Panels shall be approved safety type with protection against accidental contact. Underfloor panels to be lined with insulating material.

h) The Interrupting rating of the circuit breakers shall be selected to protect circuits based on capacity and not on current limiting features.

i) Circuit breakers shall meet vibration requirement of MIL-STD-202 Method 213 or equal. The circuit breakers must meet Environmental Fungus resistance test per MIL-STD-202 or equal.

j) AC circuit breakers shall have the appropriate tripping curve characteristic for the type of load to which they are connected.

k) There shall be no paralleling of poles for current rating purposes.

10.9 GROUNDING

All electrical equipment, including conduit and wireways, shall be electrically grounded to the carbody structure. The ground connections shall be identified on the appropriate drawings and coordinated to reflect the voltage level distribution. Connections with dissimilar metals shall be treated with a corrosion inhibitor, and their application identified on the appropriate drawings. The shunts shall be protected against corrosion. The shunts shall be sized to meet the minimum voltage drop shown in the Specification. Grounding pads shall be designed for minimum resistance. For specific details concerning ground pad design and requirements, see Section 15.21.14.

Each car shall be equipped with a 72 VDC ground fault detection system, using internal or external remote detection of faults in each system. Ground fault detection of the 480 VAC system shall be provided only on the SCRRA locomotives and is not required for the cars. LED indicators shall be provided to indicate faults in each branch system, to identify leakage to ground. The leakage setting shall be determined by the sensitivity of the particular system to ground faults or by the settings in the internal circuits. The ground fault system design and detection shall be submitted to the Engineer during the design review for review and approval. **[CDRL 10-009]**

Frames shall be electrically grounded by appropriate copper braided shunts.

LED indicators shall be provided to indicate faults where fault detection is applicable. A complete listing of the load requirement per car, based on seasonal changes of requirements shall be furnished after the determination of the design parameters. **[CDRL 10-010]**

End of Section

Contract Deliverables Requirement List

CDRL No.	Title	Car Type	Reference Paragraph
10-001	Details of the Design, Arrangement, and Installation of the Low Voltage Power Supply and Batter Charger	All	10.1
10-002	Power Consumption Analysis and Load Distribution	All	10.2.1
10-003	Details of Battery Capacity Calculations, Temperature De-rating, Aging Factor and Load Requirements	All	10.3.1
10-004	Details of Battery Container, Ventilation, and Battery Specification	All	10.3.2
10-005	Details of LVPS/Battery Charger System including Technical Data	All	10.4.1
10-006	Details of Modular Design	All	10.4.3
10-007	Details of Car Operational and Data Collection System	All	10.4.6
10-008	Location of 120 VAC Outlets	All	10.7.2
10-009	Details of Ground Fault System Design and Detection	All	10.9
10-010	Complete Listing of Load Requirement Based on Seasonal Changes of Requirements	All	10.9

SECTION 11

TRUCKS

SECTION 11

TRUCKS

SECTION 11

TRUCKS

TABLE OF CONTENTS

SECTION 11

TRUCKS

11.1 GENERAL REQUIREMENTS AND FEATURES

11.1.1 General Arrangement

The truck design shall provide a truck that is light in weight, requires low maintenance, and has high reliability when used in the SCRRA operating environment. The truck shall be capable of operating at 110 mph service in accordance with FRA, AAR and APTA requirements over trackage maintained in accordance with FRA requirements for the intended speed. The truck shall provide the required ride quality, low noise and vibration generation, low wheel flange and rail wear, good rail adhesion and high-speed stability. The truck design shall not permit sliding metal-to-metal contact surfaces, and shall not have lost motion or free play in any area. The Contractor shall follow all of the requirements and guidelines provided in APTA RP-M-009-98 (latest revision) to demonstrate through design, analysis, and testing that the truck conforms to the requirements of this Specification.

The truck and suspension subsystem is formed by all truck components from the rail up to the body bolster, including any suspension subsystem components rigidly mounted to the carbody. Any mechanical interface requiring welding or drilling on the truck shall also be considered part of the truck. Clamps for piping, cables, etc. shall be attached to tapping plates or raised bosses. All truck-mounted equipment shall be accommodated without physical interference, including the condition of one failed suspension component.

The trucks shall be designed and the truck frames manufactured by a supplier(s) who has designed and manufactured the same trucks previously, or shall be an adaptation of a design manufactured by the supplier. The Contractor shall submit the service history of the truck, noting any deviation for this application to the Engineer for review and approval, prior to truck selection. **[CDRL 11-001]** Details of the design, arrangement, installation, and testing of the truck components and assembly(ies) shall be submitted to the Engineer for review and approval, prior to construction of the truck or any truck parts. **[CDRL 11-002]**

Four-wheel, inside or outside steel frame, equalized, roller bearing trucks of approved design shall be provided. SCRRA prefers an inside bearing truck. Forces resulting from acceleration and braking must be transmitted through the frame to minimize wheel unloading. If outside-frame trucks are supplied they shall be arranged so that no part of the truck prevents scanning by wayside hot-journal detectors. Truck frames shall have provisions for the application of anti-yaw dampers to control yawing motion. The truck shall be equipped with anti-yaw dampers if analysis, tests, or operation indicates that they are required.

As part of the analysis and testing a Truck Technical Data package shall be submitted for review and approval by the Engineer. **[Part of CDRL 11-002]** The package shall consist of the following:

1. Drawings showing the truck assembly in plan, side and front view. The drawings shall identify all welds and indicate relation of welded seams to the neutral axes of the weldment. General arrangement, load paths, provision for equalization, and interfaces shall be clearly shown. A quality control procedure shall be submitted outlining the proposed methods of assuring the structural integrity of truck frame members, with particular attention to critical sections, inspection and repair of defects.

2. A list of carbody motion limits in relation to the truck shall be provided as follows:
   - Vertical (up and down),
   - Lateral,
   - Longitudinal, and
   - Roll angle.

3. Suspension data shall be provided as follows:
   - Type of primary and secondary suspension,
   - Manufacturer of air spring,
   - Damping constant of each shock absorber,
   - Spring constant of body suspension (expressed as a curve, if not linear), vertical, lateral (at working height) with ends of springs maintained parallel,
   - Relationship of air spring pressure to vertical force at constant height and also at various heights,
   - No load and maximum load air spring pressures,
   - Total air spring volume; including auxiliary reservoir volume,
   - Air spring damping orifice size and damping rates, vertical and roll for trucks,
   - Air supply requirements,
   - Vertical spring constants or load-deflection curves of all resilient truck components other than the body suspension system, and
   - Roll stabilizer arrangement and parameters.

4. Material specifications and static and dynamic design stress levels of truck frame components, axles and springs shall be included.

5. Preliminary detail drawings and material specifications shall be provided for:
   - Axles,
   - Wheels,
   - Hydraulic shock absorbers,
   - Elastomeric journal bearing support, and
   - Upstop assembly.

11.1.2 Codes and Standards

Truck to carbody attachment shall comply with 49 CFR 238.219, and APTA SS-C&S-034-99, Rev. 1. Positive mechanical means shall be used for the attachment such that the trucks shall be raised with the carbody, without disengaging any part of the suspension system. Anchor or traction rods shall not be used to supply any of the connection truck to carbody attachment strength. Additionally, each component of a truck, including axles, wheels, bearings, truck mounted brake system, suspension system components, and any other component attached to the truck by design shall remain attached to the truck when a force equivalent to 2g acting on the mass of the component is exerted in any direction on that component in accordance with 49 CFR 238.419 (b).

Truck stability shall comply with 49 CFR 238.227 and APTA RP-M-009-98. This stability will be provided while at the same time allowing the cars to negotiate curves specified in Section 2.7 without causing excessive flange or rail wear. Vehicle qualification testing and analysis as per Section 2.5 shall comply with 49 CFR 213.345, and show that at any speed up to 110 mph that the equipment shall not exceed the wheel/rail force safety limits and the truck lateral accelerations, as measured over the axle boxes, specified in 49 CFR 213.333 or Section 6.3.6 of APTA RP-M-009-98, and the carbody accelerations of 49 CFR 213.345. Qualification shall be done at an appropriate test location as approved by SCRRA. Additional qualification testing shall be performed on sections of SCRRA track that are available and appropriate for the test speed. The safety limits noted above shall not be exceeded with air bags inflated or deflated.

Reports on these tests shall be provided to SCRRA within thirty (30) days of conducting the test. **[CDRL 11-003]** Any failures of the specified criteria shall require an analysis and implementation of corrective actions to allow the truck to comply with all requirements. Complete stability and ride quality retesting shall be required of the modified truck to ensure that the modification does not degrade any performance aspect of the truck.

11.1.3 Expected Service Life

The expected service life of these trucks shall be thirty (30) years. As such, truck frames and bolsters shall be designed to maintain stresses within the endurance limits for the specified operational environment over the thirty (30) year service life while minimizing the weight of these components. The design life for elastomeric components shall be no less than seven (7) years.

11.1.4 Interchangeability

Trucks shall be interchangeable between ends of the cars with no modifications to the truck except for installation and removal of parking brake rigging, leveling valve connections, truck piping and ATS equipment. Installation and removal of the aforementioned equipment shall be achieved with bolted connections. No welding, drilling, tapping, riveting or cutting shall be necessary for application or removal of the aforementioned equipment. As a minimum truck frames, bolsters, wheels, axles, and bearings shall be interchangeable between all trucks.

11.1.5 Clearance

The completely assembled trucks with brakes and other equipment shall not exceed the clearance limits required between truck and carbody, or between truck and track and wayside structures with maximum wear and load, over minimum radius curves or tangent track. The minimum clearance above the top of running rail, except for wheels, brakes, equalizers and pedestals shall be 6.5 inches with fully worn wheels. Equalizers, brakes and pedestals shall have a minimum of 2.75 inches clearance above top of rail with fully worn wheels.

The maximum vertical and lateral deflection and maximum roll shall not exceed those values that shall keep the complete car within the construction limit and car clearance diagram. The method of meeting these requirements shall be submitted for approval before the truck design is finalized. **[CDRL 11-004]**

11.1.6 Maintenance Access

The design shall meet the inspections and maintenance recommended by APTA SS-I&M-009-98, SS-I&M-010-98, SS-I&M-011-98, and SS-I&M-012-98, as no major disassembly shall be required to perform all recommended inspections and adjustments. All major bolted, threaded, keyed, or pinned connections and structurally critical locations shall be readily accessible for visual inspection. Threaded fasteners shall be readily accessible with standard hand tools without removal of truck components or the removal of the truck from the car. All air brake piping on the truck and from the carbody to the truck shall be installed in a protected environment. Air piping shall not be routed beneath the truck. Access to all piping and hoses for inspection or replacement shall not require more than five minutes.

Provision shall be made for the use of wheel truing machines to turn wheels while the trucks are attached to the car. No part of the truck assembly or car anchor rod brackets shall interfere with or foul any part of these machines. Access to axle centers shall be readily available without removal of any components that affect the integrity of the connection between axle and truck. The axle center taper shall be the same as on current SCRRA vehicles. If further clarification on wheel truing machine dimensions is required to meet clearance and/or compatibility, SCRRA will, upon request, provide access to the machine for the Contractor’s inspection.

The truck to carbody interface shall be designed to allow truck removal with minimal lifting of the car, sufficient for the truck to clear pilot, battery box**,** coupler and draft gear. Any parts requiring disassembly to permit truck removal shall be mounted with accessible bolts, pins, or other approved fasteners which can be removed using common hand tools.

11.2 TRUCK FRAME AND BOLSTER

11.2.1 General

The truck frame and bolster shall be of welded and/or cast steel to the material requirements of Section 15.7, and Section 15.8, respectively. The base metal for all truck frame structural components shall have a Charpy V Notch (Type A) impact strength of at least 20 foot-pounds at

-40°F.

Each truck frame shall have accurately located permanent tram marks to inspect for truck tram. Means shall be provided to check the alignment and tram of journal box swing arms if provided. Pedestal tie bars, if used, shall be attached to the truck frame pedestals in a manner that provides a positive, metal-in-bearing path for loads that may be taken through the tie bars. A pedestal tie bar attachment design that depends solely on clamping friction to transmit loads between it and the pedestals shall not be acceptable. Where pockets or partially enclosed spaces exist adequate drainage shall be provided so that no moisture, or other debris collects anywhere within the truck frame and bolster.

Bolt hole stress shall be analyzed per BS 7608, or other approved international standard. Threaded fasteners, adjustment points, and structurally critical locations shall be accessible for inspection and work using conventional means and tools.

11.2.2 Requirements for Castings

Cast steel frames may be unit castings or “cast-weld,” which is a weld-fabricated assembly. If a “cast-weld” design is provided, the assembly welds shall be located such that they are not stressed in net tension across the joint by the primary loads. Castings shall be AAR Specification M-201 Grade B per Section 15.8. The quality of steel castings shall be per Sections 15.8.2 and 15.8.3.

11.2.3 Requirements for Welded Structure

Fabricated truck frames shall be fabricated from low-allow high-tensile steel (LAHT) per Section 15.7. Welding shall be in accordance with Section 15.5.

11.3 WEIGHTS AND DIMENSIONS

Trucks shall be designed to obtain the minimum weight, consistent with adequate strength, durability, reliability, performance, and low maintenance. Truck wheelbase is to be 8 feet and 6 inches; wheel diameter (new) to be 33 inches to 36 inches.

The completely assembled trucks, with brakes and other equipment, shall not exceed the clearance limits required between truck and carbody or between truck and roadway for safe operation, with maximum wear and load, over limiting lateral and vertical curves, as well as tangent track as prescribed in the construction limit outline and car clearance diagrams. All truck parts shall negotiate the minimum radius curve as specified in Section 2.7.1.

11.4 DESIGN FEATURES

11.4.1 Static Loads

The allowable stress for static loads is 55 percent of yield. Allowance shall be made on a case-by-case basis for localized areas of stress in excess of 55 percent of yield that do not compromise the ability of the affected structure to meet the requirements of the specification. Static stresses in welds shall not exceed the limits given in Table 2.3 of AWS D1.1, 2002. The following static loads shall be designed for:

- Vertical: The trucks share of 100 percent of the car weight at AW3 plus weight transfer effects due to a maximum instantaneous braking effort at 50 percent adhesion.
- Longitudinal: The trucks share of maximum instantaneous emergency braking effort at AW3 at 50 percent adhesion, including vertical augment, applied at the carbody center of gravity (cg).
- Lateral: The trucks share of a lateral load applied at the carbody cg equal to 0.25g. Additionally, a lateral load sufficient to develop vehicle overturning (zero load on one rail) shall be analyzed in conjunction with other loads and shall not cause stress in excess of yield.
- Accessory: Maximum instantaneous braking effort at 50 percent adhesion shall be the design criterium. Also, the theoretical maximum braking effort with main reservoir pressure in the brake equipment and perfect adhesion shall not cause stresses in excess of yield. The maximum load producible by any other accessory equipment, including dampers shall not produce stresses in excess of 55 percent of yield.

11.4.2 Fatigue Loads

The fatigue design of the truck frame and bolster shall be based on a design load equal to AW2 (fully seated load with limited standees) less the truck weight. Allowable stresses for base metal and welds shall be in accordance with AWS D1.1, 2002, threshold value F_{TH} per Table 2.4. The following fatigue loads shall be designed for:

- Vertical: Mean load equal to the truck’s share of AW2 vehicle load with a +/- 20 percent augment.
- Lateral: Load shall be equal to +/- 15 percent of the mean vertical load acting as if applied at the carbody cg.
- Longitudinal: Load shall be equal to +/- 15 percent of the mean vertical load acting as if applied at the carbody cg.
- Accessory: Full service breaking deceleration rate at AW2, and the nominal wheel/shoe friction per the brake shoe manufacturer, but not more than 0.25. Maximum expected damper load determined from the ride quality simulation. ATS equipments shall be analyzed based upon worse case accelerations and associated stresses.

11.4.3 Shock Loads

The truck frame and all truck parts shall be capable of withstanding the maximum stresses imposed by track-induced shock as well as the loads discussed above for the truck design life. Items attached to the wheel sets, and truck frames shall be designed and tested to withstand shocks in accordance with IEC 61373 values.

11.4.4 Stress Analysis

Prior to truck and bolster static and fatigue testing per Section 17.3.8.3, a stress analysis of the truck frame and bolster comprised of an FEA model **[CDRL 11-005]**, and stress analysis **[CDRL 11-006]** shall be submitted for review and approval. The stress analysis shall show the calculated stresses, allowable stresses, and margins of safety for all elements for all specified loading conditions. The stress analysis shall consist, as a minimum, of a finite element analysis, supplemented as necessary by manual analysis. Solid elements shall be used in the finite element analysis. Other element types (beam, plates etc.) shall only be used in limited quantities as required. The finite element model computer files shall be submitted to SCRRA in original format suitable for processing by FEMAP or ANSYS.

The initial stress analysis shall require temporary assumptions as to car weight, and other issues. The final submitted and approved stress analysis shall be for the trucks and car weight in the as-built configuration, or greater. The approved stress analysis shall be a prerequisite for approval of the structural test procedures and structural drawings required by the specification and shall be used as an aid in determining strain gage locations for use during these tests. Critical components that cannot be adequately analyzed shall be prototyped and tested to demonstrate compliance with the requirements of the design and the Specification.

11.4.5 Comparison with Test Results

Strain gage readings from the static load tests of Section 17.3.8.2 are to be compared to the FEA results to validate the FEA, and the comparison submitted to the Engineer for approval. **[CDRL 11-007]** Specifically, gages with a stress equal to or greater than 50 percent of the permissible fatigue stress shall agree with an error of less than 15 percent (using the FEA value as a basis). Errors greater than 15 percent shall require an analysis of the difference. If the analysis does not sufficiently resolve the difference, the FEA model shall be refined to reduce the error to within 15 percent.

11.4.6 Ride Quality

Trucks shall be suitable for operation at all speeds up to 110 mph and shall provide a comfortable ride at all speeds compliant with the ride quality test requirements of Section 2.5.3. The vehicle shall meet the requirements of 49 CFR 213.345. A mathematical model of the vehicle shall be developed and submitted to the Engineer prior to any vehicle testing to predict the dynamic performance and ride quality. **[CDRL 11-008]** This model shall serve in part as the basis for any decisions for correcting dynamics performance and ride quality deficiencies. The model shall be developed on an industry accepted program such as NUCARS, Vampire, or other generally accepted vehicle dynamic program.

The vehicle model will be used in conjunction with 1) actual track data from SCRRA routes, 2) combination defects at FRA limits for the applicable class, and 3) over a “Down and Out” perturbation as defined in Section 7.5.1 of the 2003 NUCARS 2.3 Users Manual, Pages 7-6 and 7-7, using displacements appropriate for Class 5 geometry with the sinusoids beginning at the start of the full body of a 2-degree curve with a superelevation of 6 inches, and a cant deficiency of 4 inches. Additionally the ability to safely negotiate curves specified in Section 2.7.1 at the greater of the curve operating speed, or 4 inches of cant deficiency shall be demonstrated.

Should the cars fail to satisfy the above-mentioned requirements, a program for correcting the deficiencies shall be submitted to the Engineer for approval within fourteen (14) days, together with a proposed schedule for completing the suggested correction. If, in the opinion of the Engineer, the program and/or schedule are inadequate or unsatisfactory, an acceptable program and schedule shall be resubmitted within seven (7) days. If the revised program and schedule are not submitted in time or is still unacceptable, SCRRA will return the cars to the Contractor's plant at the Contractor's expense.

Should the cars, after correction, still fail to produce the riding qualities specified, SCRRA will have the right to require the Contractor to make further modifications to bring performance to the required standards, and the vehicle will be characterized per AAR Appendix A, Vehicle Characterization for Chapter XI (M-1001) Testing.

Any modifications, contemplated to bring ride quality to the level required, shall be submitted to the Engineer for approval. If, in the opinion of the Engineer, the proposed modifications will increase maintenance costs or otherwise affect the serviceability of the cars, the modifications will not be approved.

11.4.7 Equalization

Truck equalization capability shall be sufficient to ensure that:

1. With the air springs inflated to operating height and with the load-leveling valves disconnected, the weight carried by any wheel on the car shall not vary by more than 55 percent with the car on level track and one (1) wheel of a truck raised or lowered 2 inches.

2. With the air springs inflated to operating height and with the load-leveling valves connected, the remaining wheels shall remain in contact with the track, with the car on level track, and one (1) wheel of a truck raised or lowered 2.5 inches.

3. The vehicle shall safely negotiate all classes of FRA track, including Class 1 Track with 3 inch cusps or low joints, up to the maximum vehicle qualification speed of 110 mph. Equalization shall meet the requirements of the equalization test in Section 17.3.8.5. A report of the testing shall be submitted for review. **[CDRL 11-009]**

11.5 WHEELS

Wheels shall be 33 inches or 36 inches diameter, multiple-wear type, AAR Class "A", cast or wrought, curved plate, hub stamped, in accordance with AAR Specification M-107-84 latest revision, including AAR Circular Letter C-9201 and APTA SS-M-012-99. Wheel profile will be 5-1/2 inch wide, in accordance with Drawing Section 20, Drawing No. 070302003. Contractor shall submit to the Engineer a wheel drawing and a list of railroads and passenger rail agencies using similar wheels. **[CDRL 11-010]** All wheels shall be of a proven design with the lowest possible mechanical and thermal stresses available. FEA of the wheel design selected shall be submitted to the Engineer for review and approval. The FEA will analyze both mechanical and thermal stresses and as required by 49 CFR 238.231(f) and in conjunction with the brake system be shown to be free of condemnable cracks. **[CDRL 11-011]**

The entire wheel shall be inspected and tested by NDT ultrasound equipment and certified before application to an axle. Each and every wheel provided for this application shall have the following data submitted to the Engineer for review and approval prior to mounting on axles, **[CDRL 11-012]** and also included in the Car History Book:

- Serial Number
- Brinell Hardness Test Data
- Fracture Toughness Test Data (per each lot/heat)
- Ultrasound Test Certification
- Ladle Analysis (per each lot/heat)

If brake discs are required to be mounted to the wheels by the approved design, particular care shall be taken with the mounting holes drilled and tapped in all wheels for brake disc attachment. These holes shall be of sufficient depth, bottom tapped, and completely free of drill cuttings or other debris to allow the application of proper torque to the required disc attaching bolts.

11.6 AXLES

11.6.1 AAR and APTA requirements

Axles shall be designed in accordance with APTA RP-M-001-98 Recommended Practice for Passenger Car Axle Design. Solid axles to AAR M-101 Grade F, double normalized and tempered shall be supplied. Steels that contain chromium or molybdenum with or without nickel are acceptable provided they met Grade F properties. All axles shall be given a sub-critical quench heat treatment. Axles shall be designed to have a fatigue life of not less than thirty (30) years.

The Contractor shall ensure the maximum fatigue resistance of all axle grooves and machine surfaces through the use of acceptable design and analysis. The Contractor's manufacturing process and quality assurance plan shall incorporate sufficient controls, inspections, and tests to ensure the axle provides the fatigue resistance required by the design. In all cases, the design of any grooves or other machine surfaces shall be subject to review and approval by the Engineer. **[CDRL 11-013]**

All axles shall be thoroughly inspected by the Contractor. The Car History Book for each car shall contain all inspection documents for the axles on that car. A list of these documents shall be proposed to SCRRA for review and approval prior to shipment of the first car. As a minimum, these documents shall include the following information: inspection and repair form/report, serial number, heat number, Brinell hardness test results, ladle analysis, fracture toughness, ultra sound test results, and magnetic particle test results. **[CDRL 11-014]**

11.6.2 Mounting

Refer to SCRRA Document SPEC 99-001 (new issue August, 1999). All mounting pressure graphs, mounting diameters, wheel tape size, concentricity and parallel measurements discussed below shall be furnished to SCRRA. **[CDRL 11-015]** The graphs obtained shall correspond with those shown as "acceptable" or better in Section 2 c), Wheel Press Practice of the AAR Wheel and Axle Manual with the following exceptions for inboard bearings:

1. Back to back wheel dimension shall be 53.375 inches to +0.005 to -0.125 inches.
2. More restrictive conditions shall apply if recommended by the truck manufacturer.
3. The bearing interference fit shall be a minimum of 0.0025 inch and a maximum of 0.0045 inch. At a minimum, bearing cone diameters and the corresponding diameters of the bearing seats shall be measured at three (3) locations on their length and at 120 degrees on the diameter, and the interference fit shall be within limits at all measured locations. For cones, nine (9) measurements are to be recorded, three (3) at each location; 0.375 inches inside from each face and at the mid-point. For seats, nine (9) measurements are to be recorded; their locations shall correspond to locations for the cone measurements when seated. This shall be strictly monitored and enforced; there shall be 100 percent surveillance of the entire bearing assembly process, including mounting.
4. There shall be a minimum 20 ton and a 30 ton maximum "spike" (defined as that tonnage increase above average before the spike) measured and recorded on a pressure chart on the bearing/axle shoulder mounting. Specific mounting recommendations of the bearing manufacturer shall have precedence over this requirement.
5. After the wheel hub has made contact with the bearing, a 40 ton minimum and 60 ton maximum "spike" shall be obtained. "Spike" is defined as the pressure increase above that which exists when the wheel hub contacts the bearing. This "spike" shall be recorded on the pressure chart.
6. Completed wheel sets, including bolt on brake discs, shall have a static imbalance of 83.3 ounce-inches or less.

Prior to pressing, the seats shall be prepared as described in the AAR Wheel and Axle manual. Particular attention shall be paid to AAR Rule 1A7 that an axle wheel seat must be checked at not less than three (3) points in its length, and on two (2) different diameters at each of these points to assure rotundity.

Wheel pairs shall be matched, not to exceed one-half tape size per axle set. Mounted wheels shall be concentric between bearing seat diameters and tread at the plane of the taping line within

0.007 inches TIR and not to exceed 0.015 TIR, inches out of parallel to each other or to a plane perpendicular to the center line of the axle per AAR requirements.

11.6.3 Marking

Each axle shall be permanently marked with the information required by AAR M-101. SCRRA shall be furnished with a record of the manufacturer's serial and heat numbers listed together with the serial numbers of the trucks and cars on which they have been installed, and included in the Car History Books. **[CDRL 11-016]**

11.7 JOURNAL BEARINGS

The journal bearings shall be fully enclosed No Field Lubrication (NFL) roller bearings, Timken Part No. HM 133444-90382 or equal including the HDL seal per Timken drawing E43798, 6-1/2 x 12, type AP, Class F. If a more robust bearing is required due to car characteristics, the suggested bearing shall be submitted to the Engineer for approval. The journal bearings shall be thoroughly packed with the recommended amount of AAR approved grease, in accordance with AAR specification M-942. Grease fittings shall not be provided.

Under normal operating conditions, bearings shall not require inspection more than once every 500,000 miles. Journal bearings shall be designed for an ANSI/AFBMA L_{10} of 1,000,000 miles of service at AW2 passenger load. The bearing type shall have had previous successful service application in railway passenger car use.

Journal boxes shall be of cast steel, AAR Spec. M-201 Grade B, and shall incorporate seats for the primary springs or equalizer, if appropriate to the design of the primary suspension. Centerline of primary springs and equalizers shall coincide with centerline of journal bearings.

The journal-bearing housing shall accept a heat sensor or "stink-bomb" hot bearing detector. Sensors shall be supplied and installed by the Contractor. These devices shall be easily accessible for inspection and replacement.

11.8 DISC BRAKE ROTORS

Disc brakes shall be attached with bolts to one wheel on each axle, and shall have the bolts secured in accordance with SAE AS 567 Revision J or later.

If axle mounted discs are provided, they shall be a split disc design and submitted to the Engineer for approval.

Disc brake rotors shall be positioned to allow for effective ventilation as required by the rotor design, but shall not affect scanning equipment to detect overheated journals or wheels. A dynamometer test of the disc system is required for approval. If thermal analysis or dynamometer test results require additional disc brake units to meet brake performance requirements, one (1) disc brake unit per wheel shall be used with the design submitted to the

Engineer for approval. If the additional disc brake units are required only for operation above 90 MPH, Contractor may omit the additional units, but shall include provisions for mounting the disc brakes and any other new or modified equipment that may be required. The Contractor shall submit the design including analysis or dynamometer test results for operation below, at and above 90 MPH, to the Engineer for approval. **[CDRL 11-017]**

11.9 SPEED AND ATS SENSORS

Speed and ATS sensors, and associated hardware, appropriate for the slide and train stop control, shall be integrated into the truck in such a way as to allow easy access for adjustment and maintenance removal and replacement, and be protected from debris. Appropriate clearance shall be provided between the speed sensor and ATS systems and truck/carbody components under all dynamic conditions, including the failure of one suspension component. Cabling shall be armored and provided with a minimum of connections to ensure reliability. Connectors shall be suitable for the harsh, under-car environment and shall allow removal of sensors without pressing off the wheel assembly. Design and application information for the speed and ATS sensors will be submitted to the Engineer for approval. **[CDRL 11-018]**

11.10 PRIMARY SUSPENSION

11.10.1 Stops

Vertical and lateral stops will be provided as required to prevent excessive displacement.

11.10.2 Steel Coil Spring

If steel coil springs are used, nested springs shall be used and shall be designed to have a 50 percent working height reserve when subjected to the normal working load. Coil springs shall be alloy steel in accordance with AAR M-114-81, shot peened and painted black. The springs shall rest on vibration and sound deadening inserts.

11.10.3 Chevrons

If chevron or equivalent elastomeric springs are used for the primary suspension they shall be sufficiently durable to last the OEM specified overhaul interval, but not less than seven years. Allowance shall be made for the worst-case rubber creep in the truck design.

11.10.4 Alignment in Curves

The primary suspension shall have sufficient longitudinal compliance to allow natural curving forces to align the axles in curves, so that lead axle yaw rotation in curves meets the requirements of the analysis described in Section 17.5.8.

11.10.5 Damper Requirements

If required, hydraulic vertical shock absorbers shall be provided at each wheel. Shock absorbers shall have sufficient durability to last the specified overhaul interval, but no less than five (5) years. In the event of damage, they shall be readily accessible for replacement and shall be arranged to permit replacement within 30 minutes using only ordinary railroad shop tools. An inspection procedure will be provided in the maintenance manuals for determining if dampers are serviceable.

11.11 SECONDARY SUSPENSION

11.11.1 Bumpers/Stops

Vertical and lateral bumpers shall have a progressive rate, replaceable elastomeric pad. Lateral and vertical bumpers shall limit motion to within clearance requirements. Bumpers shall be arranged such that they shall not go solid under any conditions that can be developed in the truck during normal operation. Solid mechanical stops shall prevent lateral displacement in excess of the allowable motion stipulated on the Construction Limit Outline. The Contractor shall submit designs and data for all primary and secondary suspension bumpers and stops to the Engineer for review and approval. **[CDRL 11-019]**

11.11.2 Air Spring Requirements

The secondary suspension springs shall be a double convolution air spring at each end of the truck bolster, Firestone Model 200C or approved equal. A rolling diaphragm type air spring may be submitted to the Engineer for approval as an alternative to the specified air spring. The air bag shall be arranged such that all surfaces (except top and bottom) can be inspected from the side of a complete, ready to run vehicle with its wheels resting on the track. Reference points for the measurement of air spring height shall be clearly marked on each assembly.

Means shall be provided so that when one air spring of a pair is deflated for any reason, the other is also deflated, regardless of whether or not they are controlled by the same leveling valve. A cutout cock in an approved location shall be provided in the air supply line to the air springs on each truck. The cutout cock shall be accessible from the side of the car. Each pair of air springs shall be connected through damping orifices to a reservoir that may be contained in the truck bolster. Orifice resistance to the transfer of air between the air spring and reservoir shall be provided. Reservoirs, including those contained in the truck shall be designed as a minimum to ASME BPV Code, Division VIII, Section 1.

An elastomeric stop shall be provided in each air spring housing to limit bolster, vertical down motion and to support the carbody in the event of air spring failure. The stop shall be designed with a progressive rate to produce allow force at initial contact and build up as the stop is compressed. Details of the air spring arrangement shall be submitted to the Engineer for review and approval. **[CDRL 11-020]**

11.11.3 Leveling System (Load Leveling & Load Compensation)

The cars shall be equipped with two (2) leveling valves at the B-end truck and one (1) leveling valve at the A-end truck. A four (4) leveling valve arrangement, two (2) leveling valves per each truck, may be proposed for review and approval by the Engineer. Leveling valves or equivalent sensors on each truck shall control air spring pressure. These valves shall control the vehicle height to compensate for changes in passenger load and distribution. Leveling valves or sensors shall have a response dead band commensurate with the floor leveling requirements, but shall not be susceptible to spring pressure oscillation. Accessible and suitable test fittings shall be provided for each leveling valve to monitor and calibrate air spring pressure. Sudden loss of suspension air pressure on either side of a truck shall initiate rapid venting of the opposite spring. If a single leveling valve is used on a truck it shall be located as close as possible to the car centerline, and shall be readily accessible for maintenance.

The leveling valves shall be of a proven design, shall have sufficient durability to last the specified overhaul interval, and shall be able to withstand the harsh environment to which they shall be subjected, including, but not limited to, debris, and water and oil entrained in the supply air.

The leveling system and buffer plates shall be designed such that buffers cannot pass one another with the air springs fully over-inflated on one car and fully deflated on the other. Any possible normal movement of the truck shall not damage these valves. The normal failure mode of these valves shall be to cause air spring deflation. A choke and cut out cock shall be provided in the leveling valve air line to both trucks to prevent rapid air loss and a consequent brake application in the event of air spring rupture.

A detailed procedure for leveling the cars, including tolerances and all required tools shall be submitted for approval. **[CDRL 11-021]**

11.11.4 Car Height Adjustment

Provision shall be made for a minimum of 1.5 inch adjustment, in at least three (3) equal steps, of the bolster or truck height to compensate for wheel wear. This equates to a 3 inch reduction in wheel diameter. The design and method of height adjustment shall allow for quick and easy adjustment without disassembly of the truck or removal of the truck from the car and shall be approved by the Engineer. **[CDRL 11-022]** The adjustment method shall be demonstrated on the Pilot Car.

11.11.5 Damper Requirements

Vertical and lateral dampers shall be provided to control carbody motion. The vertical dampers shall be either hydraulic or pneumatic, and the lateral dampers shall be hydraulic. The method of adjustment and arrangement of the dampers shall be approved by the Engineer. **[Part of CDRL 11-019]** If the design does not require anti-yaw dampers, truck-mounting points shall still be provided for them. Dampers shall have sufficient durability to last the OEM specified overhaul interval, but no less than five (5) years. In the event of damage, they shall be readily accessible for replacement and shall be arranged to permit replacement within 30 minutes using only ordinary railroad shop tools. An inspection procedure is to be provided in the maintenance manuals for determining if dampers are serviceable.

11.11.6 Anti-Roll Bars

The suspension of each truck shall be designed to minimize carbody roll. Anti-roll bars may be used if required to keep the carbody within the dynamic clearance outline. Anti-roll calculations shall take into account the roll stiffness of the bar and the associated truck and carbody connections. The design of the anti-roll bar and associated connections shall ensure that it shall not produce audible noise in the carbody during normal operation.

11.11.7 Side Bearing

The side bearings, if used, shall permit rotation of the truck and transmit vertical loads from the bolster to the truck frame. Constant contact side bearings shall eliminate dynamic instability and minimize sound and vibration transmission from truck to carbody. Wear limit grooves shall be inscribed in the material, and all bearing material shall have a minimum life of ten (10) years. The Contractor shall submit design data for side bearings to the Engineer as part of the truck design review submittal. **[CDRL 11-023]**

11.11.8 Central Bearing

The central bearing, if used, shall be designed to eliminate dynamic instability and shall be equipped with a locking center pin. Central bearing liners shall be provided and no lubrication shall be required. Central bearing liners shall minimize sound and vibration transmission from truck to carbody. Wear limit grooves shall be inscribed in the material, and all bearing material shall have a minimum life of ten (10) years. The Contractor shall submit design data for the central bearings to the Engineer as part of the truck design review submittal. **[CDRL 11-024]**

11.12 MISCELLANEOUS FEATURES

11.12.1 Parking Brake Rigging

The parking brake rigging shall be arranged so that it does not bind, or otherwise cause a brake application due to relative carbody to truck motion including a defective suspension component. The arrangement shall be ruggedly constructed, with suitable release springs, free of rattles when in operation, and designed to transmit forces with minimum loss due to friction or other reasons. The wear areas shall give long service without requiring lubrication and shall be fitted with renewable bushings or surfaces as approved by the Engineer. Proper operation of the handbrake shall not be affected by maximum permissible brake pad wear, wheel wear, and/or swivel action of the trucks.

11.12.2 Piping

ASTM A 53 or A 160, Schedule 80 black iron pipe per Section 15.10.2 shall be used for air pipes. Piping shall be clamped with double sided clamps to prevent noise, vibration, rubbing and chafing. Insulation shall be provided to protect piping in close proximity to electrical installations. Piping shall be arranged to prevent moisture traps. The piping shall be produced in jigs to ensure that it shall be interchangeable between trucks. The piping shall be designed with a minimum number of connections, and wherever possible, welded connections shall be used. The Engineer shall approve installation of all piping. **[CDRL 11-025]**

All flexible hoses shall be of a type approved by the Engineer. All hoses shall be arranged to avoid chafing and undue stresses in all operating positions. All pipes and hoses shall be routed in such a manner to utilize the minimum length of pipe or hose possible to ensure the maximum clearance possible at all dynamic conditions.

11.12.3 Wearing Parts

All wearing parts shall be provided with renewable liners of manganese steel, Teflon, Nylatron, or other approved materials that shall have sufficient durability as installed to last the specified overhaul interval.

11.12.4 Anchor Rod Attachment

If anchor rods are used, anchor rods, brackets, the attachment of the brackets to the truck and carbody, and the truck and carbody structure which supports the brackets shall be designed such that if overloaded, the anchor rods shall be sacrificial and fail, minimizing damage to the brackets, connections and supporting truck and carbody structure. Each of the rods shall, as a minimum, withstand a longitudinal load equal to two (2) times the weight of the complete truck, including brakes, and other apparatus mounted thereon, without exceeding the yield strength of the material used. Each of the brackets, by which the bolster anchor rods are attached to the truck, the truck bolster, and/or the carbody, and the members to which these brackets are attached, shall, as a minimum, withstand a longitudinal load equal to three (3) times the weight of the complete truck assembly without exceeding the yield strength of the material used. Furthermore, both radius rods together must also support the load that can occur if the maximum main reservoir pressure is applied to the brake cylinders assuming perfect wheel/rail adhesion. Perfect wheel/rail adhesion is defined as that condition where the wheels continue to roll (sufficient adhesion to prevent the wheels from sliding) with the brakes applied at maximum main reservoir pressure. This may be more or less than coefficient of friction of 1.0.

Anchor rods shall incorporate elastomeric pads to provide sound and vibration isolation between the truck and the carbody. Elastomeric pads shall have sufficient durability to last the specified overhaul period.

11.12.5 Fasteners

A minimum 0.375 inch fastener shall be used for all connections on the truck. Grade 5 fasteners shall be used, with Grade 8 fasteners used as needed for operating safety, but designed as a Grade 5. Fasteners shall be either UNC or UNF style, and comply with Section 15.4.2.2.

11.13 GROUNDING

No current shall be returned to the running rail through bearings. This shall include both normal current and overload current due to equipment failures. A grounding arrangement shall be provided to prevent currents passing through journal bearings from causing bearing damage. There shall be braided ground cables between the truck frame and the carbody. The axle bearing housing shall be grounded to the vehicle structure and truck frame through braided ground cable and grounds studs. The assembly housing shall allow removal of the ground cables without dismounting of any wheels or bearings. Ground return connections shall meet APTA SS-E-005-98 requirements. Anti-corrosion compound shall be applied to all faying surfaces of the ground connection. Ground returns shall be provided to specifically designated ground pads per Section 15.21.15.1. The design and ratings for the ground cables and ground studs and a block diagram of the grounding system shall be submitted to the Engineer during the design review of the car. **[CDRL 11-026]**

End of Section

Contract Deliverables Requirements List

CDRL No.	Title	Car Type	Reference Paragraph
11-001	Service History	All	11.1.1
11-002	Details of Design, Arrangement, Installation, and Testing of Truck Components and Assembly(ies)	All	11.1.1
11-003	Truck Stability Qualification Test Reports	All	11.1.2
11-004	Clearance Requirements	All	11.1.5
11-005	Truck Frame and Bolster FEA Model	All	11.4.4
11-006	Truck Frame and Bolster Stress Analysis	All	11.4.4
11-007	Comparison of Strain Gage Readings to FEA Results	All	11.4.5
11-008	Dynamic Performance and Ride Quality Model	All	11.4.6
11-009	Equalization Test Report	All	11.4.7
11-010	Wheel Drawing and List of Railroads and Agencies Using Similar Wheels	All	11.5
11-011	FEA of Wheel Design	All	11.5
11-012	Wheel Data Prior to Mounting on Axles	All	11.5
11-013	Axle Grooves or Other Machine Surfaces Design	All	11.6.1
11-014	Axle Inspection Documents	All	11.6.1
11-015	Mounting Pressure Graphs, Mounting Diameters, Wheel Tape Size, Concentricity and Parallel Measurements	All	11.6.2
11-016	Axle Serial and Heat numbers	All	11.6.3
11-017	Dynamometer Test of Disc System	All	11.8
11-018	Design and Application Information for Speed and ATS Sensors	All	11.9

CDRL No.	Title	Car Type	Reference Paragraph
11-019	Designs and Data for All Primary and Secondary Suspension Bumpers and Stops	All	11.11.1
11-020	Air Spring Arrangement Details	All	11.11.2
11-021	Detailed Procedure for Car Leveling	All	11.11.3
11-022	Design and Method of Height Adjustment	All	11.11.4
11-023	Design Data for Side Bearings	All	11.11.7
11-024	Design Data for Central Bearings	All	11.11.8
11-025	Piping Installation	All	11.12.2
11-026	Ground Cable and Stud Assembly and Block Diagram of Grounding System	All	11.13

SECTION 12

BRAKE AND OTHER PNEUMATIC SYSTEMS

SECTION 12

BRAKE AND OTHER PNEUMATIC SYSTEMS

TABLE OF CONTENTS

SECTION 12

BRAKE AND OTHER PNEUMATIC SYSTEMS

12.1 GENERAL REQUIREMENTS AND FEATURES

12.1.1 System Description and Configuration

All parts, necessary for the efficient operation of this equipment, shall be supplied, installed, and tested to insure proper and safe operation of the brake system as integrated into the vehicles and as further described in the Technical Specifications. The contractor shall receive certification from the brake system subcontractor that the application and method of installation, connection, and operation of the system have been reviewed and approved by the brake system supplier. A copy of this certification shall be submitted to the Engineer. **[CDRL 12-001]**

A WABCO 26-C pneumatic brake system, Knorr Brake Corporation equivalent or approved equal shall be provided on all cars. The brake system shall comply in all respects with the latest requirements of 49 CFR 229, 231, 232, and 238 and the applicable APTA Standards and Recommended Practices for Brake Equipment and Systems. The Contractor shall submit as part of its Preliminary Design Review Package a point by point analysis of the method proposed for conducting the brake tests defined in 49 CFR 238. Details of the design arrangement and installation of the brake system shall be submitted to the Engineer for review and approval. **[CDRL 12-002]** The Contractor shall submit with the package friction brake system technical data as follows:

- Capability curve of tractive effort versus command signal and speed;
- Functional diagram showing values of all input and output signals;
- Curves of operating pressures versus torque for full operating speed range;
- Documentation of safety analyses required in Section 16.5;
- System flow diagram if applicable, showing functional arrangement of all valves, reservoirs, adjustment points and operating units;
- Typical cross section and details of a tread brake unit and disc brake unit, including mounting details; and
- Description of friction material proposed together with experience data from comparable applications.

The brake system shall interface with the vigilance monitoring system, as defined in Section 14, to cause brake applications in accordance with the design of that system. The ++.friction brake system shall interface with the cab equipment, alerter and ATS systems. The interface details and responsibilities of each party in its integration shall be provided in the design review package for review and approval by the Engineer. **[Part of CDRL 12-002]**

12.1.2 Reference Documents

- APTA SS-I&M-004-98 – Standard for Handbrake Periodic Inspection and Maintenance.
- APTA SS-I&M-009-98 – Standard for Tread Brake Shoes and Disc Brake Pad Periodic Inspection and Maintenance.
- APTA SS-I&M-010-98 – Standard for Disc Brake Periodic Inspection and Maintenance.
- APTA SS-I&M-011-98 – Standard for Tread Brake Unit and Brake Cylinder Periodic Inspection and Maintenance.
- APTA SS-M-007-98 – Standard for Conductor's Valve.

12.2 CONTROL AND INTEGRATION

Normal operation of the brake system shall be controlled from the locomotive or cab car by means of a brake controller and associated equipment, which shall exhaust or charge the Brake Pipe. The system shall be arranged for graduated application and release of the brakes throughout the train. Sound attenuation shall be incorporated into the design and installation to preclude transmission of noises into the passenger compartments from the operation of the brake system. The brake valve shall be exhausted to the outside of the cab.

A load weigh system, using air spring pressure, shall adjust the brake cylinder pressure in both "FULL SERVICE" and "EMERGENCY" braking to maintain a consistent deceleration rate for a given command, as car load varies, and to insure that the adhesion limit is not exceeded over the range from empty to crush-load. Failure of any portion of the load weigh system shall result in not less than empty car brake cylinder pressure.

Sufficient brake cylinder pressure shall be maintained on a standing train to prevent its movement when all cabs are inoperative while an Operator is "changing ends".

A Brake Pipe pressure reduction of 6 psig shall result in a brake cylinder pressure of 8 to 12 psig. Thereafter, the brake cylinder pressure shall increase linearly in proportion to continued Brake Pipe reduction to maximum brake cylinder pressure. The system shall be designed such that Brake Pipe pressure is maintained during multiple brake applications, and such that the commanded brake cylinder pressure is maintained.

The Contractor shall provide a brake system that is fully compatible with the air brake systems on existing SCRRA cars and F59PH, F59PHI, F40PH locomotives over the full range of service and emergency braking. Cars shall have release times and drop off rates same as the existing cars.

The brake system shall produce the same Net Braking Ratio (NBR) for each 5 psig of Brake Pipe reduction. The NBR shall match that of the existing Contract No. EP 100 cars over the full range of service and emergency brake applications with any combination of loaded and empty cars including mixed consists of SCRRA cars.

The disc brake pad and tread brake shoe pressures shall be coordinated to provide approximately 60 percent to 70 percent of the braking effort from the disc brake equipment and the remaining percent from the tread brake units. This shall be accomplished by adjusting the disc brake actuator cylinder size and/or lever ratio or by other methods approved by the Engineer.

The Contractor shall submit to the Engineer for review and approval all brake-system performance data, test plan and other information related to the apparatus and equipment proposed for demonstrating the compatibility requirements. **[CDRL 12-003]** This data shall be provided during the design review process and shall be updated throughout the project. Available brake performance test data for existing SCRRA equipment will be provided to the Contractor upon written request to SCRRA. See Section 20 for summary of fleet braking performance.

12.3 BRAKE SYSTEM PERFORMANCE

The air brake system shall provide rapid "SERVICE" and "EMERGENCY" response at all times and shall permit quick recharge of the Brake Pipe after an "EMERGENCY" application, after the vent valves have closed.

The deceleration rates shall be as follows:

- "FULL SERVICE"

  The average "FULL SERVICE" braking rate shall be 2.00 mphps, +/- 10 percent from 80 mph to 0 mph for all load conditions. The maximum instantaneous rate during a stop shall not exceed 2.50 mphps.

- "EMERGENCY"

  The minimum "EMERGENCY" braking rate to stop shall not be less than 2.4 mphps, from 80 mph to 0 mph for all load conditions. The maximum rate during a stop shall not exceed the limit of clean, dry rail adhesion.

Higher deceleration rates shall be possible by adjustment. It shall be possible to set the car deceleration rate down to 1.5 mphps.

All braking rates shall be measured from the time of initiation of movement of the brake controller handle to the time of stop.

The performance requirements, for the "FULL SERVICE" and "EMERGENCY" rates stated above, shall be met with a train consisting of five (5) multi-level cars, with at least (1) one cab car and an SCRRA diesel-electric locomotive.

12.4 SERVICE BRAKE OPERATION AND CONTROLS

A “SERVICE” brake application shall be initiated from the brake controller. A “SERVICE” brake application shall be possible at any time or at any stage of brake application or release, provided that Brake Pipe pressure is not lower than 50 psig. The brake cylinder pressure shall be determined by the load weigh system. The maximum brake cylinder pressure shall not exceed 100 psig.

12.5 EMERGENCY BRAKE OPERATION AND CONTROLS

An “EMERGENCY” brake application shall be initiated from the brake controller, cab emergency brake valve, conductor’s emergency brake valve, or by rapid reduction of Brake Pipe pressure from any point in the train. An emergency application, initiated from any car in the train, shall promptly operate the brakes on all cars in the train at the emergency rate. It shall be timed so as to assure that the train is stopped before the brakes can be released (Stop-Insured). The stop assurance applies to “Emergency” brake application. The application, release and timing associated with release of emergency brakes shall be part of the pneumatic brake system.

An “EMERGENCY” brake application shall be possible at any time or at any stage of brake application or release, regardless of the degree of “SERVICE” application, provided that Brake Pipe pressure is not lower than 50 psig. An “EMERGENCY” application of the brakes shall cause propulsion power to be removed and all sanders on locomotive(s) to operate. The brake cylinder pressure shall be determined by the load weigh system. The maximum brake cylinder pressure shall not exceed 100 psig.

12.6 DISC BRAKE UNITS

Individually actuated disc brake units and disc/hubs shall be installed on each axle of each car.

12.6.1 Disc and Hub

The disc rotor assembly shall allow removal and replacement of the rotor from the hub without removing the wheel from the axle or cutting the rotor. The rotor shall have the necessary thermal characteristics and strength to resist warping and cracking due to thermal stress. The disc shall be vented with radial ribs separating the two (2) friction surfaces to provide a Sorocco-type blower capable of providing sufficient cooling between stops. The rotor arrangement shall permit replacement without the removal of any components or equipment other than the caliper assembly, if required. Wear indicating marks shall be provided to indicate the condemning limits of each surface. The hub and rotor design shall be submitted to the Engineer for review and approval. **[CDRL 12-004]**

12.6.2 Calipers, Actuators and Pads

The disc brake actuators shall be a floating type designed to follow the disc and move normal to the disc with each brake application as required. The actuator shall include an automatic slack adjustment feature which shall adjust for brake pad wear as well as assure drag-free running. The disc brake actuator and caliper assembly shall be designed to function in normal service for not less than five (5) years between overhauls. The disc brake pads and holders shall be designed for quick replacement without disassembly of the actuator unit or use of wrenches. The disc pads shall be interchangeable with those used on existing SCRRA cars unless otherwise required and approved by the Engineer. The brake pad retaining latch and locking pin arrangement shall be submitted to the Engineer for review and approval. **[CDRL 12-005]**

Each disc brake actuator shall be pneumatically connected with an individual hose from the truck frame piping. Connections shall utilize fittings which permit quick disconnection and facilitate brake actuator removal without the use of special tools. The hoses shall be AAR approved, single wire braid reinforced with reusable fittings. The hoses shall be provided with helical steel wire guards to protect the hose from debris damage. Brake actuator assemblies shall be resiliently mounted on the truck frame. The equipment shall be installed and located to provide for safe inspection and observation of brake application and release from the platforms. Bushings, pins, and other components that require periodic lubrication shall be supplied with protected grease fittings.

12.7 TREAD BRAKE UNITS

Individually actuated Tread Brake Units (TBU) shall be installed at each wheel of each car. Brake cylinders and automatic slack adjusters shall be furnished as part of the truck-mounted brake units. Positive clearance shall be provided between the brake shoe and wheel during brake release. Manual adjusters shall be provided to allow for manual adjustment of shoe position when replacing shoes. The adjuster mechanism shall not require special action to engage or disengage the adjuster during routine maintenance to prevent subsequent damage to the adjuster or the unit.

The geometry of the brake unit and its installation shall minimize any self-energization effect. The design of brake units shall permit the use of unflanged high-friction composition brake shoes. Units shall be installed on the truck in a manner to provide for ease of removal and replacement of brake shoes and the unit without the use of special tools. Each tread brake unit shall be installed and located to provide for safe inspection and observation of brake applications and releases from the platforms.

The air connection to each TBU shall be with an AAR approved, single wire braid reinforced hose with reusable fittings. The hoses shall be provided with a helical steel wire guard to protect from debris damage.

Brake shoes shall be machined or molded so that the entire surface of the shoe is in contact with the wheel. Brake heads shall be ductile iron of approved composition. Lugs shall be provided to maintain lateral shoe alignment. The tread brake shoes shall be interchangeable with those used on the existing SCRRA cars, unless otherwise required and approved by the Engineer.

Bushings, pins, and other components, that require periodic lubrication, shall be supplied with protected grease fittings. The tread brake unit shall be designed to function in service for not less than five (5) years between overhauls.

12.8 BRAKE CONTROL VALVE

A WABCO type 26B-1 brake control valve or Knorr Brake Corporation equivalent shall be mounted on the Operator's console and shall be within easy reach of a seated operator.

The brake control valve shall include provisions to cut out the valve (cut-out position) so that the train braking can be controlled from the locomotive. In the cut-in position, the train braking shall be controlled from the cab car. The brake control valve handle shall operate through the following positions:

- Release,
- Minimum reduction,
- Service,
- Suppression,
- Handle off, and
- Emergency.

The arrangement and installation of the brake control valve shall be integrated into, and shall permit easy removal of the brake valve for service and maintenance with minimum disassembly and removal of cab and console components.

Brake valve exhaust shall be routed to the exterior of the car under the cab floor in accordance with AAR recommended practices.

12.9 CONTROL VALVES AND OTHER VALVULAR PORTIONS

All air brake components shall be mounted on common manifolds (pipe brackets) to minimize excessive interconnections and to simplify removal, replacement, and servicing of individual components. The number of manifolds shall be minimized, taking commonality of function and physical arrangement constraints into consideration. Single side manifolds are acceptable. Air brake apparatus shall be so located as to permit full accessibility for removal of valves and devices from pipe brackets for inspection, cleaning, and repairs. The manifold(s) shall include an approved label identifying each component and its location on the manifold. Mounting gaskets for all components, which are removable from manifolds, shall be of one-piece construction. Multiple "O" rings-type gaskets for sealing at the component/manifold shall not be permitted unless approved by the Engineer.

All major brake valves/components subject to scheduled, regulated maintenance shall be serialized. The Contractor shall provide, in the preliminary design review package, a list identifying those valves and components that are serialized and those that are not serialized for review and approval by the Engineer. **[Part of CDRL 12-002]**

An access panel approved by the Engineer shall be provided to allow a member of the crew to cut-out the manifold in the event of damage enroute. The access panel shall be equipped with maintainer's key latch, and operation of the cut-out device shall require an SCRRA standard seal to be broken.

The paste type thread sealant to be used in the assembly of the brake piping, shall be submitted for review and approval by the Engineer. **[CDRL 12-006]** The sealant shall be Loctite #545 or approved equal. Use of Teflon tape or similar tape or liquid Teflon type sealant on any part of the airbrake system is expressly prohibited under all conditions.

Sound attenuation shall be provided to prevent transmission of audible noises to the passenger areas.

12.10 CUT-OUT COCKS

A vented cut-out cock, similar to that provided on the existing SCRRA cars, or approved equal, shall be provided in the brake cylinder line for each axle to allow the brake cylinders (disc and tread brake units) to be cut out and vented on a per axle basis. The cut-out cocks shall be located, such that, the pressure sensing device for the brake status indication, including the brake cylinder pressure gauge; remain activated, but the brake actuation and release indicators, if provided, shall be deactivated.

The handle of the cut-out cock shall be connected to a cable or alternative arrangement which shall pass through the floor of the car into an enclosure under a seat so that the cut-out cock may be operated (for both "cut-in" and "cut-out") from within the car and also from the outside of the car at ground level. The penetration through the floor and enclosure shall be designed to allow the floor system to comply with Section 15.23. Other cut-out cocks shall be installed in the air supply and brake system piping in approved locations to isolate the air supply to system components and equipment to permit their removal and replacement and to allow for service, repair, maintenance, and trouble-shooting of the pneumatic equipment. Details, location, and installation of all cut-out cocks shall be submitted to the Engineer for review and approval. **[CDRL 12-007]**

All cut-out cock handles, except Brake Pipe angle cocks, shall be arranged to be parallel with the pipe in the closed position and perpendicular to the pipe in the open position. Cut-out cocks shall be oriented so that valve handles cannot vibrate to the opposite position in service.

12.11 TEST FITTINGS

Pressure test fittings shall be provided in air lines to gauges and other apparatus, such as manifolds, pressure switches and transducers, requiring periodic routine calibration and function checks.

The fittings shall allow for simple and effective accuracy and calibration testing without removing the item being tested from the car. It shall be possible to perform testing while the system is fully charged through the use of an automatic shut-off valve integral with the test fitting. The valve shall, upon insertion of the test apparatus, close-off the normal supply line to the component being tested. Fittings shall be close coupled to the device which they serve and shall be mounted in accessible locations.

Separate test gauge fitting shall be installed in the brake-system piping to facilitate testing and troubleshooting the brake system.

12.12 RESERVOIRS

Reservoirs shall be of adequate capacity on all cars. On cab cars, the need for air for the horn, and other pneumatic systems, equipment and devices, as required shall be recognized and additional main reservoir capacity shall be provided for this purpose and to permit fast recharge of Brake Pipe. Horn, provisions for a pneumatic powered bell and auxiliary air supplies shall be taken from the No. 2 main reservoir. The volumetric capacity of the main reservoir system shall be arranged to supply all pneumatic systems with sufficient compressed air for all normal train operations, and scenarios defined in the Technical Specification, such as repeated braking with AW3 passenger load, activation of the horn, passenger load changes at station stops, etc. In no case shall the main reservoir volume on the cab car be less than 25,000 cubic inches. The air supply for braking shall be sufficient capacity for three (3) emergency applications and releases from full speed at AW3 load conditions with main reservoir supply at 135 psig and compressor shut down. **[Part of CDRL 12-003]**

All reservoirs on all cars shall be drilled with 0.188 inch diameter “telltale” holes and shall be designed and manufactured to comply with requirements of 49 CFR 229.49(c), in lieu of periodic testing.

Reservoirs shall be supplied with permanently affixed stainless steel identification plates with engraved lettering. The plates shall identify the part number and test certification data, and this information shall be included in the Car History Books.

Reservoirs shall be sloped to drain to one end, where a drain cock with locking handle shall be installed. Drains shall be routed to the exterior underfloor of the car. If reservoirs are mounted underfloor, guards shall be provided to protect the drain valves from damage from ballast and other debris. The details of size and installation of all air reservoirs shall be approved by the Engineer. **[CDRL 12-008]**

12.13 EMERGENCY BRAKE VALVE

An Emergency Brake Valve shall be provided at each end of each car, inside the passenger section, and adjacent to the side door for a minimum of two (2) per car. The Cab Car shall have an additional valve located in the passenger area adjacent the Operator's Control Station that is also accessible for the operation when the cab area is closed off. They shall, when actuated, cause a pneumatic "EMERGENCY" application of the brakes.

12.14 WHEEL SLIDE DETECTION AND CORRECTION SYSTEM

12.14.1 General Arrangement

A wheel-slide protective system, WABCO type E-7, Knorr Brake Corporation equivalent or approved equal, shall be provided.

The slide correction valve shall be energized-to-dump, energized-to-lap, and de-energize-to-apply. The detection and control system shall be powered from the low-voltage DC power system.

The slide correction wheel-slide system and its installation shall be submitted to the Engineer for review and approval. **[CDRL 12-009]**

12.14.2 Wheel Slide Controls

The microprocessor-controlled, wheel-slide control system shall detect random, back-to-back, and synchronous wheel slides at all four (4) axles, by means of inductive speed sensors at axle-mounted toothed wheels. Slide correction shall be made, on a per truck basis, by a slide correction valve located as close as possible to the air piping connection to the truck. Wheel-slide protection shall be effective from any car speed down to 5 mph.

12.14.3 Fail Safe Operation

The slide system shall be fail-safe, such that any system failure mode shall render the slide system ineffective and shall not prevent the application of brakes at any rate less than desired. A separate fail-safe timing and override of friction brake release on each truck shall also be provided. The dump valves shall be energized-to-dump and energized-to-lap. If an unsuccessful slide correction lasting 5 seconds is detected, the system shall de-energize the dump valves.

The system shall operate over the full range-of-service braking and during emergency braking. During service or emergency braking, as detected by a drop of Brake Pipe pressure below 50 psi, if an unsuccessful slide correction lasting longer than 5 seconds is detected, the dump valves shall be de-energized and remain de-energized until the car has come to a complete stop.

12.14.4 Wheel Size Correction

The wheel-slide correction system shall function properly with differences in wheel diameter up to two (2) inches among the wheels of a vehicle, but not on the same axle. The equipment shall be self-calibrating, requiring no manual adjustment to compensate for wheel diameter variations.

12.14.5 Speed Sensors

The axle-speed sensors shall be of an approved, service proven rugged design for direct application to the bearing housing sensor basket. The sensor shall be fitted with an appropriate length lead terminated in a waterproof, quick-disconnect fitting. The truck/carbody cabling shall be armored and fitted with two (2) waterproof, quick-disconnect fittings that connect to the speed sensor lead and the carbody splitter box. The carbody splitter box shall be equipped with three (3) waterproof, quick-disconnect fittings; two (2) fittings shall be designated for the speed sensor and one (1) fitting shall be designated for the carbody side of the wire harness. All quick-disconnect fittings shall be keyed to prevent incorrect connections. The quick-disconnect fittings shall be of an approved, service proven rugged design with a locking feature and suitable for the under car environment. A split-ring gear shall be installed on each axle to allow removal without pressing off the wheel or requiring the removal of any other equipment and components.

12.14.6 Self Diagnostics

To expedite servicing and maintenance, the unit shall be equipped with a self-test feature for internal and external fault diagnosis. The unit shall provide indication if it finds itself defective for any reason, or it shall be equipped with a test-position control switch to manually check each of the system components.

12.15 LOAD-WEIGH SYSTEM

Brake cylinder pressure in “FULL SERVICE” and “EMERGENCY” braking, shall be limited in proportion to the weight of the passenger load. Failure of any component of the load weigh control shall result in no less than an empty car “FULL SERVICE” brake cylinder pressure when a full service brake is requested, or no less than an empty car “EMERGENCY” break cylinder pressure when an emergency brake is initiated. The design criteria, component reliability, failure history, and analysis of how this shall be achieved shall be submitted to the Engineer for review and approval. **[CDRL 12-010]**

12.16 HANDBRAKE

12.16.1 Handbrake Installation

A handbrake arrangement, meeting the requirements of this Specification, shall be installed on the B-end truck of each car. The arrangement shall be ruggedly constructed, with suitable release springs, free of rattles, and designed to transmit forces with minimum loss due to friction or other reasons. The wear areas shall give long service without requiring lubrication and shall be fitted with renewable bushings or surfaces as approved by the Engineer. Proper operation of the handbrake shall not be affected by maximum permissible brake pad and wheel wear, and/or swivel action of the trucks.

The handbrake arrangement shall comply with the requirements and recommendations of APTA SS-M-006-98, and its operation shall be demonstrated on the first production car of each type. The design and operation of handbrake arrangement shall be subject to approval of the Engineer. **[CDRL 12-011]** A lever type handbrake, with the necessary body mounted brake rigging and indication shall be provided and mounted on the collision post at the B-end of each car. An actuating force of not more than 74 pounds, applied 3 inches in from the end of the brake lever, shall be sufficient to fully apply the handbrakes. With the applied force of 74 lbs, the force exerted by the two (2) tread brake units with handbrakes shall be capable of holding a fully loaded car (AW3) on a 3.5 percent grade.

The handbrake shall be of composite construction, malleable iron and steel. All bearings shall be bushed. A friction catch shall be provided for the handle to prevent vibration in the normal position. A suitable guard shall be supplied over the ball and chain section to prevent injury. The braking force shall be transmitted to the brake linkage by a suitable chain connection. The use of steel cables as links in the handbrake arrangement shall be subject to review and approval by the Engineer. **[CDRL 12-012]** The handbrake shall be similar to Elcon-National No. 800-LG, Elcon-National No. 840-FR-9, or approved equal, complying with the requirements of this Section.

12.16.2 Adjustment Provisions

The handbrake shall have a pin-and-clevis style adjustment provisions or adjustment arrangements such as "threaded rod and lock nut mechanism," that will provide enhanced adjustment capability and comply with the performance and functional requirements of this Specification. The adjustment provisions, design and arrangement shall be subject to approval by the Engineer. **[Part of CDRL 12-011]**

12.17 PIPING SUPPORT AND ISOLATION

The main reservoir equalizing pipe shall have a slope from the center of the car into two (2) small condensate-accumulating reservoirs equipped with manual drain valves, located at each end of the lower underframe. From each reservoir, the pipe is sloped up to each end-of-car connection. Each manual valve shall be operable by an extension lever from track side. Each drain valve shall have a guard to prevent damage from debris. The Contractor may submit for approval by the Engineer a similar arrangement with a level main reservoir equalizing pipe from the center of the car into two (2) small condensation accumulating reservoirs.

12.17.1 Piping

The main reservoir pipe and emergency brake pipe shall conform to ASTM A 53, Schedule 80 seamless pipe. Type "K" annealed copper tube per Federal Specification WW-T-799, latest revision, may also be used if approved by the Engineer, provided it is installed no lower than two (2) inches below the floor sheet (also referred to as the underpan) and is protected by means of equipment or approved steel guards from any potential impact damage from rail debris, especially in the truck and outboard of the bolster areas. Where suitable protection is not possible or practical, approved steel piping sections shall be provided in damage-prone areas. The diameter of the main reservoir pipe and emergency brake pipes shall meet the brake supplier's requirements; however, in no case shall these pipes be less than 0.875 inches outside diameter.

All air pipes shall be sized in accordance with the function intended and may be either ASTM A 53 schedule 80 pipe or seamless copper tubing as described previously. All joints for copper tubing shall utilize fittings of wrought copper or non-porous cast brass in accordance with ANSI Standards B16.22 and B16.88. All air piping must comply in all respects with the air brake supplier's design and installation requirements.

Where ASTM A 53 piping is provided, its application shall also comply in all respects to AAR Specification No. 2518, Standard 400, latest revision. Approved copper tube shall also comply with any relevant requirements of AAR Specification No. 2518.

All brake and other hoses, utilized within the air system, shall be in compliance with AAR Specification M-618 latest revision.

Air piping on the trucks shall be proper sized for the required functions and performance and shall not be less than 0.50 inch, ASTM A 53, Schedule 80, or approved equal. Low spots (traps) are strictly prohibited on the trucks.

Where steel piping is used, all connections and joints where disassembly for service may be required shall utilize swivel type butt-welded flange fittings with an "O" ring type seal. The use of threaded fittings is expressly prohibited.

12.17.2 Piping Support

Air pipes, hoses and tubes shall be individually supported to prevent vibration and chafing by using appropriate brackets. Employing other piping or cables as means of support is not acceptable.

12.17.3 Piping Installation and Routing

All air piping shall be installed in a manner to provide drainage away from devices, or branch pipes leading to devices, when the function of those devices could be impaired by the accumulation of water or ice.

Truck piping shall not be run on the bottom of truck side frames, transom, or bolster.

End of Section

Contract Deliverables Requirement List

CDRL No.	Title	Car Type	Reference Paragraph
12-001	Brake Supplier Certification for Intended Application and Installation	All	12.1.1
12-002	Brake System Design and Installation Details	All	12.1.1
12-003	Brake System Performance Data	All	12.2
12-004	Hub and Rotor Design	All	12.6.1
12-005	Brake Pad Latch Arrangement	All	12.6.2
12-006	Brake System Thread Sealant	All	12.9
12-007	Details, Location, and Installation of the Cut-out Cocks	All	12.10
12-008	Size and Installation of All Air Reservoirs	All	12.12
12-009	Details and Installation of the Wheel Slide Detection System	All	12.14.1
12-010	Design of the Load-Weigh System	All	12.15
12-011	Design and Operation of the Handbrake	All	12.16.1
12-012	Use of Steel Cables as Links in the Handbrake Arrangement	All	12.16.1

SECTION 13

COMMUNICATION SYSTEM

SECTION 13

COMMUNICATION SYSTEM

TABLE OF CONTENTS

SECTION 13

COMMUNICATION SYSTEM

13.1 GENERAL REQUIREMENTS AND FEATURES

The Contractor shall provide a complete and functional communication package for each car. Each communication package shall be comprised of the following units:

a) Public Address System (PA), including PA Wireless input (Crew handheld radios),

b) General Intercom System (IC),

c) Train Radio System (TR) - Cab Cars Only,

d) Provisions for Video System in the Cab Cars Only - Cameras to the front.

e) Destination Sign System, and

f) Conductor Buzzer Signal.

Details of the design, equipment, arrangement, installation, and testing of the complete communication system shall be submitted to the Engineer for approval during the design review process. **[CDRL 13-001]**

The communication system shall permit the train crew to make announcements and to page the passengers and other train crew members through the speakers in the passenger areas of the cars by using cab handsets, handsets at the crew communication station (located at the B-end lower level of each car, one on each side, see Section 6.3.1 and reference figure in Section 20), and wireless crew handheld radios. It shall permit two-way radio communication between the train crew/Operator and other trains and wayside installations. It shall permit private two-way intercommunication between any two (2) communication control panels within the train; e.g. between train crew and Operator. It shall also accommodate recorded or digitized human speech messages for announcements or other passenger information in accordance with the requirements of 49 CFR 38. Communications circuits connected to intercar audio and remote control lines shall be protected from component failure due to accidental shorting or grounding of the lines. The communication equipment described shall make use of the existing or spare car control trainlines, or by multiplexing them. It shall use wiring, and jumper cables described in Section 5.

All trainline communication shall be compatible with existing SCRRA cars. The cars shall utilize the existing cabling for analog communication for intra-car communication.

The communication system shall utilize digitized audio for trainline transmission of voice signals, along with conventional base band audio trainlines for backward compatibility with existing SCRRA rolling stock. The acoustic level of the voice communication shall be identical regardless where it is initiated. New equipment not presently installed in SCRRA's existing fleet shall be designed in a way that it is retrofitable into all locomotives and cab cars. New equipment required by SCRRA includes recorded station announcements, crew handheld radio PA system, video system provisions and the side destination signs. The cars procured through this contract shall be compatible in performance and function with the existing SCRRA rolling stock. Communication apparatus described shall be powered from the 72 VDC low voltage power supply directly through the Communications System circuit breakers and shall be capable of operation within the voltage range specified in Section 10. The PA, radio equipment and communication equipment shall be provided with separate circuit breakers. Apparatus requiring power conversion devices, because of voltage range requirements, shall have those devices designed integral to the apparatus. Power conversion devices, external to the apparatus, shall not be acceptable.

Suppliers of the communication systems shall have proven experience in the successful design and manufacture of apparatus of this type for similar railcar application. The Contractor shall follow the equipment manufacturer's recommendations for its installation and shall provide documentation that the installation has been reviewed and approved by the equipment manufacturer. **[Part of CDRL 13-001]**

All apparatus furnished under this Section shall be capable of operation without damage in the environment as specified in Section 2 with the car heating and air-conditioning systems inoperative.

13.2 PA/IC SYSTEM

The PA/IC system shall allow communication between the train crew and the passengers. Annunciation bell tone shall be enabled before a PA announcement. The system shall provide clear intelligible audio with a constant audio level regardless of position of the audio source within the train. The system shall incorporate an automatic volume adjustment feature to compensate for ambient noise conditions. With speech input, the amplifier shall operate continuously with full output, at rated input voltage, without damage to the components. The PA/IC system shall also have pre-recorded voice messages stored in the digital memory and retrievable when requested manually or automatically by the station location. In normal operation, the system shall track the progress of the train through the system and make station and other informational announcements based on the trains location and destination. The system shall make a train location determination based on starting and stopping, opening and closing of doors, leaving stations, and distance traveled information provided by RS232 output from event recorder, locomotive GPS or a GPS integrated into the PA/IC system.

The Contractor shall show through analysis, using acoustic modeling software approved by the Engineer, that the sound coverage is consistent and even throughout interior of the car. This analysis shall be submitted in advance of the Preliminary Design Review Package. **[Part of CDRL 13-002]**

The System shall include microphones, amplifiers, speakers, associated wiring and other circuits, and, when operating, shall have the following performance characteristics:

- Frequency Response: ±3 dB from 300 Hz to 8,000 Hz,

- Total Harmonic Distortion (THD): less than 1 percent over entire frequency range, and
- Signal to Noise Ratio: greater than 100:1.

Details of the design, arrangement, and installation of the PA/IC Systems shall be submitted to the Engineer for review and approval. **[CDRL 13-002]**

13.2.1 Amplifier

The PA/IC amplifier and spike suppression filters shall be mounted in an approved location in each car. The unit shall be completely solid state, with modular construction, housed in a steel or heavy gauge aluminum enclosure, and mounted on a standard AAR mounting rack or approved equal. The enclosure shall be properly grounded and sufficiently robust to guard against EMI. The amplifier unit may be arranged to permit mounting on a standard 19 inch equipment rack as approved by the Engineer. Provision shall be made for securing the unit with a cylinder lock. The amplifier shall be mounted in such a manner that it can be readily removed from the front of the enclosure.

The unit shall have a minimum output of 25 watts. The gain controls shall be adjustable and installed in a well-defined location in the amplifier enclosure with a restricted access. The amplifier unit shall be complete with transient filtering capable of withstanding 2.5 kV peak pulse with total energy of 50 watt-seconds.

The amplifier shall incorporate an automatic output level adjustment to allow messages to be heard by the passengers over the ambient noise level within the car. The automatic output level adjustment shall be adjustable and shall be capable of maintaining an audio output 10 dB higher than the ambient noise level for all car-operating conditions. The automatic output level adjustment must make use of sensing microphones located within in the passenger compartments. Use of the interior speakers as ambient noise sensors shall be prohibited. As a minimum, the system shall include four (4) sensing microphones; one (1) on each intermediate level, one (1) on the upper level, and one (1) on the lower level. The ambient noise level shall be sampled immediately before each PA announcement is initiated. The sampling method and location of sensing microphones shall be included in the design review packages. The Contractor may propose an alternative arrangement for the automatic output level adjustment for review and approval by the Engineer. **[Part of CDRL-13-001]**

13.2.2 Speakers

A minimum of eight (8) speakers shall be installed in each ceiling of the upper and lower passenger levels and four (4) speakers shall be installed in each ceiling of the intermediate level areas and one (1) speaker shall be installed in the toilet room. Speakers shall be evenly spaced longitudinally and alternately mounted on opposite sides of the ceiling. The location and number of the speakers shall be such as to provide a uniform audio level throughout each passenger compartment. The location and number of speakers, should it exceed the minimum quantity, shall be subject to the approval of the Engineer. All speakers shall be arranged in such a manner as to eliminate feedback as a result of an active microphone.

The speakers shall be connected in parallel with uniform polarity to a pair of wires from their respective amplifiers.

Each speaker shall be mounted behind a flush baffle in the car ceiling by means of screws and hinge fittings or screws only. The speaker installation shall be arranged such that speakers can be removed and replaced by removing the baffle without disturbing ceiling panels. The baffle shall be integrally colored to match or complement the decorative treatment of the car. Speakers shall be secured with tamper proof screws.

The speakers shall be arranged for replacement from the front and sufficient length shall be provided in the wiring for this purpose. Wiring for the speaker system shall conform to the requirements of Section 15.20. Fusing of the speaker distribution system shall not be required.

The speaker shall be of the direct radiating, permanent magnet field type, capable of handling up to 10 watts of audio power. The nominal axial sensitivity shall be at least 92 dB at 4 feet with a 1 watt input. The speaker shall have a wide dispersion characteristic. The frequency response of the speaker in its enclosure from 300 Hz to 8 kHz shall be no more than 6 dB below its response at 1 kHz. The off-axis coverage between any two adjacent speakers shall not be greater than 6 dB below the on-axis Sound Pressure Level for uniform sound distribution. The speakers shall be no more than 6 dB down, 50 degrees off-axis with a test tone of 5 kHz.

All speaker assemblies shall consist of a low profile speaker and a 70 volt line matching transformer rated at 4 watts, with taps at 1, 2, and 4 watts. The secondary of the transformer shall properly match the voice coil of the speaker. The primary of the matching transformer shall be connected to the speaker distribution wires by means of a two (2) conductor leads, which shall be provided at one end with two (2) Fast-on terminals or approved equal which shall plug into a matching connector in the speaker distribution circuit mounted in the ceiling. The transformer end of the leads shall be arranged to permit connection or reconnection of the conductors to any taps. The enclosure shall adequately protect the speakers from the effects of dust, moisture, magnetic materials such as steel filings, or other foreign objects. The protective enclosure shall be rustproof. The speaker shall mount on the speaker baffle completely enclosing the speaker from the rear. The enclosure shall include knockouts and gaskets for the dust-tight entrance of the speaker connection leads. The enclosures shall be so constructed that no mechanical resonance or vibration occurs. The exterior speakers shall be weatherproofed.

The speakers shall be capable of being phased such that, when the primary is connected to the distribution line according to the labeling, all speaker cones will move in the same direction at the same time. The speaker shall have a one-piece stamped steel frame with an outside diameter of approximately 6 inches and shall mount to a flat baffle with four (4) equally-spaced slots or holes. The overall depth shall not exceed 4 inches. The cone, voice coil assembly, and suspension shall be moisture resistant. All ferrous metal parts shall be made rust resistant by plating.

Speakers located adjacent to an active communication control panel or the control head shall be automatically disconnected during PA transmission to prevent feedback.

Weatherproof exterior speakers shall be installed on the exterior of the car sides near each door to enable the broadcasting of messages to passengers on the platform from the public address system from within the car. There should be two (2) exterior speakers on the Right Hand Side of the car and two (2) exterior speakers on the Left Hand Side of the car.

The Contractor may submit, for approval by the Engineer, alternative speaker arrangement and speaker configuration for the interior of the car that provides the specified performance and functionality. Alternative shall be aesthetically compatible with the interior of the car.

13.2.3 One-way Communication (Public Address)

Paging and announcements to passengers throughout the train may be made from the cab of the locomotive, the cab of the cab car, any active crew communication station (reference figure in Section 20). or crew handheld radios, as needed. When a door control station is energized and the doors are opened, the exterior speakers on that side of the car shall automatically be switched into the system, and the PA announcements shall be simultaneously broadcast over the interior and the exterior speakers. A manual feature shall be provided which allows crew to make PA announcements to the exterior speakers with the doors closed.

13.2.4 Two-way Intercommunications (Intercom)

Private communication between the crew may be established among any of the following communication panel positions: cab of the locomotive, cab of the cab car, and any activated crew communication station. Similarly, private communications may be made between activated crew communication stations on any two cars in the train. The calling buzzer will attract the attention of any activated car control station. See Section 13.11 for conductor's buzzer signal.

There shall be no feedback between car speakers and the control station handset when the PA system is in use.

The intercom system shall be preempted by the PA system.

13.2.5 Crew Handheld Radio Control of PA System

Crew shall be capable of making PA announcements through the use of crew handheld radios. These radios are Motorola HT750 sixteen-channel VHF radios. The system shall transmit along the communication trainlines under normal operation and shall transmit to each individual car in a train under emergency situations when the trainlines are not complete.

The crew handheld radio shall be programmed to receive and transmit only on FAP 89 or 161.445 MHz on each channel. To establish differentiation between the channel traffic and ultimately the individual train sets, each channel shall be programmed with a unique and distinctive private-line code. The resulting received audio product should be directly connected to a feedback termination device. It is recommended that all RF power out of the radios be adjusted to no greater than one watt of radiated power. To assure the availability of maintenance spare radios, all Motorola HT750 crew radios applied to this application shall be programmed identically.

A Motorola HT750 crew radio shall be used as the receiver on the car for the PA messages. A remote VHF antenna shall be provided for the on-board crew radio. The on-board crew radio shall be powered from the 72 VDC system which shall provide power under normal operation and emergency conditions.

Real-time links between the input and output of an audio system have the potential to create a feedback loop. This would produce undesirable audio to the passengers. To overcome this potential, a feedback termination device, Bogan Communications Digital Feedback Terminator Model DFT120 or approved equal, shall be included in the proposed audio pathway. This device will record and playback at user selectable intervals between one and ten seconds of delay.

The push-to-talk feature of the PA equipment shall be performed on the “play status contact” leads on the audio output connections of the feedback termination unit. This will transition the public address preamplifier to an active state. The push-to-talk wire termination site on the preamplifier shall be wired to terminals on the feedback termination unit. After a message is recorded or the time delay duration has been exceeded, the message will be transmitted through the PA system.

Upon initial installation, radio channel selections shall be organized into groups that will minimize common assignments to trains traveling over territories with overlapping service schedules. During the vehicle level communication system testing, see Section 17.5.20, the random assignment process shall be examined to ensure a minimum of potential crosstalk between nearby train sets. It may become necessary to extend the random nature of the channel assignments as operational activities become apparent. The crew radio control of the PA system shall be included in communications system design review package and the communication system test program. **[Part of CDRL 13-001]**

13.3 CAB COMMUNICATION CONTROL PANEL

The cab car shall have a communication control panel integrated with other cab control equipment, or the Integrated Communication Control Unit (ICCU). It shall be within easy reach of the seated Operator. The cab communication panel shall include:

- Handset equipped with press-to-talk microphone switch for radio/PA/IC
- A handset receptacle for radio/PA/IC.
- (ICCU) speaker and volume control (adjustable from 25 percent to 100 percent of full volume) with volume level indicator.

- Radio/PA/IC shall have individual push button selector switches arranged in the same relative locations as on the existing SCRRA cars.

- LED Indicator showing system activated and mode in use.

Components, which do not require the attention of the Operator, shall be mounted in the equipment locker adjacent to the cab and shall be accessible for maintenance and servicing. See Section 7.10. The ICCU shall be energized when the operating cab is energized.

The ICCU shall be designed such that the handset must be lifted from its cradle to activate the selector switches. The train radio communication mode shall be the highest priority in the event of a communication system failure. The ICCU shall include a 16 button keypad for radio selection, channel functions and dispatcher call signal programming functions. The ICCU shall include a signal programming functions. The integration and operation of the ICCU shall be submitted to the Engineer for review and approval. **[Part of CDRL 13-003]**

13.4 TRAIN RADIO

Each cab car shall be equipped with Motorola Astro Digital Spectra Clean Cab Railroad Radio meeting AAR Standards with PA/IC interface similar to the Motorola Spectra PA/IC enabled unit Part No. MBR 43k ME 11 70 AD presently used by SCRRA or approved equal. The radio shall embody the following requirements:

- The radio shall meet or exceed all applicable FCC and AAR requirements including the FCC scheduled bandwidth restriction. The FCC bandwidth restriction arrangement shall be accomplished through use of software. It shall be designed for AAR tray mounting. All electrical tests shall be either referenced to a specific test procedure or shall be described in full by the Manufacturer. The equipment shall be capable of operation without degradation when subject to the applicable temperature, shock, humidity, and vibration tests.

- The radio unit shall be designed to operate from the 72 VDC low voltage power supply. The radio shall be capable of operating with input supply voltage from 55 VDC to 85 VDC. The power supply input shall be isolated from ground on both positive and negative sides of the battery to permit operation in an ungrounded system. The power source shall not be dependant on the proper functioning of any other communication system component and shall be powered from a dedicated independent circuit breaker.

- Radio circuitry shall include a time-out feature to prevent inadvertent lockout of the transmitter and receiver.

- Transient filter protection shall be designed as an integral part of the radio and shall provide adequate protection from transients of the type encountered in commuter car and locomotive applications.

- The Contractor shall ensure that the communications equipment including, but not limited to, the train radio, crew handheld radios, the PA, and the intercommunications systems are free from onboard as well as externally caused interference. Accordingly, within ninety (90) days following contract award, the Contractor shall submit, to the Engineer for review and approval, a communications system design plan that shall, as a minimum, describe the components of the system, the function of the individual components, the functions of the integrated communications system, the function of the trainline equipment and interference mitigation measures. **[CDRL 13-003]**

- The radio unit shall be fully synthesized and capable of utilizing all 97 AAR frequencies.

- The system shall be configured so that if the PA, Crew IC modes are in use, incoming radio messages shall still be heard on the ICCU speaker.

13.5 ANTENNA

The antenna shall be a "Sinclair" Model SRL-221R, Low Profile type antenna 159-162 MHz, or approved equal. A Voltage Standing Wave Ratio (VSWR) of 1.5:1 maximum shall be required after installation when measured at center frequency of 160.5 MHz with a 2 MHz bandwith. The antenna shall be mechanically grounded to the carbody through a copper or similar conductive metal between the antenna and its mounting. The antenna lead shall pass through the roof by means of a 1-inch pipe of the same material as the roof. The pipe shall extend up to the antenna base and be welded completely to both the roof and the mounting base of the antenna. No air or moisture shall enter or escape through the antenna lead roof penetration.

13.6 VIDEO SYSTEM PROVISIONS

SCRRA is evaluating the future installation of a video/audio recording system similar to the Sequent Visual Telecommunication Technology, series Ranger 350i system, and each cab car shall include provisions to support the installation of this system or an approved equal. The proposed camera mounting location(s) shall provide for recording the unobstructed full image field of view for the right of way in front of the cab car. As a minimum, the Contractor shall provide sufficient space for installation of the complete system; hard points and car support structure necessary for mounting and protecting the system components; necessary wiring terminated and concealed adjacent to the proposed system component mounting locations; and a dedicated 72 VDC circuit breaker.

As separate portion of the design review package for the Communication System, the Contractor shall provide details of the provisions included for the future installation of the video/audio recording system for review and approval. **[CDRL 13-004]**

13.7 INTRA -TRAIN COMMUNICATION

Both the voice and text messages; and, data communication within a train shall be accomplished by using the existing trainlines. No additional trainlines shall be added. The communication system shall have the capability to share coded digital messages with each car and with the locomotive. The existing SCRRA fleet does not have the capability. These messages shall activate prerecorded audio and text messages on the PA and/or destination signs. The system shall allow the coded messages to be initiated manually from the Operator’s cab or from the crew handheld radio. Coded messages initiated from crew handheld radios shall only affect the intended train, not nearby trains.

Voice communication shall be performed on existing dedicated PA/IC lines.

13.8 DESTINATION SIGN SYSTEM

13.8.1 Equipment Description

An electronic destination sign system, compatible with the destination sign system(s) of the existing SCRRA commuter rail passenger cars, or approved equal, shall be installed on each car. It shall comply with all requirements of 49 CFR 238, IEEE P1477, and Draft Standard for Passenger Information System for Rail Transit Vehicles or latest revision and referenced IEEE Standards.

All cars shall have two (2) LCD or LED side destination signs for viewing from the exterior of the cars. Each sign shall be capable of displaying two (2) lines of text of at least eighteen (18) characters. The minimum character height shall be 3 inches. The display area shall have approximate dimensions of 6.5 inches height by 48.5 inches width. The destination sign system shall be arranged to allow each line to scroll messages, and to display to and from destination information; train number information; and special messages.

All destination signs shall be identical and mutually exchangeable. New text messages shall be created in the Portable Test Equipment (PTE) and downloaded into the destination sign system memory. The system shall be arranged to allow for selection of destination sign messages and for downloading of the new text messages for the destination signs via a trainline and locally on a per car basis for all vehicles procured under this Contract, regardless of the make-up of the operating consist. When operating in mixed consist, the sign message selected and/or new text messages downloaded via the trainline shall pass-through cars not procured under this Contract unaffected. The destination signs are not required to be interchangeable with those used on the existing fleet.

Pre-recorded audio messages shall be stored in a digital format in the communication and/or destination sign systems. Through a sound card, the audio messages shall be directed to the dedicated PA/IC trainlines.

The design of the destination sign system, including location and operation, shall be submitted to the Engineer for review during the design review process. **[CDRL 13-005]** Testing of the destination sign system shall be performed in accordance with Section 17.4.6.

13.8.2 Location of the Equipment

The externally viewed side destination signs shall be located as approved by the Engineer; one (1) on the right side and one (1) on the left side of each car. A housing with a hinged cover, compatible with the interior design, shall be provided on the interior of the car. Approved fasteners shall be provided to secure the access door. The hinged cover shall be large enough to allow troubleshooting and removal of the sign assembly without disturbing or removing of the glazing assembly.

The sign control unit (SCU) on cab cars and trailer cars shall be installed in a locker as approved by the Engineer. The SCU shall be placed in a locker in a similar location as on the existing cars. A door shall be provided with a key lock to allow authorized personnel to access the keyboard for programming, troubleshooting, or removal. A similar SCU with an approved operator's display keypad shall be located in the rear wall of the Operator's cab to allow the Operator to select and send audio and text messages. The terminal shall be placed at a suitable height for easy operation. A window shall be placed in the access door to allow viewing of the keyboard screen with the door closed.

A connector shall be provided adjacent to the SCU and behind the access door, to facilitate the connection of a portable memory transfer unit. The connector shall be Shell Part Number AMP 206043-1, Contact Part Number AMP 66101-3.

13.8.3 System Components and Wiring

All components and wiring shall meet the requirements of Sections 15.20 to 15.24. Where required to prevent interference, shielded, twisted pairs of wires shall be used. The power supply shall be capable of operating within the voltage range specified in Section 10.4.

13.9 DIAGNOSTICS PROVISIONS

The Contractor shall make provisions for potential future installation of the Monitoring and Diagnostic System, which would monitor the proper functioning of the major components on the car and report any problems to the central location on the car and eventually to a central location on the train to allow the maintenance crew to quickly find problems before they become unmanageable.

These provisions consist of the following:

a. Reserve adequate space near the destination SCU for the data collection and interface box.

b. Install the wiring connection between the major components in the car and this data collection and interface box.

The major components and systems to be monitored and diagnosed are:

a. Brakes, wheel-slide detection/correction system,
b. Door Systems,
c. Auxiliary Power Supplies,
d. HVAC, and
e. Event Recorder.

The connections shall be made by the use of a pair of twisted wires for each control point. Any future monitoring and diagnostic system would be designed according to IEEE Std 1473-1999 Standard for Communications Protocol Aboard Trains.

13.10 RADIO AND COMMUNICATIONS INTERFERENCE

The Contractor shall submit a communication system design plan that describes the communication systems and the criteria used for each system to mitigate potential interference problems during:

a. Concept development,
b. Design development,
c. System qualification testing,
d. Systems integration into the vehicle, and
e. Integration of the vehicle into the SCRRA system.

The Contractor shall ensure that the communications equipment including, but not limited to train radios, crew handheld radios, public address and intercommunications systems are free from on-board and externally caused interference. For intercommunications, SCRRA uses car borne intercom, car borne radios, crew handheld radios and cellular telephones. The application of control components, such as filtering, shielding, and bonding, shall conform to sound engineering practices and industry standards and shall be an integral part of the car system. Potential interference sources, such as electric buzzers and other trainline signals, shall be considered and adequately suppressed. See Section 17.5.20.

The Contractor shall develop the radio and communications interference mitigation plan in conjunction with the EMC Plan (See Section 2.5.4) and shall submit the plan within ninety (90) days following the Notice to Proceed. **[CDRL 13-006]**

13.11 CONDUCTOR'S BUZZER SIGNAL

Suitable trainlined electric buzzer, intercommunication signal system shall be available between any activated door control position and an appropriately equipped locomotive or cab car. The signal shall also be audible at all door control positions throughout the train if the master control drum switch is actuated at a control station. The electric buzzer signal system shall have a distinctively different tone from the private communication signal buzzer utilized between any car and locomotive. It shall operate from the low voltage DC system. See also Section 6.8 Door Signal System.

The signal shall comply with applicable radio interference regulations (See Section 13.10 above and Section 17.5.20).

End of Section

Contract Deliverables Requirement List

CDRL No.	Title	Car Type	Reference Paragraph
13-001	Design, Arrangement, Installation and Testing of Communication System	All	13.1, 13.2.1, 13.2.5
13-002	Details of Design, Arrangement and Installation of PA/IC System	All	13.2
13-003	Communication System Design Plan Describing System Trainline Equipment Interference Mitigation	Cab	13.3, 13.4
13-004	Video System Detail Design Review Package and Test Plan	Cab	13.6
13-005	Destination Sign System Design	All	13.8.1
13-006	Interference Mitigation Plan	All	13.10

SECTION 14

MONITORING SYSTEM

SECTION 14

MONITORING SYSTEM

TABLE OF CONTENTS

SECTION 14

MONITORING SYSTEM

14.1 GENERAL REQUIREMENTS AND FEATURES

This section defines the Cab Car requirements for monitoring and recording the operating parameters of the train. The system shall consist of an FRA compliant event recorder (ER) and a crew alertness control system (TMS) which included overspeed and automatic train stop (ATS).

The ER and TMS system hardware shall be based on the Bach-Simpson 54000 series or SCRRA approved equivalent. Complete system description of proposed ER and TMS including interface to the locomotive controls, data download port and data analysis shall be submitted for review and approval to the Engineer. Mechanical dimensions, mounting arrangements of various components shall be provided. **[CDRL 14-001]**

The ER and TMS systems shall be integrated into one package, which shall also provide the horn sequencing and the auxiliary light control functions. The system shall include all required speed sensors, which shall be shared by the speed indicator system. The ER/TMS shall be powered from the Cab Car battery through an independent, two pole, and 15 amp circuit breaker located on the control breaker panel.

The system shall be 49 CFR 229, 49 CFR 236, 49 CFR 238.105 and IEEE 1482.1-1999 compliant. A real-time clock within the system shall be configured from a password protected user interface. Clock frequency received from GPS or any other Trainline serial link will be recorded as a separate event.

The Contractor shall provide all necessary service and training manuals as per Section 18.

14.2 EVENT RECORDER

The ER shall be a Bach-Simpson series 54000 or SCRRA approved equal with minimum of thirty-six (36) digital channels, six (6) analog channels and three (3) frequency channels. The unit shall be installed in an approved location in the Cab Car and shall record specified operating parameters of the train.

The ER shall include the following features and functions:

1. Solid-state microprocessor,
2. An IEEE 1482.1 compliant, non-volatile, crash and fire protected memory module with a minimum of 48 hours recording capacity,
3. Bach-Simpson Download port with an SCRRA compatible download cable to be provided at the operator cab console (See Section 14.3),
4. PCMCIA compatible download feature or equivalent (See Section 14.3),

5. Fail safe operation shall cause a penalty brake upon loss of power,
6. Self-test feature,
7. A recorder status light (ON/OFF/Failed) shall be provided on the cover of the recorder for visual inspection,
8. All required electrical and pneumatic transducers and serial ports to record required data and communicate with the Cab Car controls,
9. The equipment shall meet all FRA requirements,
10. A download analysis program compatible with SCRRA (Bach-Simpson) WINDAS shall be provided,
11. Proper storage of data from all channels at four minute intervals. A record shall also be initiated with the occurrence of:
    - A speed change of 1 MPH or greater
    - A brake pipe or brake cylinder pressure change of 2 PSI or greater
    - Any digital input change of state,
12. The ER system shall provide outputs to drive:
    - Horn magnet valve when requested from the horn sequencer switch
    - Auxiliary lights when requested from either the manual button on the cab console or an active horn signal, and
13. Recorder and Download Port hardware packages shall be FRA recommended International Orange in color.

As a minimum the following parameters/events shall be recorded as digital channels:

1. Train line throttle valve “AV”,
2. Train line throttle valve “BV”,
3. Train line throttle valve “CV”,
4. Train line throttle valve “DV”,
5. Generator field excitation,
6. Direction of travel – Forward,
7. Direction of travel – Reverse,
8. Bell (ON/OFF),
9. Horn Pressure switch (ON/OFF),
10. Horn activated,
11. Horn sequencer activated,
12. PCS open,

13. Penalty brake applied,
14. Manual sand magnet valve activated (provision only signal from locomotive),
15. Operator initiated emergency brake application,
16. TMS override switch (ON/OFF),
17. Equalizing reservoir pressure switch (ON/OFF),
18. TMS reset (manual switch on operator console),
19. Head light switch (ON/OFF),
20. Head light switch (HIGH/LOW),
21. Auxiliary light (ON/OFF),
22. Zero speed system bypass,
23. Door open override switch (ON/OFF),
24. Door closed light,
25. Dynamic Brake setup,
26. ATS enable,
27. ATS request for acknowledgement,
28. ATS acknowledge,
29. HEP (ON/OFF),
30. Independent brake pressure switch,
31. Brake cylinder (>15 psi),
32. Radio handset cradle switch (If equipped), and
33. Emergency shut down (Engine Shutdown).

As a minimum the following parameters/events shall be recorded as Analog/frequency channel:

1. Brake pipe pressure,
2. Brake cylinder pressure,
3. Speed, and
4. Traction motor current.

The ER analysis program shall provide the distance traveled in miles and feet.

The ER shall include a minimum of two spare channels of each type (digital and analog).

14.3 DATA STORAGE, DATA DOWNLOAD, AND DATA ANALYSIS TOOL

The ER shall be equipped with memory capable of providing a minimum of 48 hours of recording capacity. The unit shall be equipped with local and remote SCRRA standard download cable ports. The remote port shall also have a PCMCIA download feature or equivalent. The Contractor shall provide all necessary download and analysis software, which can be installed on user selected multiple computers without restriction.

14.4 SAFETY AND OVERSPEED CONTROL

An overspeed control with an electronic speed indicator system, integral with the ER system, shall be provided. The electronic type speed indicator shall be mounted in the lower cab console in the clear line of sight of the seated Operator. See Section 7.6 for indicator display details.

The speed indicator system shall include three user selectable speed protection settings and isolated outputs. The initial factory settings shall be:

1. 3 mph for zero speed indication,
2. 83 mph for overspeed protection with ATS disabled, and
3. 93 mph for overspeed protection with ATS enabled.

The speed indicator shall include an LED display to indicate ATS “IN” and “OUT”.

A speed sensing gear and magnetic pickup shall be mounted on the number three axle seen from the B-end. The magnetic pickup and its mounting shall be fully adjustable for proper operation and shall be securely lockable in any adjusted position. Speed sensing shall be from independent magnetic pick up or shall be shared with the event recorder system. When the actual speed is above the selected overspeed setting, the overspeed brake magnet valve shall be dumped initiating a penalty brake application.

The overspeed brake magnet valve shall be mounted on the same panel as the alertness control system magnet valve and the ATS System magnet valve.

The speed indicator system shall include a self test feature. This feature shall allow the speed indicator to be calibrated for wheel size and verify overspeed settings. Complete system description of speed indicator system and mounting arrangement shall be submitted to the Engineer for review and approval. **[CDRL 14-002]**

14.5 ALERTNESS CONTROL

Crew alertness control system (TMS) shall be incorporated into the Cab Car ER system as specified in Section 14.1.

The TMS shall monitor absence of defined action by the Operator followed by alarm signal and penalty brake application. The TMS shall be subject to reset through the following Operator actions:

1. Throttle change,
2. Horn use,
3. Dynamic brake setup,
4. Change in reverser handle position,
5. Bell use,
6. Independent brake application greater then 15 psi,
7. Automatic brake application change of more than 5 psi,
8. Console manual reset button,
9. ATS acknowledgement,
10. Radio handle switch activation, if equipped,
11. Change of state of head light switch, and
12. Manual sanding activation.

If the TMS does not detect any of these actions within a prescribed period of time, audio and visual alarms shall be activated. Failure to acknowledge the alarm with a defined action shall cause the TMS to initiate a penalty brake application. The Audio/Visual alarm module shall be located in the cab at an SCRRA approved location.

TMS shall be enabled when the Cab Car is in lead position with automatic brake valve cut-in and any of the following:

1. The train speed is greater then 0.5 mph, or
2. The reverser handle is in either the forward or reverse position, or
3. The brake cylinder pressure is less then 15 psi.

When any of these conditions are not met, the TMS is disabled.

The TMS reset time interval shall be speed dependent. As the train speed increases, the TMS must be acknowledged more frequently. At the end of the allowed speed dependent time, the visual alarm light shall flash for five seconds and is accompanied by an audible alarm for 20 seconds. If no reset action is detected within this time interval, the TMS shall initiate a full service penalty brake application, by removing the energy from designated magnet valves. Speed dependent reset timing shall be:

Speed (mph)	Time (seconds)
0.5 – 1.9	240
2.0	162
10	135
20	105
30	90
40	77
50	68
60	60
>60	60

14.6 AUTOMATIC TRAIN STOP (ATS) SYSTEM-INTERMITTENT TRAIN STOP SYSTEM

Each cab car shall be equipped with an FRA compliant Intermittent Inductive Automatic Train Stop System similar to and performing the same functions as the system installed on the existing SCRRA cars and locomotives. The system shall be used and function with the present BNSF Railroad intermittent inductive automatic train stop wayside system in use on the SCRRA Metrolink system. The operation of the ATS system shall be similar to that presently used by SCRRA, i.e. acknowledgement required at signals displaying a less-than-optimum indication as well as at inert wayside inductors used prior to speed reduction locations. This shall also apply to receiver bracket mounting arrangement on the right front truck. The bracket design shall allow the receiver to be mounted at proper height to compensate for normal wheel wear. Complete system description of ATS system, interface to the brake system and mounting arrangement of various components shall be submitted to the Engineer for review and approval. **[CDRL 14-003]**

All wiring for the ATS system shall be run in a separate dedicated conduit. All conduit and wiring for the ATS system shall comply with the requirements of 49 CFR 236.552. The system shall be furnished as a complete, fully integrated and tested system ready for operation. The Contractor shall submit to SCRRA, for review and approval, the details of the system, installation and testing. **[Part of CDRL 14-003]**

14.6.1 Schedule of Equipment

The ATS system shall be PHW Inc. or equivalent intermittent train stop system similar to one on existing SCRRA locomotives and cab cars. The following hardware or approved equal shall be included:

1. ATS Control Box (D24 DO8-AO2),
2. Connector for control box with cable clamp (340008 and 342002),
3. ATS receiver complete with cable and brackets (D018F27-A02),
4. Cab Car mounted bracket (design specific to truck),

5. Cab Car mounted junction box with plug connector for receiver connection (340040),
6. Pneumatic valve (490002) and cut-out cock (B166H45-D01) for penalty application from ATS system activation,
7. Alarm module, consisting of audio (240005) and visual (128015) alarms, and
8. Operator console mounted acknowledgment push button switch (204023 and 204024).

14.6.2 System Operation

The system shall be protected by a separate ATS circuit breaker located in the circuit breaker panel in the cab. The ATS system shall be integrated with the Event Recorder and speed indicator systems. The system shall be equipped with a two (2) position selector switch with sealing provisions located within easy reach of the Operator and labeled as follows: Position #1 "ATS-IN" Position #2: "ATS-OUT". This switch shall be integrated with the overspeed/speed indicator system so that:

1. When Position #1 ("ATS-IN") is selected, the ATS system shall be energized/activated and the maximum permissible speed shall be limited to 93 mph through car overspeed/speed indicator system.
2. When Position #2 ("ATS-OUT") is selected, the ATS system shall be de-energized/deactivated and the maximum permissible speed shall be limited to 83 mph through car overspeed/speed indicator system.

A separate indicator shall illuminate when "ATS-IN" position is selected.

The system shall include an operator interface function consisting of (1) an acknowledging pushbutton (switch), (2) an ATS penalty brake/acknowledge demand light, and (3) an electronic audible alarm. The audible alarm shall have a unique sound from all other alarms being provided. In addition, a cut-out cock, which is normally sealed in the "open" position, shall be provided with the capability to be closed in the event of ATS system failure in order to preclude penalty brake application.

An ATS audible alarm shall sound when a restrictive condition is detected. The operator must acknowledge the alarm within 8 seconds to avoid a full service penalty brake application. Once a penalty brake application is initiated, and so indicated by the console mounted penalty indicator, the system cannot be reset until the train comes to a complete stop. The penalty brake application for the Operator's failure to acknowledge a speed-restricting signal indication shall be an automatic service rate brake pipe reduction (by venting of the #3 line to the P-2-A application valve by de-energizing the ATS magnet valve). The reset button shall not be in the operating cab, but located in the cab car equipment locker behind the cab.

The ATS receiver shall be installed on the F-end truck, right side. The distance from the gauge line to the outer edge of the ATS receiver shall be 4.6250 +/- 0.7875 inches. The height of the receiver (from top of rail to bottom of receiver) shall be 27.00 +/- 1.00 inches. The receiver shall be adjustable to compensate for wheel wear and tolerances associated with manufacturing and normal component wear.

The ATS electronic equipment control enclosure shall be mounted in an approved location. The acknowledging pushbutton switch shall be located on the Operator's control panel. The audible electronic alarm shall be mounted in the rear cab wall behind the Operator.

The fail safe ATS system design shall include a manually activated self test feature such that the system operation can be verified.

The ATS system shall provide the interface to the ER so that the following events are recorded:

1. ATS system Activated/Deactivated,
2. ATS acknowledgement request, and
3. ATS acknowledged.

Complete training and service manuals shall be provided.

14.7 ACKNOWLEDGEMENT

There shall be two acknowledgement pushbuttons on the cab console. One shall be dedicated for the TMS and the second for the ATS. Each pushbutton shall provide acknowledgement signals to the ATS and TMS systems. The ATS acknowledgment pushbutton must be depressed within 8 seconds of ATS alarm to avoid a penalty brake application. Penalty shall also occur if this button is depressed for more then 8 seconds.

14.8 SUPPRESSION

Speedometer generated overspeed and TMS timed out penalties shall be pneumatically suppressible by moving the automatic brake handle to the suppression position. ATS system failures or failure to acknowledge penalties shall be pneumatically non-suppressible. Description of various penalty brake suppression techniques and interface with air brake system shall be submitted to the Engineer for review and approval. **[CDRL 14-004]**

14.9 PENALTY BRAKING

The pneumatic system shall be designed to provide:

1. Full service penalty brake application for ATS, TMS, and overspeed systems.

2. Adequate warning (6 to 8 seconds), with audible alarm before initiating overspeed penalty.
3. Overspeed penalty reset after the train is under speed and automatic brake handle is in the suppression position.
4. TMS penalty brake reset by simply moving the automatic brake handle to the suppression position.
5. ATS penalty reset after the Operator activates the reset pushbutton on the ATS box, acknowledgement pushbutton on the cab console and automatic brake handle in the suppression position.
6. Fully release of automatic brakes only after the PCS light on the cab console goes out.

There shall be a total of three magnet valves, one for over speed, TMS, and ATS. Associated cut-out cocks shall be color coordinated with similar orientation and collocated in the SCRRA approved location as follows:

1. Overspeed – White,
2. TMS – Yellow, and
3. ATS – Red.

Description of various penalty brake application including visual and audible warning signals shall be provided. **[CDRL 14-005]**

End of Section

Contract Deliverables Requirement List

CDRL No.	Title	Car Type	Reference Paragraph
14-001	Event Recorder and Crew Alertness System Description	All	14.1
14-002	Speed Indicator System and Mounting Arrangement Description	All	14.4
14-003	ATS System Description	All	14.6
14-004	Penalty Brake Suppression Techniques and Interface with Air Brake System	All	14.8
14-005	Penalty Brake Application Description	All	14.9

SECTION 15

MATERIALS AND WORKMANSHIP

SECTION 15

MATERIALS AND WORKMANSHIP

TABLE OF CONTENTS

SECTION 15

MATERIALS AND WORKMANSHIP

15.1 GENERAL

This Section describes the materials to be used and the method of implementation which should be utilized to assure compliance with the rules, regulations, standards, and recommended practices of the government and the rail industry. This Section also provides guidance to the contractor for the design and manufacture of the car. Although general in content as to specific applications, this section defines in considerable detail many types of material and the manner in which the Contract requires them to be applied in the construction of the vehicle. In many cases, the individual Sections provide guidance on the specific materials parts of the car; if specific guidance is not given, the requirements of this Section shall govern.

15.1.1 Quality

Material and workmanship shall be in accordance with the requirements of this Section, unless approved by SCRRA.

Inclusion of a material or method in this Section does not indicate approval for application or use in a specific situation. When a material or method is specified in this Section, this Section shall be applicable; however, specific requirements detailed in appropriate Technical Specifications take precedence over this Section.

Material Safety Data Sheets (MSDS) shall be submitted for all materials, including lubricants, used in the fabrication of these cars, except for non-hazardous metallic materials. **[CDRL 15-001]** Information shall be in a form compliant with ANSI Z400.1-1993.

15.1.2 Marking

In accordance with Section 16, the Contractor's Quality Assurance Program shall assure that all aspects of the Contract are in conformance with the design, materials and workmanship requirements provided in this Specification.

15.1.3 Cleaning Agents

A list of recommended cleaning agents shall be provided to SCRRA for all materials exposed to normal cleaning operations. **[CDRL 15-002]** This information shall also be included in the maintenance documentation for the vehicle.

15.1.4 Prohibited Materials

The following materials are prohibited from use on the cars:

- PVC
- Asbestos

- Cadmium (except for battery)
- Lead (except for battery)
- PCBs
- Carcinogenic materials
- Materials listed in 29 CFR Sec. 1910.19

15.2 STANDARDS

15.2.1 National Codes and Standards

All materials and manufacturing techniques shall meet the latest revision, at the time of Contract award, of the appropriate APTA, AAR, ANSI, AISI, and ASTM Specifications and Standards, and FRA regulations, unless otherwise specified and approved.

15.2.2 State of California Requirements

All materials and manufacturing techniques shall meet the latest revision, at the time of manufacture, of State of California regulations. All repair techniques and materials reasonably expected to require repair shall be compatible with State of California requirements.

15.2.3 SCRRA Requirements

SCRRA requirements are contained in this specification and the references thereto. All repair techniques and all materials furnished under this Contract shall comply with these requirements.

15.2.4 Equivalent Standards

Where other or foreign standards are proposed by the Contractor, the Contractor shall submit documentation for SCRRA review and approval demonstrating the proposed standards are the equivalent of the foregoing standards and specifications. Proposed substitute specifications shall be submitted in both English and the language of the country of origin. The Contractor shall be responsible for assuring that the English translation is correct.

If equivalent standards are used, all referenced or subsidiary standards shall be from the same country/body's system and the same requirements from the preceding paragraph shall apply.

15.3 PAINTS AND COATINGS

15.3.1 General

Painting shall be done by experienced labor, using proper equipment under competent supervision. All painting shall be done using documented Contractor's procedures consistent with the manufacturer's recommendations.

15.3.2 Exterior Painting

Each vehicle shall be completely painted in accordance with the vehicle exterior paint scheme including logos, vehicle numberings and other exterior lettering to be provided by the Engineer. The portion of the vehicle body or any of its components, receiving paint shall be painted as required by the Specification and in accordance with the specified color scheme. The exterior paint scheme shall be essentially the same as that on existing fleet provided to SCRRA. The vehicles shall be numbered sequentially, as determined by the Engineer. The color of the under frame paint shall match Sico Paint Systems alkyd semi-gloss black No. 517-195.

The Contractor shall submit color samples and corresponding L*, C*, H* three component polar coordinated plot and a one component total color difference, DEcmc, for approval. **[CDRL 15-003]** The exterior finish shall have a gloss level greater than 85 as measured with a 60 degrees gloss-meter.

Orange peel shall be allowed on exterior wet coatings if it is a level 7 or greater when evaluated in accordance with ACT Laboratories “Orange Peel Visual Standards.”

All carbon and LAHT steel portions of the vehicle shall be painted unless prohibited by other specifications. Seams and overlaps shall be painted using the same system as the exterior of the vehicle on all surfaces. Disassembly shall be done as required to ensure that hidden areas are completely painted; components may be painted before installation as an alternate way of ensuring complete coverage.

Any austenitic stainless steel portions of the car body shall not be painted, unless otherwise specified by SCRRA for cosmetic reasons. Where stainless steel is painted, procedures shall be as recommended by the paint manufacturer for the application, and surfaces shall be properly prepared to ensure adhesion.

The final painted surface shall be tested on the first car to the following criteria.

15.3.2.1 Hardness

Pencil Hardness tests shall be performed according to ASTM D3363. The range of acceptance shall be between H and 2H and shall be the average of ten readings taken from typical surface locations. This is a destructive test and shall require the tested surfaces to be repaired.

15.3.2.2 Adhesion

Adhesion shall be tested per ASTM D4541 and achieve a minimum rating as provided by the paint manufacturer. This is a destructive test and shall require the tested surfaces to be repaired.

15.3.2.3 Thickness

The minimum and maximum dry film thicknesses shall be provided by the paint supplier. Dry film thicknesses beyond the manufacturer's recommendations shall not be accepted. Non-destructive testing shall be performed to verify final dry film thickness.

15.3.2.4 Paint Cure

A solvent rub test shall be performed per ASTM D5402. The test procedure requires no less than fifty double finger rubs with a cloth wetted in acetone or methyl isobutyl ketone to the painted surface. No paint color should transfer to the cloth. After 72 hours the painted surface must retain all original characteristics such as gloss and hardness.

15.3.3 Truck Painting

All truck components to be painted shall be given a full coat of primer prior to assembly. Following assembly, all exposed surfaces of each truck, including machined mounting surfaces not used, shall be cleaned by blowing off with compressed air and solvent-wiped to remove all dirt and grease. These surfaces shall then be sprayed with one (1) coat of an approved black truck paint (a type which shall not conceal cracks that may develop in service) and air-dried.

15.3.4 Apparatus and Under floor Equipment

All under floor apparatus (motors, control boxes, junction boxes, brake valves, and other equipment as specified) shall be primed and painted in accordance with the following requirements unless otherwise indicated. All other apparatus shall be painted in an approved color.

The exterior surfaces of undercar equipment enclosures and apparatus, other than propulsion control equipment, made from carbon steel shall be prepared, primed, and painted as specified in Section 15.3.8. The interior and exterior surface of all propulsion control equipment enclosures shall be coated with an approved insulating, thermosetting, resin-based, powder coating or polyurethane paint system. The interior of the boxes, including insides of covers, shall be white and the exteriors shall match the undercar paint scheme.

Parts of undercar equipment enclosures made from plastic or fiberglass shall be painted in accordance with the above requirements for metal portions except that the paint system shall be compatible with the plastic used, and an insulating coating need not be applied.

An exterior finish of polyurethane to match Sico Paint Systems alkyd semi-gloss black no. 517-195 shall be provided for equipment control groups, unless otherwise approved by SCRRA.

15.3.5 Interior Painting

All exposed interior surfaces, including molding and trim, shall be as specified in Section 4, or shall be powder-coated metal.

Interior surfaces requiring painting shall be coated with an approved thermosetting powder coating. Parts which are to be powder-coated shall be cleaned and prepared in accordance with the recommendations of the supplier.

The Contractor and its supplier shall supply a touch-up procedure and assure that a continued supply of touch-up paint in the proper colors suitable for spot application shall continue to be available in the United States for a period of five (5) years.

15.3.6 Corrosion Protection

Concealed surfaces capable of rusting or oxidation shall be properly cleaned, receive a wash primer, then primed with epoxy paint, and painted with an approved finish coat of paint. Where

arc welding is performed on joints between stainless steel and other materials, the joint shall be de-scaled, cleaned, receive a wash primer coating, and then painted in accordance with Section 15.3.2 or 15.3.3.

15.3.7 Acoustical Insulation

Acoustical insulating materials shall be applied to properly cleaned underframe, sides, ends, roof and floor sheets, as required in Section 4.2, to the supplier's recommendations. The materials shall be resistant to diluted alcohols, grease, gasoline, aliphatic oils, and vermin. The materials shall be unaffected by sunlight and ozone and shall not become brittle with age. It shall be Daubert Chemical Company's No. 368 sound deadening compound, Aquaplas No. DL-10, 3M Corporation 2552 Damping foil, or approved equal. The Contractor may propose an alternative insulation system. The alternative acoustic insulation system shall be service proven for commuter rail vehicle application and shall demonstrate compliance with the design and performance requirements specified.

15.3.8 Materials and Preparation

The requirements of this section apply to all painting and coating activities, unless information given in the individual sections conflict, in which case the individual section requirements take precedence.

Use of water-based paint is prohibited.

All painting to be applied on the car body or any component is to be conducted in accordance with the paint manufacturer's recommendations. The Contractor and its paint supplier shall supply a touch-up procedure **[CDRL 15-004]** and assure that a continuing supply of touch-up paints in colors used on the car, suitable for spot application by spray roller or brush, and compatible with State of California regulations, shall continue to be available in the United States.

All painting materials for all surfaces shall be a high quality finishing system resistant to corrosion, chipping, and fading and shall retain the gloss level. The coating shall be a two-part, high solids, low VOC, 2-part polyurethane paint system with solids content between 50 and 70 percent. Alternate paint systems, such as base coat-clear coat systems, or direct-to-metal paint systems shall be considered if the paint performance equals or exceeds two part polyurethane. Powder coating systems shall be considered if the coating performance equals or exceeds two part polyurethane. All paint and filler materials which are to be superimposed to form a finish system shall be mutually compatible and shall be warranted for use as a system by the manufacturer of the components.

All exterior surfaces that are to be painted shall be prepared as specified and the paint shall be applied according to the paint manufacturer's recommendations. The paint shall be uniformly applied over all surfaces to be covered and shall be free from runs, sags, or other application defects. Painting shall be done in a clean, dry atmosphere at an ambient temperature and humidity as recommended by the paint manufacturer.

Before painting any car surface that is exposed to view, all dents, gashes, nicks, roughness, or other surface imperfections or depressions shall be removed so far as possible by straightening and shall be properly prepared to receive the filler material. These surfaces shall be properly cleaned and wash primed following straightening. Any remaining dents or other surface imperfections shall then be filled with approved filler and sanded smooth. The maximum allowable filler thickness shall be as recommended by the filler manufacturer for the environment and service to which it is to be exposed, but in no case shall it exceed 0.125 inch.

Preparation of the substrate surface and application of painting materials by roller, brush or spray shall be in accordance with the paint supplier's recommendations. All paint materials shall be used at the consistency recommended by the paint supplier. If thinners are necessary, they shall be approved by the paint manufacturer and shall be used only to the extent recommended.

Metal portions of the car body not constructed of austenitic stainless steel shall, after fabricating, be prepared for painting by grit blasting and immediately painted with an approved epoxy primer, or washed with an alkaline solution, properly rinsed, phosphate coated or painted with a coat of wash (etch) primer, and then coated with an approved epoxy primer. After erection of the framing structure and body sheets, all undercar metal, except stainless steel, shall receive a polyurethane finish as specified above.

15.3.9 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,
- Power resistors,
- Heat transfer surfaces,
- Electrical insulators,
- Elastomeric portions of air and refrigerant lines, and
- Grounding pads.

The following truck-related items shall not be painted:

- Wheels,
- Axles,
- Elastomeric parts,
- Grease fittings,
- Linkages,
- Threaded parts used for adjustments,
- Electrical equipment,
- Wearing surfaces, and
- Couplers

15.3.10 Paint Process Documentation

The Contractor shall prepare a paint coating and application document containing procedures for surface cleaning and preparation, priming, surfacing, and painting for the car body and all equipment that is painted or powder coated. A detailed paint schedule showing the equipment painted, paint type and manufacturers, recommended thickness, and other pertinent information shall also be included. This document shall be submitted for approval prior to painting of any surfaces or components and shall be made part of the maintenance manuals. **[CDRL 15-005]**

15.3.11 Decals

Graphics and signage on surfaces that are not painted or coated (for example, stainless steel car bodies, if applicable) shall be applied by means of decals. Decals shall be made of an approved adhesive backed vinyl film, applied and edge sealed, if required, in accordance with the manufacturer's instructions. The decal pattern arrangement shall result in similar pattern and visual effect to the painted vehicles currently in service at SCRRA. Exterior graphics shall be made of exterior type reflective decorative vinyl film, 3M "Scotchlite" or approved equal, having equivalent visibility to SCRRA's current painted vehicle fleet. The location, size, text, color, and application of all exterior decals shall be approved by SCRRA. All graphics layouts shall be submitted for approval. **[CDRL 15-006]**

15.4 JOINING AND FASTENING

15.4.1 Joining

15.4.1.1 General

Certain combinations of materials require particular care in joining to avoid the possibility of corrosion. The contractor shall design the vehicles to minimize the number of such combinations, and to minimize the accumulation of water, cleaning chemicals, and chemicals present in the environment, at or near combination joints. Isolating and moisture-proofing materials, appropriate to the materials being joined, shall be used at all times where these combinations exist. Detailed requirements for protection of materials against effects of joining dissimilar materials are contained in sections 15.4.1.3, 15.4.1.4, 15.4.1.5, 15.5.7, 15.6, and 15.9.4. The contractor shall provide a detailed plan for installation of dissimilar materials in accordance with these sections and applicable industry practice. This plan shall be submitted for approval by the Engineer prior to beginning of assembly of the first car. **[CDRL 15-007]**

15.4.1.2 Joint Fitting

Joints shall be properly fitted, whether exposed or concealed. When not otherwise specified in Contractor drawings or specifications, gaps between joints shall be held to a dimension not greater than 10 percent of the thinner material being joined, or 0.002 inch, whichever is greater. Gaps shall be uniform in width across 100 percent of the surface. The edges of panels shall have a smooth, finished appearance.

Where excessive gaps (greater than those permitted by approved drawings or standards) are found to exist at the faying surfaces of structural bolted or riveted connections, metal shims of the same material as that of the deficient part may be used, but only with the written permission of SCRRA. Shims, if used, shall be permanently fastened to one of the base parts being joined. The use of epoxy or other plastic filler at such locations is expressly prohibited.

15.4.1.3 Metal-to-Metal Connections

Where metals contact each other, the contact surfaces shall be free of dirt, grease, rust, and scale. Unless specified otherwise, the contact surfaces shall be coated with a metal based primer which conforms to Society for Protective Coatings, Specification SSPC-Paint 25. Metal primer may be omitted for austenitic stainless steel to austenitic stainless steel joints.

For proper treatment of a connection involving aluminum, refer to Sections 15.9.3 and 15.9.4.

15.4.1.4 Wood-to-Metal Connections

Where wood and ferrous metal surfaces are placed together, the wood shall be coated with aluminum paint conforming to Federal Specification TT-P-38, and the metal shall be coated with a primer which conforms to Society for Protective Coatings, Specification SSPC-25.

All bolts or rods passing through wood shall be coated with aluminum paint conforming to Federal Specification TT-P-38.

15.4.1.5 Wood-to-Wood Connections

Where wood and wood are placed together, both abutting surfaces shall be coated with aluminum paint conforming to Federal Specification TT-P-38.

15.4.2 Fasteners

15.4.2.1 General

The Contractor and suppliers are responsible for selecting fastener types, sizes, styles, lengths, materials, grades, and finishes that shall meet the requirements of this Specification. The Contractor shall minimize the number of different sizes and styles of fasteners used. Throughout the car the use of inch standard fasteners is preferred. However, ISO Metric fasteners may be used in conformance with Section 15.4.2.2.b.

All fasteners used on this vehicle can be classified under one of four categories: critical; general purpose; decorative; or electrical and electronic. The criteria for classification are expressed below. All fasteners must meet the general requirements for design and material in addition to any requirements contained in the section specific to the particular category. All fasteners, in any category, which attach to car structure shall be in accordance with Section 3.3.

Critical fasteners include, but are not limited to, all fasteners applied to carbody structure, trucks, bolsters, truck-mounted brake equipment, couplers, and power collection devices. Additionally, any fastener is considered critical if failures cannot be tolerated, that is, if even a single fastener fails there is a possibility of brake failure, derailment, or accident. In the event of a dispute, SCRRA shall be the final arbitrator on which fasteners are classified as critical.

Fasteners used to attach interior lining or trim and exposed to passenger view are specified under Decorative Fasteners.

Fasteners used to secure wire terminations to an electrical or electronic device are considered Electrical and Electronic, and are specified in appropriate Materials and Workmanship subsections for electrical devices and wiring.

Fasteners not falling into one of the other three categories are classified as General Purpose.

Detailed requirements pertaining to critical, general purpose and decorative fasteners are contained in sections 15.4.2.2.f, 15.4.2.2.g, and 15.4.2.2.h respectively.

15.4.2.2 Threaded Fastener Standards

15.4.2.2 (a) Inch-Standard Fasteners

All inch-standard threaded fasteners shall conform to ASME B1.1 Standard, Unified Inch Screw Threads, (UN and UNR Thread Form) or Industrial Fasteners Institute “Inch Fastener Standards”.

15.4.2.2 (b) Metric Fasteners

Upon approval, specific Line Replacement Units (LRUs) that are provided by a supplier or sub-supplier to the Contractor may be supplied with metric fasteners to ANSI B1.13M (ISO-metric) Standards. Also see Section 2.6.2. In these cases, all internal fasteners and threaded components of the approved unit shall have ISO-metric threads. Internal to components there shall be no mixing of metric and inch threaded fasteners. External mounting fasteners and threaded connecting components shall have ISO-inch threads to ASME B1.1 Standards. Each unit, component, or group containing ISO-metric threads shall be indelibly identified, in an approved manner and in a conspicuous approved location, to signify that the unit contains metric threaded fasteners. 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.

15.4.2.3 General Requirements

15.4.2.3 (a) Fastener Materials and Coatings

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 carbon, alloy, and martensitic stainless steel fasteners shall be plated with zinc, unless specifically waived by the Engineer. Cadmium plated fasteners are not permitted. Grade 8 or metric grade 10.9, or stronger, fasteners shall not be plated if the OEM finish is other than plating. The zinc plating shall conform to ASTM B633 SC2 Type II, SC3 Type II, or SC4 Type II, or ASTM B695, Class 8, Type II.

Alternate fastener coatings are permissible if qualified by testing per ASTM B117 with no red rust or visible corrosion products after 96 hours of exposure. The Contractor shall submit qualification results for each process used at each subcontractor applying the proposed coating.

In order to use an alternate coating, the vendor shall submit 1) coating manufacturer's product data including required thickness, 2) ASTM B117 test results from an accredited third party laboratory, 3) documentation of torque/tension characteristics, and 4) a statement from the coating manufacturer regarding the propensity for the coating process to cause hydrogen embrittlement of the fastener during coating. Regardless of the coating's propensity for hydrogen embrittlement, each lot of high strength fasteners, including OEM plated zinc or yellow bolts (Grade 5 or Metric Grade 8.8 or higher) shall be tested for hydrogen embrittlement in accordance with Section 15.4.2.3.f. Each lot of lower strength fasteners shall be tested for hydrogen embrittlement if the coating has the possibility of causing hydrogen embrittlement.

If the proposed coating results in a change in the K-value for the plated fastener to outside the range of 0.13-0.15, as defined by Industrial Fasteners Institute Standard IFI-543, the vendor shall use the alternate coating on all fasteners within the particular LRU. The LRU shall contain an indelible label identifying the coating type used within the LRU and the required torque values for each size fastener used therein. Fasteners internal to a subcomponent within an LRU may use the standard coating system if they are not subject to removal during Owner's maintenance activities.

15.4.2.3 (b) Requirements for Nuts

Unless otherwise required by a specific application, all nuts shall be regular height, nylon insert, self-locking stop nuts (ESNA or approved equal), conforming to Military Standard MS-21044 and Military Specification MIL-N-25027. Where nylon-insert self-locking stop nuts cannot be used, self-locking bolts and screws conforming to MIL-DTL-18240 Type L may be used. Nylon insert lock nuts, bolts, or screws shall not be used near heat sources that shall exceed the manufacturer's recommended operating temperature or 200ºF, whichever is lower.

All-metal prevailing-torque type locknuts shall only be used where there is insufficient clearance to install ESNA type locknuts, or where the locknut is exposed to temperatures above 200ºF.

Clip nuts shall not be used.

All carbon, alloy, and martensitic stainless steel nuts shall be plated with zinc, unless specifically waived by the Engineer. Grade 8, or metric grade 10.9, or stronger, nuts shall not be plated if the OEM finish is other than plating. The zinc plating shall conform to ASTM B633, SC2 Type II, SC3 Type II, or SC4 Type II, or ASTM B695, Class 8, Type II.

Alternate coatings may be applied to nuts per the requirements of Section 15.4.2.3.a.

15.4.2.3 (c) Washers and Retention Devices

Washers, of a grade and strength compatible with the fastener, shall be used under the heads of all bolts and under all nuts. Washers shall conform to ANSI B18.22.1 or ANSI B18.22M, latest revision, as is appropriate for the application. Where high strength fasteners are applied, washers shall be hardened and comply with IFI Fastener Standards.

Lock washers shall not be used for fatigue applications where the fastener must be torqued and marked per Section 15.4.2.3.e. The use of lock washers is discouraged throughout the vehicle and all systems. Other types of washers, including Belleville washers, may be used for special applications with SCRRA's approval. Lock washers, when applied, shall conform to IFI Fastener Standards.

15.4.2.3 (d) Joint Design

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. All fasteners used to secure access covers, doors, 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 (5) years, access panels shall be equipped with quarter-turn fasteners. Quarter-turn fasteners shall have a minimum shank diameter of 0.25 inch, be of adequate strength, and as manufactured by Southco, or approved equal.

Unless otherwise approved by SCRRA, threaded fasteners shall not be threaded directly into non-metallic materials. Metal thread inserts shall be used when a threaded fastener is secured to a non-metallic material.

When bolts are used to secure apparatus where the bolt head is not accessible, a reusable mechanical locking device shall be used to prevent the bolt head from turning when the nut is being turned.

At least 1-½ screw threads shall be visible beyond all nuts. When used without elastic stop nuts, bolts shall not project more than 1-½ threads plus 0.25 inch for bolts 0.25 inch diameter or less and shall not project more than 8 threads for larger diameter bolts, unless otherwise approved. With elastic stop nuts, bolt threads shall not project more than 0.25 inch, regardless of bolt size.

Undercar equipment shall not be supported by bolts in tension.

All critical fasteners and general purpose fasteners used to secure equipment to the carbody, including truck and brake equipment bolts and all fasteners exposed to fatigue loads, shall be torqued to a minimum preload equal to 75 percent of their proof load and "torque sealed" or "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, 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”, SCRRA may require bolt torque-tension tests to verify that installed preload is equivalent to 75 percent of proof loads.

15.4.2.3 (e) Critical Fasteners

All critical fasteners shall have documentation identifying manufacturer and purchase specifications available for examination by SCRRA at the Contractor's QA department. This documentation shall include the fastener material or grade, and finish including plating material and specifications, when applicable. Whether the buyer is a sub-contractor, supplier, or the Contractor, the Contractor shall obtain and hold this documentation for a period of not less than termination of the last car's warranty period. After this period, all documentation shall be provided to SCRRA

All critical fasteners shall either a) be manufactured, tested, and distributed in accordance with ASME FAP-1-1990, Quality Assurance Program Requirements for Fastener Manufacturers, Distributors and Testing Laboratories, 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 equal. A production lot is defined as one size of fastener, from one manufacturer, 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 SCRRA. Tests conducted shall confirm that fastener material meets specified chemistry and strength requirements. The buyer shall obtain certified test results from the testing laboratory and hold the documents for a period of not less than the termination of the warranty period of the last car. After this period, all documentation shall be provided to SCRRA.

All critical fasteners that are plated or chemically cleaned shall have certifications showing freedom from hydrogen embrittlement. Testing shall be done by the Contractor or a supplier following ASTM F519 procedures. An ASTM F606 wedge test sample may be used in place of the F519 standard samples. Test loads shall be a minimum of 80 percent of yield strength or proof load and held for a minimum of 168 hours. Any failures shall reject the entire lot.

15.4.2.3 (f) General Purpose Fasteners

Mounting and attachment bolts shall be sized to the design strengths for Grade 2 bolts and Class A nuts, however in no case shall the fastener diameter be less than 0.375 inch. Grade 5 bolts and Class A nuts shall be used for installation of all equipment and/or structures.

Fasteners used within equipment shall meet all requirements of this Section other than the requirements specifically listed for critical fasteners or decorative fasteners, and shall be sized as appropriate for the application.

All general purpose 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 SCRRA to review for a period of not less than the expiration of the warranty on the last car delivered. After this period, all documentation shall be provided to SCRRA.

15.4.2.3 (g) Decorative and Appearance Fasteners

All interior fasteners exposed to passengers shall be either bright or finished to match the surfaces being joined, and installed such that the fastener head is flush with the mating surface. Bright finished fasteners used for stanchions shall be austenitic grade stainless steel. Bright finished interior fasteners may be either austenitic or plated martensitic stainless steel. Self-tapping screws are only permitted where they shall not be removed for normal maintenance more frequently than once in five (5) years and shall be plated martensitic stainless steel.

All exterior fasteners visible to passengers shall be austenitic stainless steel for steel, LAHT steel, and stainless steel car bodies. Exterior aluminum shall be joined by austenitic stainless steel or aluminum alloy fasteners, as appropriate to the design and appearance requirements. Fasteners used on the side sill to attach equipment brackets are considered either critical or general-purpose fasteners, as appropriate for the application.

Fasteners on access panels, plates, covers, or other components accessible by passengers shall be of a single style tamperproof type approved by SCRRA

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 SCRRA to review for a period of not less than the expiration of the warranty on the last car delivered. After this period, all documentation shall be provided to SCRRA

15.4.3 Bonding

The joining of elastomeric pieces shall be conducted by the hot vulcanization process. Adhesive bonding of elastomers shall not be allowed.

All adhesive applications shall be approved by the manufacturer of the adhesive system and suitable for the materials being joined and the environmental exposure to be expected. Where adhesives are in contact with painted surfaces, suitable bond strength to both the paint and substrate shall be verified by test. The Contractor shall submit manufacturer’s data for all proposed adhesive applications prior to first use of the adhesive system. **[CDRL 15-008]** After this period, all documents shall be provided to SCRRA.

15.5 WELDING AND BRAZING

15.5.1 General

The Contractor shall be responsible for the quality of its welding and brazing as well as that of its suppliers and subcontractors. Cleaning prior to welding shall be in accordance with applicable parts of Section 2, MIL-HDBK-132, "Cleaning Materials and Processes."

15.5.2 Structural

All structural welding practices shall be according to requirements of the AWS D1.1, "Structural Welding Code-Steel;" AWS D1.2, "Structural Welding Code - Aluminum;" AWS D1.3, "Structural Welding Code - Sheet Steel;" AWS D1.6, "Structural Welding Code- Stainless Steel;" AWS D15.1 "Railroad Welding Code", and the AWS Welding Handbook. Requirements for dynamically loaded structures shall be applied. Cast steel welding shall be according to ASTM A488/A488M, "Steel Castings, Welding, Qualification of Procedures and Personnel." Resistance welding shall be in accordance with AMS-W-6858B. AWS D1.1 shall apply to steel of 0.125 inch and greater thickness. AWS D1.3 shall apply to steel less than 0.125 inch thickness. Canadian Welding Bureau (CWB) Standard W59, "Welded Steel Construction," may be used in lieu of AWS D1.1 and CWB Standard W59.2, "Welded Aluminum Construction," may be used in lieu of AWS D1.2. In the case of the use of CWB standards, AWS standards shall be used for all materials and thicknesses where CWB standards do not apply.

Structural welding of ferritic and austenitic stainless steel shall primarily be governed by AWS D1.6. ASME Section IX and ASME Section VIII, Part UHA shall apply where appropriate. 201L (UNS 20103) and 301LN (UNS 30153) stainless steels shall be treated as P-No. 8, Group-No. 3, category for reference to ASME requirements. Ferrite number for welds made with austenitic stainless filler materials shall be between WRC4 and WRC10, or as proposed by the Contractor and approved by the Engineer. Weld heat-affected zones (HAZ) and weld metal shall be limited to maximum allowable stress values in ASME Section VIII, Table UHA-23, for UNS S20100 stainless steel and Table UW-12 rating of welds. Fatigue allowable stresses shall not exceed the lesser of fatigue limits in AWS D1.1, Section 2.20.6, or 50 percent of the joint strength level calculated from ASME maximum allowable stress values. Higher values shall only be used if qualified by Contractor tests.

Regardless of the governing codes, all Welding Procedure Specifications (WPS) shall be fully qualified by test by the Contractor. Qualification shall be documented by Procedure Qualification Records (PQR). WPS and PQR shall be prepared by the Contractor and reviewed and accepted by the Engineer and a Certified Welding Inspector. **[Part of CDRL 15-009]** The use of AWS-B2.1 guidelines for qualification shall not be permitted and shall not be included or referenced in WPS and PQR. The use of any WPS purchased from an outside agency shall not be permitted without separate qualification by the Contractor.

15.5.3 Welder Qualification

Welders shall make only those welds for which they have been qualified according to the requirements of the AWS, ASME Section IX, ASTM A488/A488M, or other approved qualifying procedures. AWS B2.1 "Standard for Welding Procedure and Performance Qualification", may not be used for welder qualification. Records of welder qualification tests shall be made available for review.

15.5.4 Inspection of Welds

The Contractor shall visually inspect all structural welds in accordance with AWS D1.1 requirements.

In addition to the visual inspection specified for all welds, nondestructive surface inspection (dye penetrant or magnetic particle methods, as appropriate) shall also be used to inspect all first-production welds. The Contractor shall specify a sample nondestructive inspection rate for all subsequent welds. **[CDRL 15-010]**

If ring welds are used, on the first structure all ring welds shall be nondestructively inspected by magnetic particle or dye penetrant methods. The Contractor shall submit a random sampling plan for additional metallographic examinations of ring welds for approval. **[CDRL 15-011]** The minimum acceptable sampling plan shall require inspection of one (1) ring weld sample for every 300 production ring welds. A record of all NDT inspections shall be included in the Car History Book.

On the first structure, all full penetration welds shall be nondestructively, volumetrically inspected (ultrasonic or radiographic methods) according to AWS D1.1 requirements. The Contractor shall specify a random sampling plan for volumetric inspection of subsequent, full-penetration welds for approval. **[CDRL 15-012]** The minimum acceptable inspection plan shall require inspection of one (1) portion of a full penetration weld for every 200 production welds. The proposed test welds shall be selected from among welds that are most critically loaded as determined by calculation or load test. With approval, destructive sectioning and metallurgical examination may be substituted for some or all of the required volumetric inspection requirements for production welds.

15.5.5 Post-Weld Cleaning Requirements

All welds visible to passengers or on sliding contact surfaces of truck frames and bolsters shall be completely cleaned of spatter.

15.5.6 Contractor Documentation

All welding procedures and documents, including Welding Procedure Specifications, Procedure Qualification Records, and Resistance Spot Welding Schedules, shall be submitted for approval before application. **[Part of CDRL 15-009]** Specifications for purchase of welding electrodes, welding wires, and cover gases shall be submitted for approval before their application. **[CDRL 15-013]**

15.5.7 Dissimilar Metal Welding

Procedures and qualification records for structural welding of stainless steel to LAHT shall be submitted for approval. **[CDRL 15-014]** As part of the qualification of all dissimilar metal welds, sample welds shall be sectioned and examined metallographically to determine HAZ hardness. The HAZ hardness shall not exceed 400 HV (Vickers Hardness).

Austenitic stainless steel electrodes or wire shall be used to join carbon or LAHT steels to stainless steels.

Galvanized steel shall not be welded to stainless steel.

15.5.8 Resistance Welding

Resistance welding of stainless or carbon steels shall be according to AMS-W-6858B, Class B for structural applications and Class C for non-structural applications. All resistance welding procedures shall be qualified per AMS-W-6858B; procedures and qualification records shall be submitted for review and approval. **[CDRL 15-015]** Contractor-proposed deviations from AMS-W-6858B, including, but not limited to, weld nugget diameter, tension shear strength, and minimum spacing, shall be submitted and approved before application in production.

Design strengths higher than standard certification and production strength requirements shall be qualified according to AMS-W-6858B, Figure 11b, for one (1) thickness combination. This shall require a test lot size of 180 spot welds. Additional thickness combinations with the same increased strength ratio may be qualified by twenty-five (25) spot weld shear tests plus three (3) macro-sections. Twenty (20) of the twenty-five (25) shear test specimens may be recorded from production witness tests taken from twenty (20) consecutive production days (not calendar days). The Contractor shall submit records of the settings, ultimate shear strength, weld diameter, and weld penetration for approval.

Surface indentation shall not exceed 20 percent of material thickness (t) or 0.01 inch, whichever is greater. However, for exterior resistance-welded areas exposed to passenger view, indentation shall not exceed 10 percent of t or 0.005 inch, whichever is greater. 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.

Production witness welds shall be made and tested once each day and, in addition, whenever otherwise necessary such as by change in any of the following:

- Operator
- Material, material thickness, or combination of thicknesses
- Electrodes
- Settings
-

15.5.9 Resistance Spot weld and Intermittent Weld Spacing

Spacing of resistance and spot welds shall be according to approved structural drawings. Spacing of welds contributing to carbody stiffness shall not exceed 2 inches plus twice the weld nugget diameter for any structural application, including carbody side sheets, roof sheets, and corrugation. For any application to corrugations, if the pitch of the corrugation nodes does not allow the above weld spacing, there shall be two (2) spot welds between each node.

For intermittent fusion-welds contributing to carbody stiffness, spacing pitch shall not exceed 5 inches for 2 inch (minimum) weld lengths (forty {40} percent minimum of length welded).

For structural members not contributing to carbody stiffness, the intermittent welds joining structural members contributing to the stiffness of other members must conform to the spacing criteria above. All other intermittent welds shall be designed and qualified in accordance with the appropriate welding code requirements.

15.5.10 Toughness of Welded Assemblies

The Contractor shall prove that 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. In the absence of prior operating history, and if the Contractor's approved design does not require greater toughness, the minimum impact value for Charpy V-notch specimens shall be 15 foot-pounds of absorbed energy at -20ºF.

The Engineer shall have the right to require impact tests to verify the specified toughness. If tests are required, verification of HAZ toughness shall be done on a test sample welded according to PQR parameters. Base metal toughness shall be certified on a heat basis by the steel manufacturer or steel supplier; if these data are not available, the Contractor shall perform tests on each heat of as-received base metal.

15.5.11 Torch Brazing

All brazing, defined as heating above 840ºF without base metal melting, shall follow the recommendations of the AWS Welding Handbook, Volume 2, latest issue. Procedures and personnel who perform brazing work shall be qualified in accordance with AWS B2.2, "Standard for Brazing Procedure and Performance Qualification". Records of brazing procedure and performance qualification shall be submitted for approval. **[CDRL 15-016]**

15.5.12 Torch Soldering

All structural (not electrical) soldering, defined as heating below 840ºF, shall follow the recommendations of the AWS Welding Handbook, Volume 2, latest issue. Procedures and personnel who perform torch soldering shall be qualified through the preparation and testing of samples of production torch soldering. Test samples shall be prepared and submitted for approval before production torch soldering. **[CDRL 15-017]**

15.6 STAINLESS STEEL

15.6.1 General

Permitted uses of structural stainless steels are specified throughout this Specification. Ferritic stainless steels shall be painted where exposed to passengers or the weather. Austenitic stainless steels may be unpainted. Unpainted stainless steels exposed to passengers shall be a single grade of austenitic stainless steel in which both the color and surface finish of abutting pieces shall match, except where the design specifically calls for contrasting appearance.

15.6.2 Austenitic Stainless Steel

Structural austenitic stainless steel components assembled by fusion or resistance welding shall be of AISI type 201L (UNS S20103), 301L (UNS S30103), 301LN (S30153) or JIS SUS301L (with Nitrogen) and shall conform to the requirements of ASTM A666 except that the carbon content shall not exceed 0.03 percent and type 301LN and SUS301L (with Nitrogen) shall not exceed 0.25 percent nitrogen. Other stainless steels conforming to ASTM A666 are acceptable for non-welded applications.

Stainless steel used in structural applications covered by this Specification shall also conform to APTA SS-C&S-004-98 Standard for Austenitic Stainless Steel for Railroad Passenger Equipment.

General requirements for delivery of stainless steel shall be as required by the Certification Provisions of ASTM A666. Stainless steel to be used in structural applications shall be tested for susceptibility to intergranular corrosion in accordance with ASTM A262, latest revision. Practice A of ASTM A262 can be used to accept material only; Practice E is required for final determination of acceptance or rejection of material that is not acceptable by Practice A.

15.6.3 Ferritic Stainless Steel

When specified, ferritic stainless steel conforming to ASTM A176 may be used for sheeting up to 0.2 inch thickness. Ferritic stainless steel sheet shall have a ductile-to-brittle transition temperature (DBTT) or nil-ductility temperature (NDT) below 0°F. Weld heat-affected-zones shall also have a DBTT or NDT below 0°F. Ferritic stainless steel sheet shall have a balanced composition (low carbon and/or suitable titanium content) that shall, for all conditions of fabrication and assembly into the car body, inhibit formation of martensite and limit chromium depletion in weld-heat-affected zones so that material shall meet ASTM A763 requirements for resistance to intergranular corrosion.

General requirements for delivery of ferritic stainless steel shall be as required by ASTM A480.

Where ferritic stainless steels are welded to other structural steels, the less-noble steel shall be painted with weld-through primer.

15.6.4 Testing

The Contractor shall prepare (or have prepared), submit, and receive approval of a test and inspection plan for acceptance of all stainless steel to be used in welded applications prior to purchasing any such material. **[CDRL 15-018]** The tests and inspections shall verify that the stainless steel conforms to specified requirements. For austenitic stainless steels, the test and inspection plan shall include frequency of submittal of certifications in accordance with Certification Provision of ASTM A666 and frequency of submittal of checks for susceptibility to intergranular corrosion in accordance with ASTM A262. For ferritic stainless steels, the test and inspection plan shall include frequency of submittal of checks for susceptibility to intergranular corrosion in accordance with ASTM A763.

15.7 LOW-ALLOY, HIGH-TENSILE STEEL

15.7.1 General

Low-alloy high-tensile (LAHT) steel structural shapes, plates, and bars shall, as a minimum, conform to the requirements of ASTM A588, where available. Plate steel may alternatively conform to ASTM A710, Grade A, Class 1, 2 or 3. Where not available in A588, hot rolled or formed structural shapes conforming to ASTM A36 may be used for limited applications including equipment supports and jack pads. General requirements for delivery of LAHT shapes, plates, and bars shall be as required by ASTM A6.

Cold and hot rolled LAHT sheet and strip shall, as a minimum, conform to the requirements of ASTM A606, Type 4. General requirements for delivery of these products shall be as required by ASTM A568.

Other low-alloy, high-tensile steels which meet or exceed the above minimum requirements may be used, provided their detailed specifications are submitted and approved as equivalent, or better material, for the proposed applications. All LAHT steels shall be applied according to their specification properties.

Welded LAHT steel shall develop 15 foot-pounds Charpy V Notch impact strength in the CGHAZ (Coarse grain heat affected zone) 0.03937 inches from the fusion area at -20°F.

15.7.2 Testing

The Contractor shall prepare (or have prepared), submit, and receive approval of a test and inspection plan for acceptance of all structural steels in accordance with the requirements of this Section before purchasing any such material. **[CDRL 15-019]** The test and inspection plan shall include provisions for submission of reports and certification to SCRRA for each shipment in accordance with the applicable requirements of Purchase Specification and specified CGHAZ impact tests.

15.8 STEEL CASTINGS

15.8.1 General

The Contractor shall be responsible for selecting casting grade, composition, strength, and finishing. Steel castings used in the carbody structure and truck assemblies shall meet AAR Specification M-201 latest revision, Grade “B“, plus 2 percent nickel, minimum. These castings shall be heat treated to develop a minimum tensile strength of 75,000 psi, with minimum yield strength of 48,000 psi, elongation of not less than 25 percent in 2 inches, and reduction of area of not less than 50 percent. Steel castings used for coupler, drawbars, and anchors, shall meet AAR Specification M-201, latest revision, Grade C or E, quenched and tempered.

Where cast steel of superior properties is required for a specific application, the Contractor may propose such castings for SCRRA review and approval.

15.8.2 Design Qualification of Structural Castings

One casting, selected by SCRRA from the first lot of production castings, shall be subjected to a qualification test of the casting design by the Contractor. Qualification tests shall include radiographic examination for material soundness using reference radiographs to ASTM E446 and any mechanical testing.

Acceptance levels for the design qualification radiographic examinations shall be selected by the Contractor as appropriate for the service intended, subject to the approval by SCRRA before any castings are produced. **[CDRL 15-020]** Radiographs shall meet the requirements of ANSI/ASTM E94 and E142, and the quality level in the area of inspection shall be at least 2 percent (2-2T).

A qualification test report shall be prepared and submitted for the Engineer’s approval. **[CDRL 15-021]** The production of any castings before receipt of the Engineer's approval of this report shall be at the Contractor's risk. All radiographs that resulted from the qualification test shall be made available to SCRRA for review. In case the casting selected for qualification fails to qualify, a plan of action including details of how failed material shall be handled shall be included in the qualification test report. Once a design is qualified and accepted by SCRRA, no changes shall be made in the casting pattern, technique, heat treatment, or material composition without requalification in accordance with the requirements of this Section.

15.8.3 Quality of Structural Castings in Production

All structural castings supplied shall be equal to or better than the design qualification castings in all respects. The casting supplier or Contractor shall test, inspect and accept castings in accordance with procedures described in AAR Specification M-201. In addition, the inspections below shall be performed and a written report of the results of the tests and inspections shall be furnished for each lot of castings produced. **[CDRL 15-022]**

15.8.3.1 Magnetic Particle Inspection

Magnetic particle inspections of all surfaces of each casting visible to the naked eye or with inspection mirrors shall be conducted according to ASTM E709, by personnel certified to MIL-STD-410. With respect to structural castings, including coupler castings, the maximum permissible magnetic particle indications shall be 0.25 inch in the direction transverse to the usual direction of loading, and 0.75 inch in the direction parallel to the usual direction of loading.

15.8.3.2 Radiographic Inspection

Radiographic inspection shall be conducted according to the requirements of ASTM Standards E94 and E142 using reference radiographs to ASTM E446. A sampling frequency shall be proposed by the Contractor and submitted for SCRRA approval. **[CDRL 15-023]**

Structural castings shall not exceed severity level 3 of ASTM E446 in all critical areas of such castings and shall not exceed level 5 in all other areas of the castings. During demonstration that the stated severity level requirements of ASTM E446 have been met, successively-produced castings shall be reinspected by radiography in the defective areas shown in the prior radiographic inspection. After such severity levels have been proved, the sampling frequency for structural castings shall be one casting out of each ten produced. If no castings are rejected by radiographic inspection, this frequency may be extended to one casting in 25.

15.8.3.3 Repair Welding and Cast-Weld Designs

Repair welding of castings is permitted, provided the casting supplier performs all repair welds according to the structural welding requirements of TP15.5. Castings requiring repair or modification by welding after completion of heat treatment may be stress relieved locally by using electrically controlled heating not greater than 1150º F and slow cooling. Manual torch stress relief shall not be permitted, except for cosmetic welds and only then after the procedures have been submitted to the Engineer for review and approval.

For cast-weld designs, the entire length of all assembly welds on any welded assembly of several separate castings selected for design qualification shall be radio-graphically inspected to ANSI/ASTM E94 and E142, using reference radiographs from the International Institute of Welding’s ”Collection of Reference Radiographs of Welds,” quality level Green. Portions of assembly welds stressed in tension by service loads shall meet quality level Blue.

15.8.3.4 Disposal of Non-Conforming Castings

If castings are found to be non-conforming to requirements determined by the design qualification castings, the material shall be repaired, retested, and reinspected, or it shall be destroyed at the Contractor's expense.

15.9 ALUMINUM

15.9.1 General

Aluminum alloy mill products shall be identified by Unified Numbering System designations and shall conform to The Aluminum Association specifications contained in the Association's publication “Aluminum Standards and Data”. Aluminum alloy castings shall conform to ASTM B26, B85, or B108 for, respectively, sand, die, or permanent mold castings. Aluminum alloy forgings shall conform to ASTM B247. Copies of all test reports for sheet, extrusion, and forgings used in the car structure shall be submitted to SCRRA. **[CDRL 15-024]**

15.9.2 Design Stresses

All aluminum structural members shall be designed so that calculated stresses under the specified AW3 passenger load do not exceed the allowable stresses per APTA SS-C&S-015-99, Standard for Aluminum and Aluminum Alloys for Passenger Equipment Car Body Construction. Proper allowance shall be made for the effects of fatigue, for column and plate stability effects, and for strength reduction at welded regions.

Permissible fatigue stresses under the loads specified in Section 3.3.1.6 shall be established, with approval based on available relevant research data or on prototype testing under the variable load patterns expected to occur in service. **[CDRL 15-025]**

15.9.3 Fabrication and Fastening

The forming of aluminum parts; joining of parts by bolting, riveting, and welding; and the protection of contact surfaces shall, as a minimum, conform to the requirements of the Aluminum Company of America’s Technical Report No. 524, ‘Specification Covering Use of Aluminum in Passenger Carrying Railway Vehicles”, except as otherwise specified herein.

Fabrication techniques shall be such that the strength and corrosion resistance of the aluminum shall not be impaired nor the surface finish permanently marred or discolored during construction.

15.9.4 Protection of Contact Surfaces

The specific measures to be taken by the Contractor to prevent the risk of direct metal-to-metal contact and resultant possible electrolytic corrosion shall be approved and shall depend upon the determination of the most suitable method which can be adapted to the design involved. **[CDRL 15-026]** The following instructions shall be the minimum protection.

Aluminum alloy surfaces shall not be secured to or make direct contact with the surfaces of copper, copper bearing aluminum alloy, brass, bronze, silver, nickel, nickel alloys, nickel plated parts, lead, tin, or wood.

The contact surfaces of aluminum alloy with aluminum alloy shall be painted with zinc chromate primer or approved equal before securing.

The surfaces of aluminum alloy parts secured to steel parts, where exposed to weathering or harsh environments, shall be protected with a one-part polysulphide sealant, zinc chromate paste, mica insulation joint material, or an approved equivalent material which completely covers the faying surfaces. The insulating material shall be non-hygroscopic and, if fibrous, shall be impregnated with bitumen or an approved, non-corrosive, water and moisture-repellant substance. After driving, fasteners shall be primed and painted with red oxide or aluminum paint.

Stainless steel and carbon steel fasteners plated with zinc shall be coated with zinc chromate paste or approved equal before installation. Where possible, only the head and the shank of the bolt shall be in contact with the aluminum part when secured in place. Suitable bushings may be used in place of the zinc-chromate paste.

15.9.5 Interior Trim

Where unpainted aluminum is exposed to contact by passengers, it shall have a clear (natural) anodic finish. The finish process shall be the Aluminum Company of America's “Alumilite 204” with a minimum coating thickness of 0.0004 inch and a minimum coating weight of 21 milligrams per square inch, or approved equal process.

15.10 PIPING AND TUBING

15.10.1 General

All piping, valves, fittings, installation methods, and testing shall be in accordance with the Code for Pressure Piping, ANSI B31.1. All joints shall be easily accessible.

Following installation, all piping systems shall be cleaned to remove dirt, metal chips, oily contamination, and moisture. After cleaning, all piping systems shall be pressure tested in accordance with the latest edition of ANSI B31.1. All leaks shall be repaired and the system re-cleaned and retested until leak-free.

Pipes must be supported throughout their length and at all connections to prevent vibration or noise and to limit stresses in the pipe to less than 50 percent of the pipe’s fatigue endurance limit. Pipes and their connections shall not interfere with the removal of other components. Pipe routing and support shall be planned and accomplished in an efficient, organized manner to keep the total length and number of fittings and bends to an absolute minimum. All changes in direction shall be accomplished by bending the pipe to a radius of not less than specified by AAR Specification No. 2518, Standard S-400. Direction-change fittings are not permitted in the trainlined brake pipe or in the brake cylinder pipe. Support and clearances provided between adjacent pipes and between pipes and surrounding structure, equipment or other appurtenances shall be sufficient to prevent chafing or contact due to any combination of car loading and deflection, car dynamics, and thermally induced movement. The minimum clearance shall be 0.125 inch.

At all locations where pipe or tubing passes through holes in the floor, bulkheads, structure, or any fixed member, it shall be rigidly clamped to protect against possible damage or noise due to bearing, abrasion, or car dynamics-induced rattling. Clamps shall not be welded, brazed or otherwise permanently fastened to any pipe or tubing.

Pipe and tubing interfaces with clamps shall be insulated with an elastomeric or woven non-asbestos mineral fabric tape material to protect and sound-insulate the pipe or tubing.

Wherever car body piping interfaces with vibration-isolated rotating equipment, such as the air compressor and air conditioning compressor-condenser unit; approved flexible vibration eliminators shall be used. The pipe connection at either end of the flexible elements shall be rigidly clamped no farther than 2 inches from the flexible elements. All pipe clamps shall be inherently rigid and shall be firmly attached to car structure. Cantilevered clamps or clamp supports that are weaker than service-proven designs shall not be accepted. All clamps shall be of a suitable material for the application.

15.10.2 Air Piping, Tubing, and Fittings

The main reservoir pipe and brake pipe shall conform to ASTM A53 or ASTM A106, Schedule 80 seamless pipe. Where ASTM A53 or ASTM A106 piping is provided, its application shall also comply in all respects to AAR Specification No. 2518, Standard 400, latest revision.

Type "K" annealed copper tube per ASTM B88, latest revision, may also be used, provided it is installed no lower than 2 inches below the floor sheet or structural member and is protected by means of equipment or approved steel guards from any potential impact damage from rail debris, especially in the truck and outboard of the bolster areas. Approved copper tube shall also comply with any relevant requirements of AAR Specification No. 2518. Where suitable protection in damage-prone areas is not possible or practical, approved steel or stainless steel piping sections shall be provided. All joints for copper tubing shall utilize fittings of wrought copper or non-porous cast brass in accordance with ANSI B16.22 and B16.18.

All air hoses shall conform to the requirements of AAR Specification M-618 with AAR approved reusable fittings meeting AAR Specification M-927.

All air piping must comply in all respects with the air brake supplier's design and installation requirements. The diameter of the main reservoir pipe and brake pipes shall meet the brake supplier's requirements; however, in no case shall these pipes be less than 0.875 inch Outside Diameter. All air pipes shall be sized in accordance with the function intended and may be either ASTM A53 or ASTM A106 schedule 80 pipe or seamless copper tubing as described previously.

Within one hundred-eighty (180) days of Contract Award and prior to manufacture of production cars, the Contractor shall provide SCRRA with a report containing written approval from the air brake supplier of the Contractor's air brake piping fabrication, installation, and design concept. **[CDRL 15-027]** The following information shall be contained in the report:

- All critical line sizes and materials including the main reservoir pipe, the emergency brake pipe, and the brake cylinder piping.
- The installation details of the above critical lines including routing, total length and volume, elevation and slopes, and major joint and direction change locations. A list of all proposed bend radii shall also be provided.
- Pipe processing details including welding, brazing, cleaning, and fabrication methods are provided in Section 15.5.
- Locations of all major air brake control, relay, and emergency venting devices, and the proposed location and volume of all reservoirs.
- An air consumption analysis that justifies the proposed air storage system design.
- All air piping shall be installed in a manner to provide drainage away from devices, or branch pipes leading to devices, when the function of those devices could be impaired by the accumulation of water or ice.
- All cut-out cocks shall be of the vented type, except where function prohibits. All cut-out cock handles and their arrangements shall be as described in Section 12.10.

Air piping on the trucks shall be 0.50 inch ASTM A53 or A106, Schedule 80, or approved equal. Low spots (traps) are strictly prohibited on the trucks. Truck piping shall not be run on the bottom of truck side frames, transom, or bolster, unless approved by SCRRA.

Where steel piping is used, all connections and joints where disassembly for service may be required shall utilize swivel type butt-welded flange fittings with an “O” ring type seal. The use of threaded fittings is expressly prohibited. Approval may be granted for the use of threaded fittings in extreme cases where adequate proof is provided that flanged fittings cannot be used.

15.10.3 Air Conditioning System Piping, Tubing, and Fittings

Air conditioning refrigerant lines shall be of seamless copper tubing, ASTM B88 type “K” or type “L” or ASTM B280, with wrought copper sweat type fittings. Refrigerant lines below the upper surface of the floor or subject to damage during operation shall be ASTM B88, type “K” only. Condensate drain lines shall be seamless copper tubing, type “K” or seamless stainless steel tubing.

Joints shall be kept to a minimum and all inaccessible runs of tubing shall be without joints. Finned tubing in evaporators and condensers shall be copper. Instead of elbows, tubing may be bent utilizing a bending tool designed specifically for bending of the tubing to be used.

Suction lines shall be designed and installed without traps. The suction line shall be sized for 3 psi (gauge) maximum system pressure drop and the liquid line shall be sized adequately to prevent flashing due to pressure drop.

Lines subject to condensation shall be insulated with an approved insulation, applied with an approved contact cement. The liquid line shall be insulated in all areas where required to provide additional mechanical or thermal protection. Insulation at all joints and fittings shall be mitered and sealed with an approved material. The insulation, adhesive, and sealant shall meet the Specification requirements for thermal, smoke emission, and flammability performance.

All piping and pipe subassemblies shall be deburred, cleaned, dried, and capped with tight fitting plastic caps, or approved equal on all openings after fabrication. Caps shall remain in place until immediately prior to incorporation into the final assembly.

Vibration eliminators shall be used in piping connections to the compressor unless deemed unnecessary by SCRRA. Tubing installations shall be designed so that ease of maintenance can be achieved, as approved by SCRRA.

15.10.4 Brazing and Soldering of Piping, Tubing, and Fittings

All brazing and soldering shall comply with the applicable parts of Section 15.5, and the following requirements. All refrigerant piping and air system copper tubing shall be joined using silver solder conforming to Federal Specification QQ-B-654A, BAg-5, BCuP-5, or for copper to copper connections only BCuP-3. Refrigeration piping and tubing shall be internally swept with a continuous flow of a non-oxidizing gas such as dry nitrogen during brazing.

Condensate drain tubing shall be joined using 95-5 solder or Silver Solder as above.

Solder joints shall be wiped and have flux cleaned from tubing and fittings after soldering. After fabrication, the refrigeration and air systems shall each be cleared of all dirt and foreign matter, flushed with a degreasing agent and dried, all according to a written procedure prepared for each by the Contractor and approved by SCRRA. **[CDRL 15-028]**

15.11 PRESSURE VESSELS

All pressure vessels shall conform to the latest revision of Section VIII of the ASME Boiler and Pressure Vessel Code for Unfired Pressure Vessels. Test reports shall be furnished for each pressure vessel, and each pressure vessel shall be stamped to document the test. **[CDRL 15-029]**

15.12 ELASTOMERS, SEALS, AND GASKETS

15.12.1 General

Elastomers shall be compounded and cured to perform as intended in the SCRRA environment specified in Section 2. Elastomers shall have high resistance to ultraviolet and other solar radiation, weather and to all SCRRA car-washing and cleaning fluids. All elastomeric parts shall be resistant to ozone, oxidation, heat, oil, grease and acid, and shall have the longest possible life, consistent with the other characteristics specified.

The following elastomeric parts shall be of neoprene unless otherwise specified or approved:

- Glazing Rubber,
- Door Seals,
- Door Nosing,
- Other parts exposed to the outdoor ambient environment, except where otherwise specified.

The following elastomeric parts shall be of natural rubber, (Synthetic rubber compounds are not permitted) unless otherwise specified or approved:

- All resilient mounts,
- Elastomeric truck components.

Elastomers used within pneumatic or hydraulic equipment shall be as necessary to meet the performance requirements of this specification for the pneumatic or hydraulic device.

15.12.2 Life Expectancy

For all parts made by vulcanizing an elastomer to metal, any premature failure (less than six 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.

15.12.3 Metal Parts

Metal parts to which elastomeric material is vulcanized shall be made of SAE 1020 or 1045 hot-rolled steel.

15.12.4 Truck Parts

Truck bumpers, snubbers, and the exterior surfaces of air springs shall be made of natural rubber or approved equal. They shall be compounded to be resistant to abrasion, oil, grease, and acid.

15.12.5 Seals

Glazing strips shall be of neoprene conforming to ASTM C542, or approved equal material.

All door mating edges, door and window seals, and glazing strips shall be of neoprene material. The durometer hardness measured with a Shore Type "A" durometer at a temperature between 70°F to 90°F shall be 70 ±5 except for the side door mating edges where it shall be 80 ± 5.

15.12.6 Bonding

The joining of elastomeric pieces shall be conducted by the hot vulcanization process. Bonding of elastomers by other processes 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.

15.12.7 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 procedures outlined for elastomers in Section 15.23; the results of the testing shall be submitted to the SCRRA. **[CDRL 15-030]**

The test specimens shall be cut out from the extruded material, and at least one tensile strength and elongation test and one accelerated aging test shall be made on the material used for each order. If the compound or cure, or both, are changed during the production of material for one order, at least one test of each type shall be made for each different batch.

When testing the 6 inch by 0.50 inch ASTM "dumb bell" type test specimen (or smaller size if the size of the part necessitates) by the methods specified in ASTM D3182, D3183, D3190, and D412, the tensile strength shall not be less than 1,500 psi and elongation shall be a minimum 350 percent. The tensile strength of the elastomer shall not be reduced more than 25 percent when subjected to accelerated aging by the methods specified in ASTM D573, for a period of 96 hours in an air oven at 158°F.

The ozone resistance of the elastomer shall be tested in accordance with ASTM D1149 using an ozone concentration of 100 pphm, an exposure time of 100 hours at 100°F, and a specimen elongation of 20 percent. The elastomer shall not exhibit any cracks during the test period.

15.13 GLAZING MATERIALS

15.13.1 Safety Glass

Safety glass shall meet the requirements under Item 1, Table 1 of ANSI Z26.1, "American National Standard for Safety Glazing Materials for Glazing Motor Vehicles and Motor Vehicle Equipment Operating on Land Highways - Safety Code" and FRA 49 CFR 223 and 238 Type I or II test as appropriate for the application.

15.13.1.1 Glass Type

All safety glass shall be of the laminated type.

15.13.1.2 Size and Configuration

15.13.1.2 (a) Flatness

When an individual light 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.

15.13.1.2 (b) Dimension Tolerance

The overall dimensions of individual lights as supplied shall be held within 0.60 inch of the dimensions ordered.

15.13.1.2 (c) Overlap Tolerance

The overlap of one laminate of the light with respect to the other at an edge shall not exceed 0.03125 inch. Corners and burrs shall be ground smooth and all edges shall be treated in accordance with ANSI Z26.1, Section 6.

15.13.1.3 Optical Characteristics

15.13.1.3 (a) Color

The color of the glass shall be as required by Section 4.8.1. When new, there shall be no more than ±4 percent variation in the color of individual lights of laminated sheet glass when examined over a white background. Visible light transmission through safety glass shall be a minimum of 85 percent.

15.13.1.3 (b) Haze

All the laminates of the safety glass shall be so nearly free from haze that the glass shall have approximately the same clarity as a light of the same nominal thickness of plate glass when viewed against a north light.

15.13.1.4 Workmanship

15.13.1.4 (a) Specks and Scratches

Occasional specks of foreign material and scratches are permissible, provided such specks do not exceed 0.020 inch in greatest dimension and scratches do not exceed a total of 3 inches in length and neither are within the central three-quarters area of the light. SCRRA reserves the right to determine which lights are to be rejected.

15.13.1.4 (b) 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 shall be no separation between the glass sheets. Lights that contain unbonded areas (“let-go’s”) shall not be used.

15.13.2 Quality Assurance

The Contractor shall be responsible for the performance of all inspection and test requirements. Except as otherwise specified, the Contractor may utilize the facilities of its supplier or any approved commercial laboratory.

15.13.3 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 stripped from the material and not leave a gummy or sticky residue.

15.13.4 Identification

Each light shall be marked for identification in accordance with the requirements of ANSI Z26.1, Section 7 and 49 CFR 223 by the supplier in legible letters 0.1 inch high in the lower right hand corner as viewed from the inside of the vehicle. This identification shall be no closer than 0.75 inch to the edge. The identification shall give the product name, the manufacturer, month and year of manufacture, and FRA Type I or II designation. Marking 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. The light shall be installed so that the marking can be read from the inside.

15.13.5 Documentation

The Contractor shall certify that the shipped material complies with the requirements in this Specification. **[CDRL 15-031]**

15.14 AIR FILTERS

15.14.1 HVAC and Equipment Ventilation Filters

Filters shall be selected in accordance with manufacturer's recommendations for the specific equipment involved. All filters shall have an integral frame. Filters shall be the throw-away type, except reusable filters 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. Filters shall meet the requirements of UL 900, Class 2.

15.14.2 High Pressure Air Filters

Air filter assemblies with replaceable filter elements shall be provided in the air line that connects each subsystem to the air supply system. The air filter filtering capability, flow rate capability, and overall size shall be appropriate for the application so that the filter replacement interval is greater than one (1) year. It shall be possible to gain access to the filter element for replacement without requiring any pipe fittings to be disconnected or loosened. Filters shall be provided for each of the following systems and any others operated from the air supply system:

- Each air brake control assembly,
- Input and output of each height control valve,
- Coupler controls,
- Door controls, and
- Horn.

15.14.3 Low Pressure Air Filters

Replaceable media type filters shall use resin-bound, spun-glass fiber materials having an uncompressed thickness not less than 3.50 inches. 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 0.50 inch oversize to ensure adequate sealing between the edge of pad and its integral frame.

15.15 SEAT CUSHIONS AND UPHOLSTERY

15.15.1 Seat Cushions

15.15.1.1 General

Seat cushion fill material shall be low-smoke flexible foam constructed of inherently fire-retardant materials. The thickness shall be approved during design review. The material shall have a polymerized or vulcanized homogeneous (free from foreign material), cellular structure with a porous surface and open cells. The cells shall be interconnecting and uniform in size. Cellular material may be molded in one piece or may be assembled by laminating to achieve the required thickness. Laminated cushions shall be bonded together. Cushion material shall be properly cured to prevent any objectionable odor.

15.15.1.2 Physical Properties

Flexible foam shall meet the following physical property criteria when tested without upholstery material to the latest version of the following ASTM methods:

Test No.	**Description**	**Criteria**
D-3574 Test E	Tensile Strength	5.0 lbf/psi min.
D-3574 Test E	Elongation	70 percent min.
D-3574 Test E	Compression Set at 50 percent	15 percent max.
D-1055	Flex Fatigue	Thickness less 5 percent max.
D-3574	Tear Strength	2.0 lbs/psi min.

15.15.2 Upholstery

15.15.2.1 Cloth Fabrics

15.15.2.1 (a) General

Cloth fabrics used for seat upholstery shall be made of woven, transportation grade fabrics of wool, wool/nylon blend (90/10), or an approved flame resistant polyester. The maximum fabric shrinkage shall be 2 percent in either the warp or fill direction.

15.15.2.1 (b) Physical Properties

Seat upholstery material shall be subjected to the physical tests of textile products required by the latest revision of the following ASTM methods, and the results shall not be less than the following values:

Test No.	Description	Criteria - Wool and Wool/Nylon Blends	Criteria - Bold
D-3776	Fabric Weight	15.5 oz/sq yd without back coating	12 oz/sq yd without back coating
D-3775	Fabric Count	Warp – (ends) 88 epi Fill - (picks) 40 to 72 ppi	Warp – (ends) 88 epi Fill - (picks) 40 to 72 ppi
D-5034	Breaking Strength and Elongation	Warp – 200 lbs. Fill – 200 lbs.	Warp – 270 lbs. Fill – 200 lbs.
D-2261	Tear Strength (Tongue)	Warp – 20 lbs. Fill – 20 lbs.	Warp – 20 lbs. Fill – 20 lbs.
D-4034	Yarn Slippage	Warp – 30 lbs. Fill – 40 lbs.	Warp – 75 lbs. Fill – 65 lbs.
D-3597	Color Fastness	Water – Class 4 min. Solvent – Class 4 min. Crocking – Class 4 min. Light – Class 4 min.	Water – Class 4 min. Solvent – Class 4 min. Crocking – Class 4 min. Light – Class 4 min.

15.15.2.2 Fabric-Backed Vinyl

15.15.2.2 (a) General

Vinyl used for seat upholstery shall be made of woven transportation grade fabric-backed vinyl with a weight of 24 ounces per square yard.

15.15.2.2 (b) Physical Properties

Fabric-backed vinyl used for seat upholstery shall be subjected to the physical tests of textile products required by the FED-STD-191, latest revision, and the results shall not be less than the following values:

Test No.	Description	Criteria
5106	Tensile Strength	Warp – 110 lbs. Fill – 100 lbs.
5110	Seam Strength	85 lbs.
5134	Tear Strength (Tongue)	Warp – 10 lbs. Fill – 12 lbs.
5136	Tear Strength (Trapezoid)	Warp – 36 lbs. Fill – 42 lbs.
5660	Colorfastness – 200 hrs.	No change
5970	Adhesion of Coating	10 lbs.

15.15.3 Smoke, Flame, and Toxicity

All cushion and upholstery material shall meet the requirements of Section 15.23.

15.16 RUBBER FLOOR COVERING

15.16.1 General

Rubber floor covering shall contain 38 percent (nominal, by weight of compound) Butadiene Styrene rubber, shall be non-staining, non-discoloring, and 100 percent non-oil extended. Only high quality, fine, hard clay shall be used as filler. No whitening (limestone) shall be used in the compound. The rubber tile shall be free from reground rubber, natural rubber or coarse fillers.

At 68° F, the rubber flooring shall bend 180 degrees around a 0.75 inch 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.

15.16.2 Inspection Criteria

SCRRA shall not allow defects in the flooring. Defect items discovered during inspection shall require the Contractor to replace the flooring material. Common defects are described below:

- Thin-Skinned Blister - A thin-skinned blister is a blister which, when finger-pushed, shall collapse upon itself.

- Thick-Skinned Blister - A thick-skinned blister is a blister which, when finger-pushed, shall collapse and then returns to its original condition.
- Lump - A lump is a blister without a void, consisting of solid material.
- Hole - A hole is a defect which is 50 percent through the material.
- Thin Area - A thin area is a defect where the sheet is of reduced thickness locally.
- Color and Speckle Distribution - Color and speckle distribution is an appearance judgment and shall be subject to the approval of the SCRRA. If the base coloring is not within 5 percent between production runs, or the speckling is not consistent over the entire surface, the roll shall be rejected.

15.17 FIBERGLASS-REINFORCED PLASTIC

15.17.1 General

Fiberglass-reinforced plastic (FRP) shall be a laminated material, composed of a gel coated surface, fiberglass reinforcement, and an approved resin. FRP shall withstand, without any physical deformation or structural damage, the environmental conditions in Section 2.7.3, and be resistant to acids, alkalies, and cleaning solutions recommended by the Contractor.

FRP shall be manufactured by an open molding or matched die molding process. Production techniques shall ensure that the glass fiber reinforcement is uniformly distributed throughout the final product in such a manner as to avoid resin-rich or resin-starved sections. An analysis shall be performed to confirm that the construction method chosen is adequate for its intended purpose and meets the strength requirements within Section 15.17.3. Finished gelcoated surfaces exposed to passenger view shall have a minimum gloss value of 85 when measured with a 60 degree gloss-meter. All finished gelcoated surfaces shall exhibit no print through of the reinforcements or have any appreciable orange peel. Where fiberglass reinforced plastic is used in the car interior and exposed, it shall have Tedlar© applied using in mold process unless specifically approved by the Engineer.

FRP parts shall have a greater thickness at attachment points and edges, unless otherwise approved by the Engineer. If fasteners are used to attach and/or assemble FRP parts, the parts shall be reinforced in a manner approved by the Engineer to preclude the development of cracks. Exposed sharp edges shall not be allowed on any parts.

15.17.2 Construction

15.17.2.1 Resin

The resin shall be of good commercial grade, thermosetting, polyester, phenolic, vinyl-ester or acrylic material selected to meet the physical, flammability and smoke emissions properties of this Specification, Section 15.23, and molding process requirements.

15.17.2.2 Reinforcement

The fiberglass reinforcement shall be mat, fabric woven roving, continuous roving, or swirl mat as required to meet the physical properties of this Specification and the molding process requirements. The glass content shall be a minimum of 20 percent by weight.

15.17.2.3 Gel Coat

The gel coat shall be resistant to scuffing, fire, weather, water absorption and cleaning agents. The gel coat shall have a minimum thickness of 0.016 inches and a maximum thickness of 0.032 inches. If the surface of the FRP panel is to be painted, a primer gel coat shall be used and the part shall be painted in accordance with Section 15.3. If the FRP panel does not receive paint, then the gel coat shall be pigmented to match the color scheme selected by SCRRA.

15.17.2.4 Additives

Additives, fillers, monomers, catalysts, activators, pigments, fire retardants, and smoke inhibitors shall be added to the resin mixes to obtain finished products with the required physical characteristics of Section 15.17.3, and the flammability requirements of Section 15.23. Antimony Trioxide shall not be used.

Mineral filler shall not exceed 28 percent of the finished weight for any preformed matched die molding process.

15.17.3 Strength Requirements

Independent laboratory tests shall be performed on test coupons that are trimmed from production parts.

Independent laboratory test certificates shall be provided stating that the production reinforced plastic material complies with the requirements of the following standards. **[CDRL 15-032]** Test specimens shall be conditioned in accordance with ASTM D618.

Minimum Requirements			
Mechanical Property	**ASTM Test**	**Open Moldings**	**Matched Die Moldings**
Tensile Strength	D 638	10,000 psi	18,000 psi
Compressive Strength	D 695	18,000 psi	24,000 psi
Flexural Strength	D 790	15,000 psi	30,000 psi

Minimum Requirements			
Mechanical Property	**ASTM Test**	**Open Moldings**	**Matched Die Moldings**
Impact Strength	D 256	6 ft-lb per inch of notch	8 ft-lb per inch of notch
Hardness	-	45 Barcol	45 Barcol

15.18 WOOD AND PANELS

15.18.1 Lumber

Lumber shall be sugar or black maple, sweet or yellow birch, only. Lumber shall be thoroughly air seasoned or kiln dried before using, so as not to have a moisture content of greater than 12 percent. Lumber shall be dressed on all surfaces to full dimensions. 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.

15.18.2 Plymetal

The term "plymetal" as used in this Specification means metal-faced plywood. All plymetal panels shall conform to the following requirements:

Mechanical Properties	Minimum Metal to Wood Average Shear Value or 80 Percent Wood Failure
Dry shear	250 lbf/in^2
Boil shear, 3 hr. boil, tested wet at room temperature	150 lbf/in^2
Soak shear, 48 hr. soak wet at room temperature	150 lbf/in^2
Creep or cold flow, under static load for 48 hrs., at room temperature	250 lbf/in^2

The metal face of the plymetal panel that is faced with melamine shall be constructed in accordance with Section 15.18.5 prior to the melamine-faced metal panel being laminated to the plywood core.

15.18.3 Plywood

All plywood shall be manufactured to conform with the requirements of Grade - Structural I of the National Bureau of Standards Voluntary Product Standard (American Plywood Association) PS 1-95, and then stored under cover. Scarf or finger jointed panels are not allowed. All plywood shall be sealed with two coats of an epoxy paint on all edges and cutouts as soon as possible after fabrication. All exposed edges of the panels, joints between panels, fastener heads, and openings of panels used in areas accessible to moisture shall be water-proofed and sealed with an approved coating prior to installation in the car.

15.18.4 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 faced, stainless steel honeycomb panels shall be constructed in accordance with the requirements of MIL-A-9067. The adhesive bond strength of the honeycomb core to the stainless steel face shall not be less than fifteen (15)-lb/inch climbing drum strength when tested in accordance with MIL-STD-401. The adhesive bond strength of the integral stainless frame to stainless steel face shall not be less than thirty (30)-lb/inch climbing drum strength when tested in accordance with MIL-STD-401. Stainless steel honeycomb panels shall be tested in accordance with MIL-STD-401B to demonstrate the following requirements:

Mechanical Property	**Minimum Requirements**
Core shear yield at 200º F	250 lbf/in^2
Flatwise tension at 200º F	250 lbf/in^2
Beam flexure at 200º F	75,000 lbf/in^2
Core shear fatigue at R.T.	150 lbf/in^2 @ 10^6 cycles
Flatwise tension at R.T.	250 lbf/in^2 @ 10^6 cycles
Beam flexure at R.T.	50,000 lbf/in^2 @ 10^6 cycles

No other honeycomb materials are permitted.

15.18.5 Melamine-Faced Aluminum

Melamine-faced aluminum panels shall be constructed by laminating melamine to aluminum sheets. The melamine-impregnated papers shall be directly molded to the aluminum sheets at temperatures of no less than 270°F and pressure no less than 1000 psi. The surface characteristics, after manufacture, shall be no less than that required of type GP (General Purpose) in the NEMA Standards Publication No. LD-3, latest revision. The melamine and the required binder sheets shall be 0.015±0.005 inches thick. The aluminum sheets shall not be less than 0.025 inch in thickness when used as a facing on plywood. The aluminum sheets shall not be less than 0.081 inch in thickness when not laminated to a substrate such as plywood. Aluminum sheets shall be properly cleaned by etching, sanding, or other approved process to ensure full, permanent, adhesion.

The use of contact adhesives to bond the melamine sheets to the aluminum backing is not acceptable.

The bond between the melamine and aluminum sheets shall, as a minimum, meet the following requirements:

Mechanical Property	**Minimum Requirements**
Internal bond (ASTM D952):	2,600 lbf/in^2
Flexural strength - (S) (ASTM D790) ▪ with grain: ▪ crossgrain:	 26,500 lbf/in^2 25,300 lbf/in^2
Modulus of elasticity - (E) (ASTM D790) ▪ with grain: ▪ crossgrain:	 2.8 x 10^6 lbf/in^2 3.1 x 10^6 lbf/in^2
Tensile strength (ASTM D638) with grain: crossgrain:	 22,300 lbf/in^2 20,300 lbf/in^2

15.18.6 Phenolic Composite Floor Panels

Phenolic composite floor panels consisting of a balsa core and phenolic outer skin are preferred for the car flooring.

Phenolic composite floor panels shall be designed to withstand the following physical requirements with no visible or audible indications of de-lamination of the panel skin from the core. Permanent deformation of the top surface shall be less than 0.010 inch unless otherwise specified. There shall be no puncture or damage to fibers of the top surface. There shall be no separation of any internal core from the top or bottom skin. There shall be no fracture of the balsa core. All test results are required to be submitted to the Engineer for approval. **[CDRL 15-033]**

- Indentation Resistance – The floor panel shall withstand a concentrated load of 300 pounds applied to a test dowel that has an overall 0.375 square inch surface area, with a 0.0625 inch radius on bottom edge of test dowel.
- Static Load Test - Average Loading – A representative sample section of the flooring (without rubber floor covering attached) shall be supported on beams spaced at the maximum spacing used on the car using production bonding and fastening techniques. A uniformly distributed load in accordance with the crush loading requirements of Section 2 shall be applied to both sides of the joint (butt and/or shiplap). There shall be less than 0.088 inch deflection.
- Static Load Test – Maximum Loading – Using the identical floor panel-mounting configuration as described above, a uniformly distributed load of 200 lb./ft^2 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 pound load shall be applied to a 1.0 inch x 3.0 inch contact area directly over the midspan, 6 inches from the outer carbody sidewall edge. The footprint shall be machined flat within 0.010 inch and the edges shall have a radius of not more than 0.125 inch. There shall be less than 0.200 inch deflection as a result of the load applied.
- Small Object Impact Test - Using the identical floor panel mounting configuration as described above, a 16 pound standard bowling ball shall be raised directly over the mid-span, 24 inches from the edge of the panel and dropped from height of 60 inches. Permanent deformation of the top surface shall be less than 0.063 inch.
- Large Object Impact Test - Using the identical floor panel mounting configuration as described above, a 150 pound load shall be dropped upon a 3.0 inch x 8.0 inch contact "footprint" pad located directly over the midspan, 24 inches from the edge of the panel and dropped from a height of 12 inches. The "footprint" pad shall have a rubber pad on the downside surface with a Shore D 70 minimum, at a 1 inch thickness machined flat within 0.060 inch with edges having a radius of not more than 0.030 inch. Permanent deformation of the top surface shall be less than 0.030 inch. Some damage to the top phenolic composite skin is allowed.

- Rolling Load Test - Using the identical floor panel mounting configuration as described above, a 4 wheeled cart with a load of 200 pounds per wheel shall be rolled on the panels laterally, longitudinally and in a circular path with a 2.0 foot radius. The wheels shall be 3 inches in diameter, 1 inch wide.

15.18.7 Panel Contour Tolerance

Surfaces exposed to passengers shall not deviate from the specified contour by more than inch in any 36 inch distance. The slope of any such deviation shall not exceed inch in 12 inches.

15.19 THERMOPLASTIC SHEET

15.19.1 General

Thermoplastic sheet used in the construction of this vehicle shall not contain PVC vinyl and shall withstand, without any physical deformation or structural damage, the environmental conditions described in Section 2, and shall be resistant to SCRRA cleaning solutions. Thermoplastic sheet shall be used as extruded or vacuum-formed.

Thermoplastic sheet shall be homogeneous and extruded from virgin stock which does not include any regrind of vacuum formed parts. The exposed surface of this material shall conform to the color, texture, and gloss specified in Sections 4.1 and 4.5. Only UV stabilized pigments shall be used to create the specified color of the thermoplastic sheet. The color and surface finish of parts manufactured from this material shall be approved prior to the production run of any parts. **[CDRL 15-034]**

15.19.2 Quality

The finished parts shall be free of waves and quilting on both sides. Degraded polymer in the sheet shall not be allowed, and if present, shall be cause for rejection of the piece. Voids, lumps, and contamination shall also be cause for rejection of parts if the defects are larger than 0.010 inch and the population of these defects is greater than one defect in 4 square feet.

15.19.3 Strength Requirements

Independent laboratory test certificates shall be provided stating that the thermoplastic sheet complies with the requirements of the following standards. **[CDRL 15-035]** Extruded sheet in the surface finish specified shall be used for testing.

Mechanical Properties	ASTM Method	Value
Specific Gravity	D 792	1.20 to 1.45
Tensile Strength	D 638	5,500 lbf/in2 minimum
Elongation	D 638	50 percent minimum
Flexural Strength	D 790	8,000 lbf/in2 minimum
Flexural Modulus	D 790	3.3 x 105 lbf/in2
Hardness Rockwell "R" Scale	D 785	90 to 110
Heat Shrinkage 15 minutes at 350°F	------	10 percent maximum
Heat Deflection (annealed) @ 264 lbf/in2	D 648	165°F minimum
Impact Strength Fabricated Parts Gardener Dart Drop 0.5 inch dia. ball	D 3029	
At 73°F		320 in-lb minimum
At 20°F		80 in-lb minimum

15.20 WIRE AND CABLE

15.20.1 General Requirements

The Contractor's design and construction shall ensure that the minimum number of wire types and sizes shall be used in the vehicle.

Selection of wire sizes and insulations shall be based on the current carrying capacity, voltage drop, mechanical strength, temperature and flexibility requirements in accordance with applicable APTA, AAR, ICEA, ASTM, NEC, and MIL Specifications. However, in no case shall the properties of the wire and cable be less than those properties delineated in this Specification. Extra-fine wire stranding shall be utilized on applications subject to repetitive motion.

All applications of shielded cable shall be subject to the approval of SCRRA

The Contractor and each manufacturer of equipment through the Contractor shall submit to the Engineer for approval samples at least 12 inches long, specifications, and 3 copies of certified qualification test documentation of each size and type of wire and cable specified before utilizing said wire and cable. **[CDRL 15-036]**

15.20.2 Conductors

Conductors for wire AWG No. 12 and smaller shall be soft, annealed nickel plated copper constructed in accordance with MIL-W-22759/6B. Conductors of all sizes insulated with irradiated, cross-linked polyolefin wire shall be soft, annealed tinned copper, in accordance with ASTM B33. Minimum stranding shall conform to AAR Standard S501, S502 (No. 589), or ASTM B-172 Class K, or ICEA S-66-524/NEMA WC7, Table L-7, Class K for AWG No. 10 or larger, as appropriate for the application.

Stranding and conductor construction for wire sizes AWG No. 12 to AWG No. 16 shall be in accordance with AAR Recommended Practice RP-585, ASTM B-174, Class K, or ICEA S-66-524/NEMA WC7, Table L-8, Class M, as appropriate for the application.

Stranding and conductor construction for wire sizes AWG No. 18 and smaller shall be in accordance with ASTM B-174 Class L or ICEA S-19-81/NEMA WC3, Table L-8, Class M, or shall be nineteen (19) strand construction as appropriate for the wire size.

The use of solid wire shall not be permitted except for approved wire wrap applications.

Wiring shall be sized for the intended load, voltage drop, installation method, and applicable codes. Calculations of wire sizes shall be in accordance with APTA-RP-E-009-98, "Recommended Practice for Wire used on Passenger Equipment." When the free air rating is used, the Contractor shall furnish data to show that the cables shall not exceed their rated temperature at the rated current. Wire ampacities shall be derated to meet the temperature requirements of all devices to which the wire connects. When short time ratings, short time overload temperatures, and thermal time constants are used to determine cable size, the parameters used shall be submitted for approval.

In no case shall wire smaller than the following sizes be used:

- Wire which is pulled through conduits or wire ways - AWG No. 14.
- Wire on electronic units, cards, and card racks - AWG No. 28.
- Wire within control compartments - AWG No. 18.
- Multi-conductor cables where current is not a factor in wire size selection - AWG No. 18.
- All other wire, including that which is not pulled through wire ways and conduits - AWG No. 16.

The Engineer may approve smaller wire sizes for selected applications upon submission of appropriate applicable data for justification.

15.20.3 Insulation

15.20.3.1 General Wiring Insulation

Teflon, mineral filled, abrasion resistant insulation may be used on wire sizes AWG No. 12 to AWG No. 28. Otherwise, for all general car body wiring, the insulation shall be a flame retardant, flexible, irradiated cross-linked polyolefin material having a continuous temperature rating of 230º F. The insulation shall be rated at 2,000 VAC and VDC, in the case of wires carrying a nominal voltage greater than 150 VAC or VDC, and rated at 600 VAC and VDC, in the case of wires carrying a nominal voltage of 150 VAC or VDC or less. For wire sizes AWG No. 6 and larger, the insulation material shall be formulated for extra flexibility.

Insulation shall meet the following flammability requirements:

- Cross-linked polyolefin shall be tested in accordance with test method ICEA S-66-524/NEMA WC7, Paragraph 6.12.5. After five (5) applications of fifteen (15) seconds each, with a three second rest period between applications, flame shall extinguish in ten (10) seconds or less.

- Other insulation materials shall be tested in accordance with IEEE-383.

15.20.3.2 Cross-Linked Polyolefin Wire Insulation

The irradiated cross-linked polyolefin wire insulation shall be constructed and tested in accordance with the following requirements:

15.20.3.2 (a) Flexibility Tests for Cables

Flexibility tests for cable sizes up to AWG No. 2/0 shall be performed in accordance with AAR Recommended Practice RP-585, paragraph 5.9.7.1, for the appropriate wire size.

Flexibility tests for cable sizes AWG No. 2/0 and larger shall be performed in accordance with AAR Recommended Practice RP-585, paragraph 5.9.7.

15.20.3.2 (b) Single Conductor Thermal Overload Test

A continuous current of 115 Amperes shall be applied to an 18 foot length of AWG No. 10 test wire in 77°F still air. A 3000C VDC potential shall be maintained between the test wire and an AWG No. 18 bare copper wire wrapped snugly around the outer insulation surface of the test wire. Failure shall occur when a short circuit is established between the bare copper wire and the test wire. Minimum time to failure shall be 3 minutes.

15.20.3.2 (c) Bundle Overload

A bundle overload test using a 7 wire bundle shall be performed in accordance with AAR Standard RP585, paragraph 5.9.1.

15.20.3.2 (d) Temperature Cycling Tests

This test shall be performed on an 8 foot length of AWG No. 10 wire with 2 kV insulation.

Thermocouples shall be attached to the outer jacket surface, and on the conductor, under a small incision in the insulation approximately 12 inches from one end of the sample. Both ends of the sample shall be securely clamped using hose clamps.

Prior to temperature cycling, the sample shall be conditioned for 2 hours at a temperature of 302ºF.

The sample shall then be temperature cycled between ambients of 257 ˚and -22°F by transferring the sample between an air-circulating oven, set at 257°F and an air-circulating cold box set at -22°F. The time during which the sample stays in each chamber shall be sufficient to allow both thermocouples on the sample to read the same temperature as the environment.

One cycle shall be defined as an approved dwell time at both 257°F and -22°F. The sample shall be subjected to a total of 250 cycles, with a visual observation at the end of each cycle for cracks and other damage. After 250 cycles, the sample shall be immersed in water for 6 hours with both ends out of the water, and then subjected to a dielectric test of 5 kVAC for 5 minutes and also examined by microscope to verify that no cracks exist.

Flame-retardant, flexible, irradiated, cross-linked polyolefin insulation rated at 257°F may be used, provided that it meets the requirements of all the above tests and standards, modified to reflect the temperature rating related characteristics. The revised values, and the use of such wire, must be approved by the Engineer. Cross-linked polyolefin insulation shall not be permitted for use on wires connected to heater elements or any other high-temperature device.

15.20.3.3 Other Wire Insulation

All insulation other than irradiated, cross-linked polyolefin shall meet the following test requirements, based on MIL-W-22759, and using the following parameters:

15.20.3.3 (a) Dielectric

Test per MIL-W-22759/10B (for 1,000 V wire with tests at 9.5 kV impulses) or MIL-W-22759/6B (for 600 V wires with tests at 8 kV impulses).

15.20.3.3 (b) Insulation Resistance

Test per ASTM D-470. Minimum accepted value shall be 1,000 megohms per 1,000 feet, using a 1,000 VDC megohmmeter.

15.20.3.3 (c) Spark test

One hundred percent of all single conductor cables and all single conductor cables being used in a multi-conductor cable shall be inspected by Impulse Dielectric Test or by chain electrode Spark

Test. Spark Test Apparatus and Procedure shall be in accordance with MIL-W-22759. Spark Test voltages shall be equivalent to impulse test voltages by corresponding RMS value at 3 kHz.

Impulse Test Voltage kV Peak	3 kHz Test Voltage kV RMS
8	5.7
9.5	6.7
10	7.1

15.20.3.3 (d) Air aging

Test per ASTM D-638. Age sample for seven (7) days at 302°F in an air oven. Minimum tensile strength and elongation shall not be less than 85percent of the unaged values. Also test per IEEE STD 383-1974 and ASTM D-573 for extended life.

15.20.3.3 (e) Cold Bend

Test per NEMA WC3, except test temperature shall be -58ºF.

15.20.3.3 (f) Weight Loss

Weight loss of the insulation material shall not exceed one percent when subjected to an oven temperature of 266°F for 500 hours.

15.20.3.3 (g) Chemical Resistance

An appropriate length sample shall be measured for insulation diameter and total weight to record initial values. The wire shall be immersed to within 3 inches of each end in the test fluid for 24 hours at 149° F. During the immersion stage, the minimum bend radius of the wire shall be ten (10) times the diameter of the wire being tested. Upon removal from the test fluid, the specimen shall be cooled to room temperature for 1 hour and the diameter gauged and reweighed for comparison with the original values. The maximum diameter and weight increase shall not exceed 30 percent. Typical fluids for this test include:

- Humble No. 2214 Railroad Diesel Lubricating Oil and lubricants (100 percent solution);
- Humble Diesel 260 or Railroad T fuel oil (100 percent solution);
- Mineral oil (100 percent solution);
- Hydrochloric acid, nitric acid, sodium hydroxide, sulfuric acid (0.1 percent solution);
- Potassium hydroxide (0.1 percent solution);
- Petroleum distillates and other graffiti removers and cleaning compounds;
- Kerosene solvents (100 percent solution);

- Trisodium phosphate solution (50 percent solution);
- Skydrol 500 B hydraulic fluid (100 percent solution); and
- Water.

15.20.3.3 (h) Temperature Cycling Testing

The test shall be performed on an 8 foot length sample of AWG No. 12 wire.

Thermocouples shall be attached to the outer jacket surface and on the conductor under a small incision in the insulation about 12 inches from one end of the sample. Both ends of the sample shall be securely clamped using hose clamps.

The sample shall be conditioned for 2 hours at a temperature of 302˚F. The sample shall then be temperature cycled between ambients of 257°F and -22°F by transferring the sample between an air-circulating oven, set at 257°F and an air-circulating cold box set at -22˚F. The time during which the sample stays in each chamber shall be sufficient to allow both thermocouples on the sample to read the same temperature as the environment.

One cycle shall be defined as an approved dwell time at both 257°F and -22°F. The sample shall be subjected to a total of 250 cycles, with visual observation at the end of each cycle for cracks and other damage. After 250 cycles, the sample shall be immersed in water for 6 hours with both ends out of the water, and then subjected to a dielectric test of five (5) kVAC for 5 minutes and also examined by microscope to verify that no cracks exist.

15.20.3.3 (i) Single Conductor Thermal Overload Test

A continuous current of 115 amperes shall be applied to an 18 inch length of AWG No. 12 test wire in 77°F still air. A 1,000-VDC potential shall be maintained between the test wire and an AWG No. 18 bare copper wire wrapped snugly around the outer insulating surface of the test wire. Failure shall occur when a short circuit is established between the copper wire and the test wire. Minimum time to failure shall be 3 minutes.

15.20.3.3 (j) Seven-Wire Bundle Thermal Overload Test

A 7 wire cable bundle shall be formed by twisting 6 insulated AWG No. 12 conductors around a center insulated AWG No. 12 conductor.

A 120 Ampere current shall be passed through the center conductor for 7 minutes. After the test period, the cable bundle shall be examined for visible damage to the outer 6 conductors. Failure shall occur if any of the outer conductors split, rupture, or melt and adhere to the center conductor insulation.

15.20.3.3 (k) Qualification and Production Tests

The tests required for this Specification concerning Qualification and Production shall be in accordance with tests in MIL-W-22759 for all lots produced.

All test reports covering Production and Qualification tests shall be submitted to the Engineer for approval with samples prior to any shipment of materials. **[CDRL 15-037]**

15.20.3.4 Wire Insulation for High Temperature Applications

High temperature insulation shall be used where connected to heat-generating apparatus, where the ambient temperature can exceed 257ºF, or where Teflon is specified as a requirement. The insulation shall be rated at 1,000 VAC and VDC in the case of wires carrying a nominal voltage greater than 150 VAC or VDC, and rated at 600 VAC and VDC in the case of wires carrying a nominal voltage equal to or less than 150 VAC or VDC. The insulation shall have a continuous temperature rating of 257°C or above and be in accordance with the following requirements:

- For wire sizes AWG No. 16 and larger, abrasion resistant Teflon (Polytetrafluorethylene - PTFE) meeting MIL-W-22759/6B or 10B, as appropriate for the voltage level used, or silicone rubber meeting AAR Standard RP-587C.
- For wire sizes AWG No. 18 and smaller, abrasion resistant Teflon (PTFE) meeting MIL-W-22759/6B or 10B, as appropriate. When used for interconnecting pieces of apparatus, this type wire shall be in bundles with a protective covering of high temperature rated, low smoke generating insulation.

The Contractor may propose other insulated wire specifications for approval in a specific high temperature application, specifying the design ambient temperature, routing, RMS ampere value, worst-case ampere value, worst-case temperature rise, stranding, and insulation material specification.

No high temperature insulated wire shall be used in conduit or raceways without specific approval. The Contractor shall submit all applications of high temperature wire insulation for approval.

15.20.3.5 Wire Insulation Within Equipment

Insulation on wiring within replaceable modular units, electronic apparatus such as cards and card racks, and other equipment, as approved, shall be Tefzel (Ethylenetetrafluoroethylene - ETFE) per ASTM D3159 and insulation construction per Military Specification MIL-W-22759/16 (AS), irradiated cross-linked polyolefin per Section 15.20.3.1, or Teflon (Polytetrafluorethylene - PTFE) type EE per Military Specification MIL-W-16878/5.

15.20.3.6 Wire Insulation at Crowded Locations

Wire for connections to the control console, or in any other locations where there are equally crowded concentrations of low voltage control wiring, may be insulated with Tefzel (ETFE) per ASTM D3159 and insulation construction per Military Specification MIL-W-22759/16 (AS), except the wall thickness shall be 0.025 inches. When used for this application, these type wires shall be bundled with a protective covering of irradiated cross-linked modified polyolefin or similar, approved, high temperature rated, low smoke generating insulation.

15.20.4 Multi-Conductor Cables

15.20.4.1 General

Multi-conductor cables, where approved, shall be constructed using wiring as described in Sections 15.20.2 and 15.20.3. For high temperature applications, the cable shall conform to MIL-C-27072, with Type V connectors, Style 4 sheaths, Class D jackets, if needed, and shields, if needed. All conductors in multi-conductor cables shall be color coded or otherwise permanently identified as approved. Materials used in the construction of multi-conductor cables shall meet the requirements below. In applications where current is not a factor in wire size selection, such as LED indicator lights or status displays, AWG No. 16 may be used between repeater devices and displays. For multiconductor cables carrying low-voltage, high-speed, serial data, exceptions to the wiring requirements may be submitted for approval, based upon availability of wire to meet the application requirements.

15.20.4.2 Fillers

Where required to obtain a circular cross-section, fillers shall be made of non-hygroscopic materials compatible with the wire insulation and jacket, and shall be of the same or of a higher temperature rating than the wire insulation.

15.20.4.3 Tape

A binder tape shall be employed over the assembly of conductors in multi-conductor cables if needed to assist in cable manufacture, or as required to permit the cable to function as intended in its application. The binder tape material shall be non-hygroscopic and shall be of the same (or better) temperature class as the wire insulation, and shall be of a compatible material.

15.20.4.4 Shield

The shield, if required, shall consist of either tin plated copper braid (concentrically served) or aluminum/polyester tape with a drain wire, as is appropriate for the application. Tape shields shall be permitted for fixed installations only. The shields shall have the following minimum properties:

Copper shield shall be made of either tinned, coated copper strands which conform to ASTM B33, or silver-coated copper strands which conform to ASTM B298, as is appropriate for the wire insulation. Shield coverage shall not be less than 85 percent. Shield strand size and application shall be as recommended by the cable manufacturer for the particular application, but shall not be smaller than AWG No. 38.

Aluminum/polyester tape shields shall consist of a helical wrap of aluminum/polyester tape with a nominal thickness of 0.0004 inch aluminum on a backing of 0.001 inch polyester. The tape shall have a minimum overlap of 10 percent of the tape width to ensure complete coverage. In contact with the aluminum side of the shielding tape shall be a AWG No. 22 7/30 tinned copper drain wire conforming to ASTM B33 and B174.

15.20.4.5 Jackets

The overall jacket of multiconductor cables shall be of flame retardant, irradiated, cross-linked, modified polyolefin; Tefzel (ETFE); or Teflon (PTFE) to be fully compatible with the wire insulation and application as approved. The coupler cable shall have a jacket of low temperature arctic grade neoprene per MIL-C-13777, with a wall thickness suitable for 600 VAC. The jacket shall be extruded and vulcanized over the cabled conductors, and shall be centered, with a smooth appearance without objectionable roughness or irregularities, consistent with good industry practice. The nominal jacket thickness for polyolefin, Teflon, Tefzel and Neoprene shall be that shown below, with the minimum wall not less than 80 percent nominal value.

Cable Diameter Under Jacket	**Modified Polyolefin**	**Teflon or Tefzel**	**Neoprene**
0.000-0.250	0.045	0.010	0.072
0.251-0.500	0.045	0.015	0.087
0.501-0.750	0.060	0.021	0.1
0.751-1.000	0.080	0.021	0.1
1.000-1.500	0.080	0.025	0.115
1.501-2.000	0.11	-	0.135
2.001-2.500	0.13	-	0.152
2.501-3.000	0.14	-	0.195

15.20.5 Wire Wrap

Wire wrap connections may be used in selected electronic applications, where approved. Where used, the following standards, as a minimum, shall be followed:

- Only soft or annealed oxygen-free solid copper conductor shall be used.
- Wire size shall be AWG No. 28.
- A silver conductor coating, with a minimum coating thickness of 40 micro-inches, shall be applied to the wire.

- Wire shall have "MIL-ENE" insulation, or approved equal manufactured to MIL-W-81822/1A. The insulation shall have a minimum 300 VAC/VDC voltage rating and shall allow a 275°F maximum conductor temperature.

Wrapping shall be “modified” wrap, nominal 7-1/2 turns, including 1-1/2 turns for strain-relief.

15.20.6 Insulation Smoke Test

15.20.6.1 Scope

This test method describes the equipment and the procedure for preparing insulated wire samples from which the specific optical density (D_s) of smoke generated can be determined in the Aminco-NBS Smoke Chamber. This method is used for wire sizes up to and including AWG No. 12. For wire sizes above AWG No. 12, the standard procedure outlined in ASTM E662 shall be used. Equipment calibration, standardization, and operation are to be in accordance with ASTM E662, Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials. The performance criteria shall be Ds (4.0) </= 200 (flaming) and Ds </= 75 (non-flaming).

15.20.6.2 Apparatus

- Aminco - NBS Smoke Chamber and Recorder.
- Aminco 6 tube, 90 degree burner assembly for flaming mode testing. Burners are all directed in one plane at the sample.
- Notchless wire frame (Aminco AWG No. 20 wire frame with notches machined off).
- Aminco troughless wire specimen holder assembly.
- Air oven.
- Humidification chamber.
- Heavy duty aluminum foil 0.001 ±0.0005 inch.
- Razor blade.
- Tape measure.

15.20.6.3 Procedure

Determine the length of insulated wire required for testing. The individual sample length shall be calculated to produce a sample area of 35 square inches.

Calculate the sample length as follows:

$$l = \frac{35}{3.1.416 \times d}$$

where: l = sample length

d = diameter of insulated wire

Cut and identify a minimum of three samples of the required length.

Condition samples prior to testing by pre-drying in an air oven for 24 hours at 140°F ±5°F followed by humidification at 73°F ±5°F, and a relative humidity of 50 percent ±5 percent, for a minimum of 24 hours.

After conditioning, wind a sample uniformly around the wire frame so that the frame opening is uniformly covered.

Cover the wire-wrapped frame with aluminum foil across the back, along the edges, and over the front surface's periphery with a single sheet of aluminum foil, with the dull side in contact with the wire.

Place the foil-wrapped wire in a trough less sample holder such that the wire is vertically oriented. Insert millboard backing, spring, and retaining clip.

Carefully trim the aluminum foil from the front opening of the sample holder.

Adjust wire turns, if necessary, to assure that the sample holder opening is uniformly covered.

Perform smoke testing in accordance with ASTM E662, noting any unusual behavior that occurs during the test; for example, self ignition of the sample in the non-flaming test mode or any extinguishment of a burner triplet during the test.

Report the sample orientation, test conditions, results, and observations made during the test.

15.21 WIRING, TERMINALS, AND CONNECTIONS

15.21.1 General

All car wiring shall be in conformance with APTA RP-E-002-98, “Recommended Practice for Wiring of Passenger Equipment,” 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. Circuit protection shall be in conformance with Chapter 2 of NFPA 70, Article 240.

All equipment enclosures and junction boxes, except primary power circuits, shall be fitted with terminal boards or connectors. Primary power circuits shall be fitted with compression terminals and knuckle joint connectors as described herein.

All wire passages into equipment enclosures junction boxes, equipment boxes shall be protected and support to prevent any damage from chaffing and rubbing on surfaces.

The Contractor shall submit the proposed design and product line for all connections for approval. Terminal boards with M4 or Number 6 or smaller screws and quick-disconnect terminals, other than those stated herein, shall only be permitted with approval. **[CDRL 15-038]**

15.21.2 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 43.13-1A, Section 449, "Stripping Insulation". Additionally, the following criteria apply:

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

* Definitions:

- A cutoff strand shall count as two nicked strands.
- A nick is defined as 25 percent or more of the strand area damaged, or cut more than 33 percent of its diameter.

Longitudinal scratches in a copper strand are not considered cause for rejection.

15.21.3 Wiring Layout and Installation

15.21.3.1 Wire Harness

The layout of wiring, for both car 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 or tied with spiral wrap or tie wraps. Harnesses shall be installed with identical arrangement and location in each car 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 separated by means of terminal boards to isolate portions from others for troubleshooting and searching for undesired grounds. All circuits subject to periodic high potential tests shall be so arranged that they can be conveniently set up for the tests.

Alternative methods for fabricating and installing wiring, which are standard Contractor practice, shall be considered for approval by SCRRA.

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 percent spares, but no less than one spare for each wire size whichever is greater.

15.21.3.2 Circuit Separation

Circuits shall be physically separated to reduce the possibility of unsafe conditions, interference, or equipment damage.

The following major circuit groups shall not be harnessed or bundled together, shall not run in the same conduit, and shall be physically separated and secured in enclosures, wire ducts, junction boxes, or other wire routing devices:

- High voltage circuits,
- AC circuits,
- Communication circuits,
- Battery voltage level circuits,
- Semiconductor gating voltage level circuits, and
- Conductors carrying in excess of 100 Amperes.

Wires which are connected in circuits with potentials differing by 50 Volts or more shall be separated by a physical barrier. The wires shall not be cabled together and shall not be placed in the same conduit, junction box, or enclosure. Where a raceway, duct, junction box or enclosure is divided into two or more distinct areas by metallic partitions, each area may be considered separately in the application of this rule.

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 approved otherwise. All wiring connected to a piece of apparatus shall be insulated for the highest voltage connected. Wiring connected to transient-generating apparatus, such as unsuppressed contactor coils, shall not be run adjacent to wiring carrying signals to, from, or between semiconductor circuits, logic circuits, vital no-motion circuits, or communication circuits. In cases in which adequate physical separation is impossible, shielded wire shall be used for all conductors involved.

15.21.3.3 Wire and Cable Runs

Wire runs shall be continuous and unbroken between connection points, shall be supported at no greater than 2 foot spacing, and be protected at each support point against mechanical crushing and abrasion. A watertight bushing and drip loop shall be provided on all exposed cable entries. All cable bundles and wires shall be routed a minimum of 1 inch above the bottom of equipment enclosures.

All undercar wiring smaller than AWG No. 6 shall be run in closed wire ducts, conduits, or open wire mesh wireways in an approved manner. Wire and cable shall be secured within ducts or open wireways, including each entrance and exit point, to prevent chafing movement. Wire ducts and 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, cables or harnesses enter or exit conduit, ducts, apparatus and equipment enclosures. In addition, strain relief bushings on equipment enclosures shall include a permanently retained O-ring type seal.

Lead wires to resiliently-mounted electrical apparatus shall be carried in conduit to a point as close to the apparatus as possible. The length of the leads between the end of the conduit and each piece of apparatus shall be as approved. Short runs of cables or harnesses entering or leaving conduit and apparatus shall have an approved guard mounted to the car body to protect the wires from mechanical damage. Lead wires to solidly-mounted, electrical apparatus and equipment enclosures shall run in conduit connected to the apparatus or enclosure.

All wiring routed from enclosed areas of the carbody to areas exposed to the elements (including underframe and roof areas) or between interior levels shall be run in ducts or conduit. Wiring, even if enclosed in loom, must not be run through partitions without suitable bushings being provided at such points of passage.

Cables shall be laid in place with sufficient slack at the bends so that cables shall clear the inside bend surface of the wireway/wire duct.

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.

Wires or cables shall not pass through or over the battery compartment and shall not pass over heat generating equipment such as acceleration and braking resistors, even if the wires or cables are in conduit.

Exposed harnesses, short cable runs or harness entering or leaving exposed raceways shall have approved, fire-resistant flexible dielectric sleeving over the raceway edges and grommet-type insulation of any penetration holes. Wiring shall be retained to the sleeving with tie-wraps.

15.21.3.3 (a) Cable Cleating and Support

All cable and wiring exiting wireways/wire ducts, or that which is not installed in conduit, shall be cleated using split-block cleats of molded neoprene rubber, fabricated plastic or fiberglass with neoprene cushion inserts. In no case shall nylon wire ties be used as the means of supporting the weight of wire bundles and cables. Cables shall be cleated and bushed when passing through bulkheads and structural members. The cushioning material shall be non-conductive, fire retardant insulating material with a durometer of 50 to 60 meeting the requirements of Section 15.12. Each cleat shall have a 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. The Contractor shall minimize the quantity of different configuration cable cleats.

AWG No. 6 or larger insulated wire may be cleated in place without conduit, duct or open wireway. However, in the areas over the truck, in the wheel wash and not protected by underfloor-mounted equipment, the wire shall be mechanically protected by an open mesh, expanded metal or other type of approved guard. The guard may be attached to the bottom of each cleat with the cleat clamping bolts or other approved arrangement.

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. Each cable in the cleat shall have its own cutout sized to the correct wire diameter. Cleated cables shall be routed and supported such that they cannot, under any combination of forces and car movement, touch each other or any other part of the car, except the cleat cushioning material.

Wire and cable runs shall be continuous and unbroken between terminations and shall be supported at not greater than 24 inch intervals in ducts, open wireways or when cleated. The wire shall be protected at each support point against mechanical crushing and abrasion.

Wire splices shall not be permitted, except with express written approval and in accordance with the wire splicing requirements of Section 15.21.16.

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 access panels. 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.

15.21.3.3 (b) 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.

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 in Section 15.21.3.3. Exterior junction boxes shall be weather tight.

In cases where it is necessary to anchor wires or cables to metallic parts of the car, cleats or approved stainless steel bottle clamps shall be used. Wires and cables shall not be allowed to chafe or rub against any part of the car or each other under any circumstances.

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 reterminations without applying tension to the wire and without splicing the wire, as follows:

- AWG No. 10 and smaller - Three reterminations
- AWG No. 8 and larger - Two reterminations

A drip loop shall be provided on all exposed wires and cables to prevent fluid runoff into connected equipment.

Spare wires, which are part of a wire harness, shall be bundled separately inside of the equipment box to which the harness is being terminated. Spare wires shall have enough length to reach any location within the box, including sufficient slack for the required number of reterminations. The spare wire “break-out” bundle may be ty-wrapped to the main harness, but shall be easily removed from the main harness without disassembling it. The ends of the spare wires shall be insulated against inadvertent contact with any nearby conductive surfaces or terminals.

Wire tying devices shall be of such material and construction that they shall 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 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.

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, unless otherwise approved by SCRRA. 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, and shall be provided with clamp supports and abrasion protection. T-splices shall 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 of the car.

Any wiring needed to calibrate and test car functions shall be a part of the permanent car wiring to enable the SCRRA to conveniently maintain the equipment. This wiring shall terminate in approved connectors in the respective control groups and cabinets.

The SCRRA desires to have wiring and cabling readily accessible for inspection and maintenance. Extensive wiring and cabling in the vehicle interior is contrary to accessibility, even though access panels, false floors, and other portals may be provided. To control this, the Contractor shall submit a complete wiring plan for approval. **[CDRL 15-039]**

Wire and cables that are subject to high currents in fault conditions or normal operation must be secured against secondary damage due to the high magnetic forces that are developed. Propulsion inverter circuits are a typical example. This includes damage to bus bars or devices to which the cables terminate.

15.21.3.4 Circuit Shielding

Wire shields used in trainline circuits shall be continuous up to the car's electrical coupler contacts, including contacts of the jumper cable connector at the intermediate couplers. The wire shields shall be connected through all applicable connectors and junction boxes. Circuits shall be categorized. Shields contained in one circuit category shall not be interconnected with shields contained in another category. Shields used to protect against interference shall not carry signal current.

Shields on low-level signal wires shall not be interconnected with shields on high-level signal wires in the same category. Each group of shields (other than at the electric couplers, including the jumper cable connectors at the intermediate coupler) shall be carried through on a connector pin or pins, or on terminal strips which shall be in the immediate proximity of the categorized group of circuits. Loops due to interconnections of shields shall not be permitted.

Coaxial cables used as constant impedance transmission lines shall be terminated as dictated by the circuit termination design and shall not be considered to be shielded conductors. Triaxial cables may be used as coaxial impedance transmission lines with the outer conductor employed as an RF shield.

The following three items shall be considered as guidelines and are not absolute requirements:

Shields used to suppress electromagnetic interference (EMI) at all frequencies shall be terminated only at the low potential side of the interference circuit, at the termination which exhibits maximum susceptibility.

Shields used to protect against the effect of, or to exclude, EMI at frequencies below 150 kHz, shall be terminated either to the low potential side or at the balance point of the protected circuit at the termination which exhibits maximum susceptibility.

Cables requiring both audio frequency (AF) and radio frequency (RF) shields shall be electrically isolated from each other. The resistance between these circuits shall be at least 500 megohms when 500 VDC is applied. Double shielding shall be required on circuits that are both AF-susceptible and RF-susceptible.

15.21.4 Insulation Resistance

Refer to 15.20.3 for insulation resistance requirements.

15.21.5 Marking and Designation

The Contractor shall devise, and submit for approval, a wire and terminal marking and designation system that shall coordinate all electrical circuits in the car into a unified system. **[CDRL 15-040]** The system shall identify all wiring, including circuit return wiring, and terminals according to their respective circuit function(s) and shall accurately correlate these designations with the car schematic diagrams. Each circuit shall be individually designated from point to point. Common designations for return circuits are not permitted.

Each wire and cable shall have printed on the outer surface, the manufacturer's identification, conductor size, temperature rating, and voltage rating. For wire size 1/0 and larger, stranding shall be given in addition to the other parameters.

Except for spares, TFE Teflon insulated wires and wires entirely within an equipment enclosure, each wire #8 AWG and smaller shall be permanently and legibly marked along its entire length. Wires larger than #8 AWG and TFE Teflon insulated wires may have wire markers applied at each end of the wire. Blank spaces between markings shall measure approximately 1.5 inches. Spare wires and wiring entirely within an equipment enclosure may have a single wire marker at each end, subject to approval by SCRRA in lieu of continuous marking. Wires shall be marked with their alpha-numeric circuit designation. A circuit designation shall change only when it goes through an active or passive component such as a relay coil or relay contact, fuse or circuit breakers, lamp, motor or resistor. A circuit designation shall remain unchanged when it goes through a terminal strip or junction box stud regardless of how many wires of that circuit are common to that point. There shall be no duplication of wire codes in unrelated circuits throughout the car. Where there are more than one of a particular assembly per car, each assembly shall be wired identically to the other(s) and wire marking of harnesses shall be identical in each assembly.

For premanufactured multiconductor cables and for cases where individual circuit identification markers may be approved the following requirements apply:

All wires and terminals shall be clearly identified. Wires attached to terminal studs shall also have a marker indicating the terminal stud to which it is attached.

Identification of wires and terminals shall be by white or yellow permanent markers, with black printing or by continuous wire marking printed on the wire. All wires shall be marked 6 inches from of the end of the wire (both ends) and every 24 inches over the remainder of the wire. Wire markers shall be stamped in two places, approximately 180 degrees apart, to facilitate readability of the marking. Wires in multiple-conductor cables shall be color-coded.

Wire markers shall meet the adherence and solvent resistance requirements as specified by MIL-M-81531 Sections 3.4.2 and 3.4.3, latest revision, and shall withstand all combinations of ambient and equipment temperatures. Hand printing is prohibited.

For cable identification, the contractor shall use a basic identification system in conformance with ANSI/IEEE 200 and shall submit the system selected for review by the SCRRA. **[CDRL 15-041]**

15.21.6 Pulling Compound

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

15.21.7 Solder

Solder shall be in accordance with ASTM B32, Grade Sn60. A flux of non-corrosive type shall be applied immediately before soldering.

15.21.8 Tape

Electrical tape shall be in accordance with AAR Standard S-540 of Section F of the AAR Manual Standards and Recommended Practices, or equivalent approved railway practice. Electrical tape shall meet or exceed the voltage rating of wire where the tape is applied.

15.21.9 Terminal Boards & Terminal Points

Electrical terminal points and terminal boards 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 percent spares, but not less than one spare unless approved. Binding head, screw type terminal boards shall be permitted only where approved. Terminal boards of this type shall be in accordance with Military Specification MIL-T-55164A.

Threaded studs shall have a minimum of 2-1/2 threads exposed beyond the final nuts. Adequate space shall be provided to permit connecting wire terminals with standard tools. All terminals shall be properly torqued to assure sound connections. Spacers shall not be used.

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.

Molded case, modular terminal blocks which utilize a spring clamp to hold the wire may be used for low voltage circuits. Each terminal block shall be properly identified with a permanent marking and each assembly shall be secured to the mounting (DIN) rail by end clamps which incorporate metallic hardware. All wires AWG 12 and smaller shall receive a ferrule. Plug-in style (split) terminal blocks will only be permitted if, as part of the design, these plugs will be used as a connector when performing maintenance, testing or replacement of a Line Replaceable Unit. All molded case, modular terminal blocks are subject to review and approval by the Engineer.

Jumpers between terminal board points shall be brass or plated steel. Wire jumpers between adjacent terminals of terminal boards shall not be permitted.

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 and/or the wires connected to terminal boards shall have the terminal point location printed on the wire.

15.21.10 Wire Terminations

Terminals and connections used throughout the car 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. All terminals for the same wire size shall be crimped with the same model tool. The Contractor shall minimize the total number of crimping tool types needed for all crimp connections. Terminals fitting wire sizes AWG No. 10-22 shall require no more than three tool models to provide certified crimp connections. The Contractor shall submit the proposed product line for approval. **[CDRL 15-042]** Terminals to be approved shall be tested to Military Specification MIL-T-16366F for temperature rise, voltage drop, vibration, current overload, and corrosion. Test results shall be submitted for approval on a by part number basis.

Terminals and connections shall be attached to the wiring with proper crimping tools and dies as recommended by the manufacturer. The terminals used on conductors of size AWG No. 10 or smaller shall be of the type which securely grips and holds the insulation of the conductor, unless approved. Terminals shall be ring lugs in accordance with Military Standard MS-25036. For components that do not accept ring tongue terminals, appropriate alternate terminations such as ferrules, locking forks or quick disconnects may be used subject to approval by the Engineer. Corrosion 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.

Wherever several wires are connected to terminals of a terminal strip on a device which is removable from the car for maintenance, the wires shall be terminated, with double ring terminations which shall be screwed to an insulating fanning strip which shall serve to keep the terminations in the correct relative locations while removed from the device, unless otherwise approved by the SCRRA.

15.21.11 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.

15.21.12 Cable Connectors

All cable connector applications shall be approved.

All cable connectors shall conform to MIL-C-5015, or an equivalent standard as approved. 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 inch of gold over a minimum of 0.000050 inch of low stress nickel. For high current applications, the connector contact area shall be plated with a minimum of 0.00010 inch of silver. Adjacent connectors shall either use different inserts or different insert orientations to prevent erroneous connections. The receptacle half of all cable connectors shall be rigidly mounted.

All cable connectors used in exterior locations shall be of the environmental watertight variety. Cable connectors shall be equipped with sealing gaskets on the front mating surface and on the back where the cable enters. 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 in exterior locations. Quarter turn, bayonet-lock, quick-disconnect type connectors shall not be used on trainline jumper cables.

Except as specified above all cable connectors in exterior locations, shall be quarter turn, bayonet-lock, quick disconnect type CIR connectors as made by Litton-Veam SPA, or approved equal. Quarter turn, bayonet-lock connectors shall conform to all provisions in MIL-C-5015, or an approved standard, except for the screw coupling requirement.

Connectors in high vibration or high motion areas, such as speed sensors and trainline jumpers, shall have the wire connections soldered and potted and shall have a watertight jacket molded over the cable and connector to form a unitized assembly. Trainline jumper connectors used shall be as made by Pyle-National, or approved equal (see Sections 5.7). The Contractor shall conduct an approved vibration test on these unitized assemblies.

Non-metallic body, non-environmentally sealed connectors are limited for use on non-vital, interior applications, such as lighting and speaker connections. These connectors must be threaded or include a positive locking mechanism. All such connectors must include a suitable means of strain relief for the wires. If a spring-clamp is used to terminate the wire within the connector body, a properly sized ferrule must be applied to the wire. The receptacle half of each connector assembly shall be rigidly mounted. Proposed connectors shall have a minimum of 2 years of successful service in similar applications and are subject to approval by the Engineer.

15.21.13 Quick-Disconnect Terminals

Approved quick-disconnect terminals shall be utilized to facilitate maintenance and inspection. 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” (FASTON) type terminals shall be permitted unless specifically approved by the SCRRA. **[CDRL 15-043]**

15.21.14 Grounding Return Connections

15.21.14.1 Grounding

Grounding connections to the car body and equipment shall be made through copper pads of an adequate area, silver soldered or brazed. Alternative ground pad material may be permitted in certain cases as approved by SCRRA. Transition (base) plates if used, shall be made from the same alloy group as the respective car body and piece of equipment. The base plate shall be welded to the car body or equipment. Grounding connections shall not be made to aluminum alloy members. All ground pads shall be visible and accessible for inspection and troubleshooting. The ground connections shall be attached by a bolt, washer, and nut designed for the purpose. An anti-corrosive grease shall be applied over the connection.

All equipment enclosures and shock-mounted equipment, except the operator cab lights, shall be grounded with flexible, grounding leads bolted between a car body grounding pad and the equipment's grounding pad. Braided, strap-type leads shall be used where there is relative motion between the two items being connected. The ground strap termination method shall apply uniform pressure to the conductive surface and the current density shall not exceed the bonding requirements of Section 15.21.14.2.

The Contractor shall design a complete grounding scheme, which shall indicate the means by which it is proposed to prevent currents from passing through journal and truck-center bearings. Refer to other sections of this Specification for ground brush and related requirements. Low voltage and high voltage circuits shall not be grounded to the same ground.

15.21.14.2 Bonding

All grounding and bonding jumpers and straps shall be sized to handle fault current and lightning discharge current, for which the voltage drop shall not exceed 25 Volts. The bonding method employed shall not produce a DC resistance in excess of 0.0025 Ohms, or more than 0.025 Ohms at 150 kHz for any applied AC voltage. Grounding and bonding jumpers, and brazed shunt straps shall be "extra-flexible".

15.21.15 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 shall not be permitted. In the event a splice is approved, it shall be in a junction box and the spliced joint shall be mechanically as strong and have the same conductivity as any other part of the conductor. The splice shall be an insulated permanent crimp splice in accordance with Military Specification MIL-T-7928G, Type II, Class I, and shall be installed with the crimping tool and die of the splice manufacturer. All splices shall be insulated with a self-sealing, weather-tight, 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 percent. Splices shall be identified in the integrated schematic.

15.22 WIREWAYS, CONDUIT, JUNCTION BOXES, AND FITTINGS

15.22.1 General

The conduit, conduit fittings, and junction boxes for car wiring shall be as manufactured by the Contractor or by a supplier of a comprehensive line of parts. The Contractor shall submit the proposed product line for approval. **[CDRL 15-044]** All conduit fittings and junction boxes shall be provided with gasketed covers as described in Section 15.22.4. All conduits and their connections to electrical equipment shall be installed to make a continuous ground.

15.22.2 Conduit Types

All conduit and conduit couplings shall be of an ANSI-approved type. All conduit shall be standard weight, galvanized steel with threaded fittings. All conduit ends shall be deburred inside and out to remove sharp edges and all pieces shall be blown out with compressed air and cleaned before installation to remove filings and other foreign material.

Steel conduit shall be mild steel in standard lengths with threaded ends and hot-dipped zinc-coated exterior and interior surfaces. It shall be free of burrs and projections, circular in cross-section, of uniform wall thickness and shall conform to the requirements of ANSI Standard C-80.1. The threads per inch and length of threading shall conform to ANSI Standard B-2.1 on Pipe Threads.

Steel fittings shall be used to assemble steel conduit. Elbows, nipples, and couplings shall be made of the same grade of steel as that employed in the conduit. All fittings shall be treated, coated, and threaded according to the requirements for zinc-coated, rigid steel conduit and shall conform to UL 6.

Thin-walled, Electrical Metallic Tubing (EMT) or aluminum conduit shall be permitted for interior use only. All applications of such conduits shall utilize compression-style connectors and couplings.

Flexible conduit, if used, shall be watertight and interlocking aluminum such as Anaconda seal tite or steel strip-protected, with an approved rust resistive coating. Flexible covering on conduit shall not contain polyurethane or PVC vinyl.

Liquid tight flexible nonmetallic conduit, if required for special applications, may be used with SCRRA's approval. Liquid tight flexible nonmetallic conduit shall not be used where subject to physical damage or in lengths longer than 6 feet.

Conduit shall be color-coded: red for those carrying circuits above 100 Volts and yellow for under 100 Volts.

15.22.3 Junction Boxes

All exterior junction boxes shall be fabricated of minimum 14 gauge steel or aluminum. All exterior junction boxes shall be weatherproof and shall be connected in such a way that drainage from equipment groups shall not pass through conduit into the junction boxes. Interiors of all junction boxes shall be primed and then protected with a white, insulating coating as specified in Section 15.3.

15.22.4 Covers

All junction box covers shall be dust proof, retained by compressive spring-type latches, or captive screws as approved on a location-by-location basis. 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.

15.22.5 Wireways

Wireways shall be permitted in approved exterior and ceiling locations only. They shall not be permitted in the car body sidewall area. Only conduit shall be permitted in the car body.

All wireways shall be of rigid, stainless steel construction. Wireways shall be color-coded; red for those carrying circuits above 100 Volts and yellow for fewer than 100 Volts. The trays shall be adequately supported throughout their entire length in an approved manner. The trays shall be completely de-burred, leaving absolutely no sharp edges, 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. Heads of screws or bolts inside the raceways shall be flush with the metal surface. Metal wireways, elbows, couplings and similar fittings shall be flush with the metal surface. Points of screws or fasteners shall not be directed toward the interior of wireways. Removable wireway covers shall be secured with captive fasteners.

Wireways shall be designed to prohibit the collection of dirt and debris, and shall be perforated, without compromising their requisite strength, to permit ventilation and drainage. They shall preclude water entrapment.

15.22.6 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.

15.22.7 Size and Fill

Conductor area, including wire, insulation, and jacket shall not exceed 40 percent of the interior cross-sectional area of the conduit unless approved by the authority, but in no case should exceed 60 percent. Where conduit having a length not exceeding 24 inches without bends of more than 15 degrees is used between enclosures, a maximum fill of 60 percent shall be permitted.

Wireways shall not contain more than 30 current-carrying (i.e., power source as opposed to signaling) conductors at any cross-section. Conductor area, including wire, insulation, and jacket shall not exceed 40 percent of the interior cross-sectional area of the wireway unless approved by the authority, but in no case should exceed 60 percent.

15.22.8 Installation

15.22.8.1 Conduit

A run of conduit between junction boxes and/or pulling outlets shall not contain more than the equivalent of four quarter bends, 360 degrees total, including the outlet fittings. Bend radii at the inner 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. Conduit installation shall not create situations of dissimilar metals.

All conduit shall be arranged to prevent moisture traps and shall drain toward control boxes, except that all open-ended conduits shall be installed in such a manner as to ensure gravity drainage out the end. The conduit arrangement and installation shall be subject to approval. **[CDRL 15-045]**

15.22.8.2 Wireways

Wireways shall be located to provide access to the harnesses contained within for maintenance action. They shall be provided with approved covers which may be interrupted wherever desired for entry and exit of wires and cables. Edges of such interruptions shall be completely covered with protective bushings.

The wireways shall be routed such that they avoid:

- Sources of heat such as propulsion and dynamic brake grid resistors;
- Wheel splash areas; and
- Areas along the vehicle where the trays may be subject to foreign object damage.

Metal raceways and the elbows, couplings, and similar fittings shall be electrically and mechanically coupled while protecting wires from abrasion and shall make a continuous ground with the car structure.

Bends in wireways shall be avoided; however, if they are required, approved protection shall be provided to avoid insulation chafing at the bends.

All wire and cable shall be securely fastened within wireways to eliminate movement and resultant chafing.

15.23 FLAMMABILITY AND SMOKE EMISSION REQUIREMENTS

15.23.1 General

All combustible material used in the construction of the car shall satisfy the flammability, smoke emission, and toxicity requirements of this Section, 49 CFR 238.103, and NFPA 130, latest version. In case of conflict, the most restrictive requirement shall prevail. The Contractor shall comply with all provisions of 49 CFR 238.103 (c), Fire Safety Analysis for Procuring New Passenger Equipment, and APTA RP-PS-005-00, “Fire Safety Analysis of Existing Passenger Rail Equipment”.

All combustible materials shall be tested at SCRRA approved, independent laboratories. Test reports indicating successful compliance with these requirements are required for all materials. **[CDRL 15-046]** Testing must be conducted within the Contract duration period and preferably on a production batch of material. Each laboratory must have tested a standard test sample no greater than thirty (30) days prior to performing the tests which shall be submitted to SCRRA. The Contractor shall be responsible for complete conformance with these standards for itself and its subcontractors and suppliers. The SCRRA may, at its discretion, require that the current batch of material being provided for this contract be retested for conformance with these standards.

A matrix showing the total weight of all materials, where used, flammability and smoke emission test identity, test facility, test requirements, test results, and nature and quantity of the products of combustion shall be submitted by the Contractor during detailed design review. **[CDRL 15-047]**

15.23.2 Combustible Content

The design of the vehicle shall minimize the total combustible material content of the vehicle. Each combustible material shall be specifically identified by supplier's name and type, use in the vehicle, total weight, and heating value in Btu/lb and Btu/hour. **[CDRL 15-048]** The combustible content data may be included in the combustible material matrix.

15.23.3 Flammability and Smoke Emission

Materials used in passenger vehicles shall be tested to demonstrate compliance with the requirements set forth in Section 15.23.1.

The Contractor shall test the floor assembly in accordance with ASTM E119 to demonstrate a 30-minute endurance rating. The test procedure, test facility, and test results shall be approved by the SCRRA prior to the Contractor's procurement of any flooring material necessary for vehicle production. **[CDRL 15-049]**

The test specimen shall be a full width vehicle section including side sills or that portion of the wall which extends below the floor. Specimen shall have a minimum exposed area of 100 square feet. If approved, the exposed area may be reduced to meet a length limitation imposed by the size of the test furnace, but the length shall not be less than 11 feet. No fewer than two (2) typical penetrations, spaced at a distance from each other no greater than that which shall exist in actual construction, shall be included in the test specimen floor splice configurations, any penetrations through the floor including but not limited to ventilation ducts, conduits, etc, and any areas of the floor that are thinner than the standard floor section. The specimen shall include typical floor splice configurations. Test specimen shall be loaded to simulate “crush” passenger loading conditions. The Concentrated loads shall be applied to simulate underfloor equipment. The Test specimen shall include at least three typical transverse supports. The Test specimen shall represent the actual construction utilized in production. This includes the floor covering, floor boards, floor structure, thermal and acoustical insulation, and floor pans.

The Conditions of acceptance for this test shall be those required for unrestrained assembly.

15.23.4 Toxicity

Those materials and products generally recognized to have highly toxic products of combustion shall not be used.

All materials used in the car construction, except for materials used in small parts (such as knobs, rollers, fasteners, clips, grommets, and small electrical parts) that would not contribute significantly to fire propagation or to smoke or toxic gas generation, shall be tested for toxicity using Boeing Specification Support Standard BSS-7239. Materials shall meet the following maximum toxic gas release limits (ppm) as determined per BSS-7239:

Carbon Monoxide (CO)	3500 ppm
Hydrogen Fluoride (HF)	200 ppm
Nitrogen Dioxide (NO_2)	100 ppm
Hydrogen Chloride (HCL)	500 ppm
Hydrogen Cyanide (HCN)	150 ppm
Sulfur Dioxide (SO_2)	100 ppm

The tests are to 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.

15.23.5 Electrical Fire Safety

Electrical equipment shall conform to NFPA 130 (latest edition), except where more restrictive requirements are imposed by this Specification.

15.24 ELECTRICAL DEVICES AND HARDWARE

15.24.1 General

All electrical devices shall be transit industry-proven.

15.24.2 Contactors and Relays

All contactors and relays shall meet or exceed the requirements of MIL-R-6106 and MIL-R-5757 respectively, with the following qualifications:

- Devices shall be tested for proper functioning in orientations up to 30 degrees from the orientation in which they are mounted in the vehicle, in each of the three possible rotations: pitch, yaw, and roll.
- If adequate documentation exists demonstrating that during functional and operational testing of the vehicle the contactors underwent normal duty cycle tests, it shall be considered as an acceptable alternative to a burn-in.

- In selected applications, contactors and relays shall comply with the requirements of MIL-R-6106 (for ratings of 10 Amperes or greater) and MIL-R-5757 (for ratings of less than 10 A) but need not be qualified to these documents if all of the following requirements are met:
- The device is service proven in the exact same application.
- The device is service proven in transit service.
- All other requirements of this Specification are met.
- SCRRA approves of this application.

All devices shall be constructed and utilized in a fail-safe manner; that is, all failures shall be in a direction so that neither the passengers, the crew nor the equipment are placed in jeopardy.

All devices shall be installed so that they are fully accessible for inspection, repair-in-place, or removal and replacement. All contactor terminals shall be fully accessible for trouble shooting purposes. Contactors and relays shall incorporate means of visually determining whether they are picked up or dropped out. Relays on printed circuit boards or within electronic assemblies may be exempted from the requirement for a visual indication, as approved by SCRRA.

There shall be a maximum of two wire terminations on any one contact of the device.

The coils of all devices shall be suppressed to protect the low-voltage network from generated transients.

Under no circumstances shall either the main or auxiliary contact tips of the devices be placed in parallel for the purpose of carrying a current load at or above the manufacturer’s contact tip rating.

Contact tip ratings shall be stated for the worst condition of reduced surface contact which may result from tip misalignment during normal operation of the device.

Contactor installation shall be such that the arc spray is directed by an arc chute away from ground and any other electrical devices proximate to the contactor.

Devices shall be constructed in a very heavy-duty fashion suitable for use in railroad service. The SCRRA reserves the right to review and approve the design and selection of all contactors and relays.

Contactor tip replacement shall not exceed 10 percent of the total number of tips at ninety (90) day intervals.

All contactors shall be constructed so that the main contact tips make and break with a motion (wipe) that prevents deposits and pitting.

All DC contactors shall be built with series-fed blowout coils. The Contractor shall demonstrate the ability of each contactor type to reliably interrupt current over the full design operating range.

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 shall 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.

Adequate gap and creepage distances shall be maintained from high voltage contactor tips and low voltage coil and auxiliary contacts to prevent entry of high voltage arcs or transients into the low voltage circuits. The same applies to grounded mounting surfaces.

Relays shall not be affected by the accumulation of airborne dust.

15.24.3 Switches

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.

Switches shall be provided with a "keying" feature so that after installation, the body of the switch is constrained from mechanical rotation.

All switches provided shall be of the highest quality procurable and shall be fully suitable for the rigors of the SCRRA's service environment. 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 Train Operator's control console, shall be environmentally sealed. Toggle and push button switches shall be per MIL-S-3950, MIL-S-8805, MIL-S-83731, or equal. All safety-critical switches, such as those that can cause door openings, shall be designed to withstand a high potential test of 1,500 Volts for 1 second, in a clean, dry condition, without false conduction. The design and selection of all switches shall be subject to review and approval.

There shall be a maximum of two (2) 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.

In addition to the above requirements, all switches and pushbuttons shall meet the following requirements:

- Contact resistance shall be less than 0.1 Ohm at 3 VDC and a 10 milliampere load.
- Open circuit resistance shall be 50 mega Ohms minimum.
- Resistance to case shall be 1000 mega Ohms minimum at 500 VDC.
-

15.24.4 Circuit Breakers

15.24.4.1 General

All circuit breakers provided shall be extremely rugged and fully suitable for the service intended.

They shall be of the highest quality procurable. Design and selection of all circuit breakers shall be subject to review and approval.

All circuit breakers of the same rating shall be of the same manufacture and model throughout the vehicle.

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 over-current or shunt trip elements. All circuit breakers shall be mounted in the vertical direction with the “ON” position up.

Circuit breakers shall be individually replaceable without disconnecting or removing anything other than the mounting fasteners and electrical connections of the breaker to be replaced.

Electrical connections to circuit breakers shall either be threaded to accept machine screws or use a threaded stud. Wires to circuit breakers shall use ring terminals.

Circuit breaker terminals shall not be used as junction points.

Each and every input power circuit shall be protected by an individual circuit breaker. Separate circuit breakers shall be provided for major assemblies or functions. No circuit breaker shall protect more than one circuit, nor shall any one circuit be protected by more than one circuit breaker.

All circuit breakers shall be sized by current rating and tripping time to protect both the associated equipment and the minimum size wire used for power distribution within the protected circuit without causing nuisance tripping.

High voltage circuit breaker poles may be connected in series if necessary to achieve the stated voltage interruption requirements.

Each circuit breaker pole shall be equipped with adequate means of arc extinction to prevent flashover.

The continuous current rating of thermal-magnetic trip circuit breakers shall be selected in accordance with ANSI C37.16 for the load and type of service specified.

All thermal-magnetic trip circuit breakers shall conform to the requirements of ANSI C37.13 and ANSI C37.14.

Circuit breaker current rating shall be clearly and permanently marked and shall be completely visible after installation.

Electrically operated circuit breakers shall be arranged for operation from the low voltage dc supply.

15.24.4.2 High-Voltage Circuit Breakers

All high voltage circuit breakers shall be devices with not less than 3 poles connected in series.

All distribution-type, high voltage circuit breakers shall be Westinghouse Series C, FDB frame, Heinemann type GH, or approved equal.

The trip elements shall be thermal-magnetic, or magnetic, connected in series.

The circuit breaker handle shall protrude from the circuit breaker panel cover sufficiently to be manipulated in all positions.

15.24.4.3 Low-Voltage Circuit Breakers

Low voltage circuit breakers shall be either one-pole or two-pole devices depending on the intended function. Trip elements shall be thermal-magnetic, or magnetic, as is appropriate for the application.

All low voltage circuit breakers shall be:

- General Use - Westinghouse Series C, Quicklag C frame, Heinemann Series AM or approved equal, front connection or approved access arrangement, and approved labeling.
- Fast Operation - Airpax type IMLK, dust sealed, magnetic breaker, or Airpax type UP, hermetically sealed, magnetic breaker, or an approved equal.

15.24.5 Fuses

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, and
- Where current or voltage levels prohibit circuit breakers.

Fuses shall be permanently identified adjacent to the fuse. 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.

Air gap and creepage distances shall be as approved. Fuses used in nominal 600 VDC circuits shall be rated for no less than 1,000 VDC.

High voltage fuses shall be mounted in totally enclosed, dead front fuseholders, with no exposed high voltage connections. The fuse shall be extracted from the circuit when the fuse holder is opened and the exposed fuse shall be safely isolated from any circuit connection.

Where circuits use multiple fuses or fuses and circuit breakers, the coordination between the protective devices shall be discussed in design review.

15.24.6 Bus Bars

Bus bars are to be fabricated from OFE (Oxygen Free Electronic CDA C10100) or ETP (Electrolytic Tough Pitch CDA C11000) copper. The bus bar conductivity shall be 100 percent IACS. All bus bar joints shall be silver or tin plated.

Current densities, other than at joints, shall not exceed 1,000 Ampere per square inch, and in any case shall not exceed a value which would cause a bus bar temperature rise greater than 96ºF. Current densities in joints shall not exceed 150 Ampere 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, heat shrink tubing or other approved means. Tape is not acceptable. Bus bars that are behind insulating panels are exempt from this requirement.

15.24.7 Capacitors and Resistors

Hermetically sealed, dry tantalum capacitors, in metal cases, shall be used in place of aluminum electrolytics, except for very high values which are not commercially practical or available, in which case long life grade aluminum electrolytics shall be used.

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 twenty (20) years. Filter capacitors shall have high ripple current rating for long life.

Capacitors shall be derated 20 percent for voltage based on the nominal supply voltage and maximum case temperature. If filter capacitors are exposed to low ripple voltages, lesser values of derating may be accepted if it can be shown that reduced operating temperatures can be achieved due to lower dissipation; however, the sum of the DC and AC ripple voltages shall always be less than the capacitor's voltage rating at a maximum case temperature of 185˚F.

Except for braking power resistors, all resistors shall be derated 50 percent for power dissipation. Other power resistor applications may be submitted for approval of lower derating, on a case-by-case basis.

15.24.8 Transformers and Inductors

Transformers and inductors shall be derated 10 percent for current. Transformers shall:

- Have vacuum-impregnated windings.
- Be rated to withstand at least twice the maximum peak-to-peak voltage that they shall be subjected to in operation.
- Not emit audible noise in excess of 60 dB referenced to 20 micropascals at a distance of 2 feet while operating at rated voltage and load.
- Be designed to minimize radiated and induced EMI.
- The location, orientation, mounting, cable connections and cable routing shall be in accordance to the overall EMI/EMC control plan for the vehicle.
-

15.24.9 Switch, Circuit Breaker, and Fuse Panels

All switch, circuit breaker and fuse panels shall be dead front types mounted in the specified equipment enclosures.

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. Furthermore, 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 70, Article 384. The dead fronts shall be made of moisture-proof, electrically insulating, laminated phenolic or fiberglass, of approved quality suitable for switchboards. Asbestos shall not be used.

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 shall not be permitted.

15.24.10 Battery Backup Circuits

Backup batteries are not permitted, unless specifically approved by SCRRA.

15.25 ELECTRICAL AND ELECTRONIC DESIGNS

15.25.1 General

Except as otherwise noted herein, electronic equipment shall conform to IEC 60571, Electronic Equipment Used on Rail Vehicles, Class TX, unless otherwise approved by SCRRA.

15.25.2 Reliability Standards

A standardized MIL-HDBK-217F reliability part stress prediction shall be performed on all electrical and electronic control systems. This reliability prediction shall be based on the "ground Mobile" environment. Use of alternative reliability database information may be permitted for parts not contained in MIL-HDBK-217F, subject to SCRRA approval. Submittal of the reliability prediction shall be identified in the Reliability Program Plan. The prediction shall be used during design and development to compare competing designs, perform design tradeoffs, detect overstressed parts and identify high failure rate items.

A documented closed-looped Failure Reporting and Corrective Action System (FRACAS) (per Reliability Toolkit: Commercial Practices Edition) shall be established and maintained to provide for the identification, tracking, and repair of all product/process failures. Early elimination of failure causes or trends shall contribute significantly to reliability growth and continuous process improvement.

All semiconductor devices shall be derated to operate within the acceptable region for electrical and temperature stress as specified in "Reliability Toolkit: Commercial Practices Edition". If there is a conflict between guidelines given elsewhere in this Specification (e.g., Section 15.27.2) and the Reliability Toolkit, the more restrictive condition shall govern. Other service-proven devices may be submitted for approval.

All electronic assemblies shall undergo Environmental Stress Screening (ESS). The temperature cycling regimen shall be in accordance with table 7.5-2, unit column, of the Reliability Design Toolkit: Commercial Practices Edition, from the Reliability Analysis center, except as indicated below. The temperature extremes may be limited to –13˚F to + 158˚F, at the discretion of the supplier. A minimum of 20 complete temperature cycles shall be conducted. The ESS shall be performed with the equipment operational, powered, and oriented as per the ultimate application. Input signals and output loads to simulate the maximum power dissipating condition in the equipment shall be applied during the rising temperature and maximum temperature portions of the temperature cycle. The equipment shall be given a full functional test before and after the ESS, and monitored for failure throughout the ESS. In the event of equipment failure, the repaired equipment shall be given another complete ESS test. Alternatives to this baseline ESS may be acceptable at the discretion of the SCRRA. Assemblies consisting exclusively of components rated at 50Amperes or greater are exempt from this requirement.

15.25.3 Ability to Repair

All electrical assemblies, where practical, including such items as PC boards, shall be designed for repair by the SCRRA, in their electronics workshop.

Assemblies shall not be sealed, potted, or constructed to prohibit repair by the SCRRA. Assemblies that must be potted or sealed by design shall have a minimum ten (10) year warranty.

15.25.4 Hardware

Refer to Section 15.4.2 for general hardware requirements. All hardware associated with electronic and electrical control systems shall be protected against moisture, oxidation, and common airborne contaminants. Hinges and latches shall be of stainless steel.

15.25.5 Enclosures/Racks

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 as required to meet the requirements of this document.

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, unless specifically designed to do so.

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. A brief functional designation shall also be included on each label.

The enclosure/rack shall not be connected to the power supply return or signal circuit, unless approved by SCRRA.

Where it is necessary to use printed circuit boards that are not plug-in and not mounted in an enclosure, the following additional requirements apply:

- The PC board must be protected from mechanical damage and hostile environments such as arc discharge or contact with high voltage.
- If the PC board is part of a high voltage circuit, special caution shall be used in its design with regard to strike distance and creepage in the transit vehicle environment. This includes between PC board components and with respect to any grounded mounting surfaces.
- Any test points required in routine testing or fault isolation to the user replaceable level shall be easily accessible with no disassembly or tools.
- If replacement of the PC board is required (as part of secondary maintenance), no special tools or soldering shall be required.

Each PC board use and application of this type is subject to SCRRA approval.

15.25.6 Optical Fibers

Any application of optical fibers shall be approved prior to implementation. This approval is not intended to discourage the use of optical fibers. Rather, it is to verify reliability and maintainability of the proposed application. In no case shall the on-car repair of an optical fiber require sophisticated or complex polishing and alignment. The connections between optical fibers and car-replaceable units shall be via approved "quick disconnects".

15.26 MICROPROCESSOR BASED SYSTEMS

15.26.1 General

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 similar to those available for the Motorola 68XXX or Intel 80XXX family of devices.

Program code and fixed data shall be stored in PROM's or EPROM's. Either static or dynamic RAM or EEPROM may be used for temporary data storage. All EPROM windows shall be covered with labels that are opaque at the UV erasing wavelengths.

Battery-backed RAM shall be used only to store fault information. Batteries shall be sized to retain data for at least six (6) months without charging and shall be located such that leakage cannot damage any control system components. Battery life shall be no less than five (5) years, regardless of type. All batteries must be approved by the Engineer.

At least 30 percent additional memory space shall be installed and available for future modifications to program code, fixed data space, and temporary data space.

Flash memory may be proposed for the Engineer's approval.

15.26.2 Software

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, take appropriate actions to preserve proper functioning, and capture appropriate information to facilitate root cause analysis and repair when necessary.
- 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.
- Provide the functions required for the Monitoring and Diagnostics System.
- Report Software Version ID's and CRC values for all Application Software Items. CRC values shall be based on CRC-16 calculations on the stored software.
- Respond safely and predictably when powering up or recovering from power interruptions. All power interruptions likely to have corrupted temporary storage shall be detected and cause the system to re-initialize all affected routines and temporary data. Detection of power interruptions may be by hardware.
- Permit thorough interrogation of all input, output, and internal conditions by external diagnostic equipment.

15.26.3 Isolation and Interfacing

The control system shall be powered by dedicated transformer-isolated power supplies driven from the vehicle battery circuit.

All control system input and output signals shall be through isolation buffers. High voltage inputs and outputs shall be isolated external to the microcomputer card rack. Low voltage (battery and logic voltage level) inputs and outputs shall be isolated 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 opens.
- Perform necessary voltage translations.
- Remove noise and undesired signals.

- Limit or otherwise pre-process those signals that would otherwise require excessive processor time.
- Consist of optical isolators, transformer isolators, and other circuits appropriate to the application.

15.26.4 Software Categories

Software shall be divided into two (2) classifications subject to the Engineer’s approval. The first classification shall be programs which are Commercial off the Shelf (COTS) Software Items. These are general market software items typically supplied to a wide range of users for a range of applications. The second classification, Application Software Items, shall include all non-COTS items.

For an item to be considered, COTS approval by the Engineer is required; however, COTS Software Items typically include the following:

- Purchased real-time operating systems,
- Network interface software from a networking supplier,
- General purpose commercial database management software.

The Application Software Items shall include all other software such as the vehicle logic, subsystem integration, and fault and diagnostic routines. These programs are usually tailored to meet the requirements of this Specification, although they may include Software Items used on other projects. The development and documentation of these programs shall be subject to the requirements of this Section. The Contractor shall accept that SCRRA may, at a future date, need to change elements of these programs and shall provide SCRRA with sufficient information to alter this software without the Contractor's or Supplier’s assistance.

The processors used to execute Application Software Items shall have at least 30 percent available processing time for future software changes. They also shall have available additional I/O of each type used in that application to allow for future changes.

The Application Software Items shall be programmed in a high level language, such as C, Java, or PL/M, as approved by the Engineer. Compilation of the application dependent programs shall be performed on an IBM-compatible computer. The source code and all necessary files for the linking, locating, and conversion to loadable files shall be supplied to SCRRA on CD ROM, or other form as approved by the Engineer. The compiler and other development tools used shall be commercially available with all interfaces in English.

15.26.5 Software Quality Assurance and Documentation

The Contractor and each Supplier shall perform planning, analysis, and high level design early in the project before the Preliminary Design Review. The results of these activities shall be documented and submitted for approval. **[CDRL 15-50]**

The Contractor shall submit, for approval, a Software Quality Assurance Plan in accordance with ANSI/IEEE Standard 730-1998 and a Software Verification and Validation Plan in accordance with ANSI/IEEE Standard 1012-1998. **[CDRL 15-051]** These two (2) plans together shall constitute a CDRL item. These documents shall describe the Quality Assurance and the Verification and Validation activities to be performed by the Contractor. These documents shall be approved before the first PDR and updated for the CDR.

In addition to the above documents submitted 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 twenty (20) years. Filter capacitors shall have high ripple current rating for long life.

a) A Software Project Management Plan (SPMP) in accordance with IEEE Standard 1058-1998.

b) A Software Quality Assurance Plan (SQAP) in accordance with IEEE Standard 730-1998.

c) A Software Verification and Validation Plan (SVVP) in accordance with IEEE Standard 1012-1998.

d) A Software Configuration Management Plan (SCMP) in accordance with IEEE Standard 828-1998.

e) For each subsystem, a System Functional Description (SFD) defining the subsystem requirements and design. It shall define all hardware and software components, partition the requirements amongst the components, and define the external and internal interfaces. It shall include a context diagram showing the external interfaces and a decomposition diagram showing the internal components and their interfaces. Each SFD shall include a Software Configuration Item Table providing information for each Software Configuration Item (SCI). The table shall provide the Item name, classification as COTS or Application Software, names and document ID's of the SRS and SDD, and method for loading the software item. For COTS items, the requirements may be identified in a section of the SFD along with references to the COTS item provider's documentation that states the requirements are provided. These SFD sections may then be referenced in the Software Configuration Item Table in lieu of the SRS and SDD references.

f) A Software Verification and Validation Report (SVVR) in accordance with IEEE Standard 1012-1998 and in accordance with the SVVP.

g) For each Application Software Item, a Software Requirements Specification (SRS) in accordance with ANSI/IEEE Standard 830-1998, and a Software Design Description (SDD) in accordance with ANSI/IEEE Standard 1016-1998. Each of the specific individual requirements must be identified in the SRS with a project specific unique identifier. Timing requirements must be given and specific allowable ranges for parameters.

For each supplier, items a through e together shall constitute a CDRL item **[CDRL 15-052]**, all the SRS documents a separate CDRL item **[CDRL 15-054]**, the SVVR another CDRL item **[CDRL 15-054]**, and the all the SDD and SRTM documents (items g and h) a CDRL item **[CDRL 15-055]**. Items a through e and the SRS documents shall be submitted and approved before the PDR for the associated system. Revisions of these documents and the other remaining documents shall be submitted and approved before the CDRL for the corresponding system.

The source code for all Application Software Items shall be clearly documented in comments and must be well structured, providing easy tracing from source code to the design in the Software Design Descriptions. The comments shall also include explanations of all significant memory addresses such as interrupt vectors, I/O addresses, addresses for RAM or ROM memory, and other device addresses.

SCRRA may participate in the Supplier's internal Software Requirements Reviews, as defined by ANSI/IEEE Standard 730-1998. These reviews must precede the submittal, for approval, of the Software Requirements Specifications.

Following approval, all subsequent changes to these documents shall also be submitted and approved prior to implementation in the source code.

15.26.6 Software Escrow

The Contractor and Suppliers may request that the design details and Source code files for certain specific Application Software Items be placed in an escrow account in lieu of submittal to SCRRA. Such requests shall be subject to approval by the Engineer.

If approved, sufficient information shall be provided for review to enable SCRRA to evaluate overall system performance and future changeability.

A demonstration shall be performed and witnessed by SCRRA for all software to be in escrow. This test shall verify that all software and developmental tools have been included to generate loadable software from the source code and that the files generated are identical to the files used in final tests of the corresponding system.

The materials in escrow shall be made available to SCRRA for its own use for any of the following reasons:

If the Contractor or any Supplier is no longer in business or no longer supports the product and has not transferred the rights to another entity that supports the product.

If, based on an independent third party assessment, the Contractor or Supplier no longer supports the product at a reasonable cost.

15.27 SEMICONDUCTOR STANDARDS

15.27.1 General

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.

15.27.2 Ratings

Semiconductors, except diodes (see below), operated from the battery supply, or those connected to trainlines, shall have minimum breakdown ratings of four times the maximum achievable circuit voltage. Suppression devices shall be provided as necessary to protect the devices and limit the circuit voltage.

Diodes operated from the battery supply, used as suppression devices, or connected to trainlines shall have a minimum breakdown rating (PIV) of 1,000 Volt. Diodes with less than 1,000 Volt PIV rating may be used if adequate circuit transient protection is also provided.

All discrete semiconductors operated from inverters or other isolating devices shall have a minimum breakdown rating of two times the maximum circuit voltage, except where specifically detailed otherwise. Suppression devices shall be provided as necessary to protect the devices and limit the circuit voltage.

All semiconductor junction temperatures shall be limited to 257°F (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 percent of the maximum continuous current rating or 50 percent of the maximum continuous power rating, whichever is more restrictive. High power/current devices may be exempt from this requirement with prior approval, on a case-by-case basis. The Contractor shall submit complete device information, including all manufacturer's application recommendations, and calculated current and power demands with all waiver requests. If approved, such waivers do not reduce other requirements, including reliability.

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, de-rated to less than 50 percent 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 percent below the manufacturer's recommended maximum. In addition, the maximum power shall be limited to 50 percent of the manufacturer's specified maximum at the maximum operating temperature.

Silicon semiconductors shall be rated for operation over the temperature range of -40°F to 185°F, and shall be hermetically sealed to the extent required by the application.

All Gallium Arsenide and similar optical semi-conductors shall be rated for operation over the temperature range of -40°F to 185°F.

15.27.3 Availability and Identification

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 by SCRRA. Such devices shall be essential to the proposed equipment, shall meet the proven service requirements, and shall be supplied by veteran manufacturers likely to support the device.

Each device shall be labeled to identify both the manufacturer and the complete part number. Operational characteristics of the device shall be published and available to SCRRA.

15.27.4 Burn-in

Refer to Section 15.25.2.

15.27.5 Other Prohibitions

Electronic equipment shall utilize stock components and shall function properly with the component manufacture's full range of tolerances such that after-purchase screening or testing of components shall not be required.

Matching of components is permitted only if the components are normally available from the manufacturer in matched sets.

Germanium semiconductors shall not be used.

15.28 PRINTED CIRCUIT BOARD STANDARDS

15.28.1 General

Printed circuit boards shall be designed, constructed and inspected to ANSI/IPC-D-275, latest revision, except where more stringent requirements are noted here. Within ANSI/IPC-D-275, printed circuit board classes are designated. Printed circuit boards supplied under this Specification shall be Class 2, minimum, with the exception of wayside computers that are not utilized in vehicle operation. Class 3 requirements shall apply to all vital equipment.

Circuit board material shall be per NEMA Standard LI 1, Type FR-4 (MIL-P-13949, Type GF), for boards which have no components whose power dissipation is greater than 2 Watts and when said board is not mounted adjacent to components dissipating greater than two watts. Otherwise, circuit board material shall be per NEMA Standard LI 1, Type FR-5 (MIL-P-13949, Type GH).

Printed circuit boards shall have a minimum thickness of 0.0625 inch base material. All conductor material shall be copper and shall be firmly attached to the board and shall be resistant to blistering and peeling when heated with a soldering iron.

All printed circuit boards shall be designed for ease of testability per ANSI/IPS-D-275, "Testability design check list".

Traces shall be made as wide as practical, with the minimum width being based on a 18°F temperature rise.

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. SMT devices 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. Circuit boards larger than 100 square inches shall be centrally stiffened unless otherwise approved.

All printed circuit boards with the same function shall be interchangeable between equipment groups without additional adjustment.

All printed circuit boards shall be of the "plug-in" type, with positive support against vibration. Single board applications, where approved by the SCRRA, may be of a "non-plug-in" type.

Printed circuit boards shall be designed for insertion and removal with power applied, except where power is removed by a switch adjacent to the card rack and except where the mechanical construction would generally prohibit removal and insertion with power applied. Where a switch is used, it shall be labeled with a warning regarding its proper use.

15.28.2 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, except as approved by SCRRA. 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; additionally the first pin on all IC packages shall be identified on the wiring side of the board. The labels used to identify components on the printed circuit board shall match those used in the schematic drawings for that particular component.

15.28.3 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 shall not discolor or damage the board.

15.28.4 IC and Device Sockets

IC and device sockets are prohibited except for components that must be removed for reprogramming or initial calibration procedures or devices that are available only in mounting in sockets. All socket applications are subject to SCRRA approval. All other components shall be soldered in place.

Where approved, IC sockets shall comply with approved standards such as MIL-S-83502 and MIL-S-83734, as is applicable for the device, and shall be made of the following materials:

The bodies shall be molded from diallyl phthalate, PTFE Teflon, or approved equal.

The contacts shall be fabricated from beryllium copper and shall be plated with a minimum of 0.000030 inch of gold over a minimum of 0.000050 inch of low stress nickel in the area of contact with IC pins.

15.28.5 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-46058 latest revision, 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.

15.28.6 Keying

All printed-circuit boards shall be mechanically "keyed" to prevent insertion into the wrong slot or in the wrong orientation. Further, circuit boards in safety related control systems, such as friction brakes, cab signal, ATC, ATS, 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 to disable the vehicle if a circuit board is removed.

15.28.7 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 SCRRA prior to commencing design. **[CDRL 15-056]**

Connectors which comply with MIL-C-55302 or DIN 41612 Level 1 or 2, 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 0.000030 inch f gold over a minimum of 0.000050 inch of low stress nickel.

Card edge connectors are prohibited.

15.28.8 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 for manual testing shall either accept and hold a standard 0.080 inch 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.

15.28.9 Extenders

Printed circuit board extenders 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 and shall be delivered to SCRRA upon the acceptance of the BTE. The interfaces between extender and enclosure and PC board must be positive and secure and must prevent malfunction and falling out during testing. Mechanical locking means shall be considered on large PC boards.

End of Section

Contract Deliverables List

CDRL No.	Title	Car Type	Reference Paragraph
15-001	MSDS Sheets	All	15.1.1
15-002	List of Cleaning Agents	All	15.1.3
15-003	Paint Gloss Samples	All	15.3.2
15-004	Paint Touch Up Procedure	All	15.3.8
15-005	Paint Coating and Application Document	All	15.3.10
15-006	Layout of Graphics	All	15.3.11
15-007	Dissimilar Metal Installation Plan	All	15.4.1.1
15-008	Manufacturer's Data for Proposed Adhesives	All	15.4.3
15-009	Welding Procedures	All	15.5.2, 15.5.6
15-010	NDE Sampling Plan For Welds	All	15.5.4
15-011	Ring Weld Sampling Plan	All	15.5.4
15-012	Full Penetration Weld Sampling Plan	All	15.5.4
15-013	Specs for Purchase of Welding Supplies/Equipment	All	15.5.6
15-014	Dissimilar Metal Weld Procedures	All	15.5.7

CDRL No.	Title	Car Type	Reference Paragraph
15-015	Resistance Welding Procedure Qualifications	All	15.5.8
15-016	Brazing Performance and Procedure Qualifications	All	15.5.11
15-017	Torch Soldering Samples	All	15.5.12
15-018	Stainless Test and Inspection Plan	All	15.6.4
15-019	LAHT Steel Test and Inspection Plan	All	15.7.2
15-020	Radiography Acceptance Standards	All	15.8.2
15-021	Structural Casting Qualification Test Report	All	15.8.3
15-022	Lot Inspection Records for Castings	All	15.8.3
15-023	Radiographic Inspection Frequency	All	15.8.3.2
15-024	Aluminum Test Reports	All	15.9.1
15-025	Aluminum Fatigue Allowable Stress Values	All	15.9.2
15-026	Measures for Protection of Dissimilar Metal Surfaces	All	15.9.4
15-027	Air Brake Piping Design Certification By Air Brake Supplier	All	15.10.2
15-028	Cleaning and Preservation Procedure for Refrigeration and Air Systems	All	15.10.4
15-029	Pressure Vessel Test Reports	All	15.11

CDRL No.	Title	Car Type	Reference Paragraph
15-030	Test Results for Elastomers	All	15.12.7
15-031	Glazing Documentation	All	15.13.5
15-032	Fiberglass Strength Test Results	All	15.17.3
15-033	Phenolic Panel Test Results	All	15.18.6
15-034	Color and Surface Finish of Thermoplastic Sheet	All	15.19.1
15-035	Thermoplastic Sheet Strength Test Results	All	15.19.3
15-036	Samples of Wire and Cable	All	15.20.1
15-037	Production and Qualification Test Results for Cable	All	15.20.3.3
15-038	Design and Product Line for Wire Connections	All	15.21.1
15-039	Wiring Plan	All	15.21.3.3.b
15-040	Wire and Terminal Marking and Designation System	All	15.21.5
15-041	Cable Identification System	All	15.21.5

CDRL No.	Title	Car Type	Reference Paragraph
15-042	Product Line for Terminals and Connections	All	15.21.10
15-043	Push to Fit Terminals	All	15.21.14
15-044	Product Line for Conduit, Conduit Fittings, and Junction Boxes	All	15.22.1
15-045	Conduit Arrangement and Installation	All	15.22.8.1
15-046	Flammability Test Results on All Materials	All	15.23
15-047	Matrix of Flammable Materials	All	15.23
15-048	Combustible Content List	All	15.23.2
15-049	Floor Assembly Fire Test Procedure	All	15.23.3
15-050	Software Planning, Analysis, and High Level Design	All	15.26.5
15-051	Software Quality Assurance Plan and Software Verification and Validation Plan	All	15.26.5
15-052	Software Project Management. Plan, Verification and Validation Plan, Quality Assurance Plan, Configuration Management. Plan, and System Functional Description	All	15.26.5
15-053	Software Requirements Specification	All	15.26.5
15-054	Software Verification and Validation Report	All	15.26.5

CDRL No.	Title	Car Type	Reference Paragraph
15-055	Software Requirements Traceability Matrix and Software Design Description	All	15.26.5
15-056	PC Board Connectors	All	15.28.7

SECTION 16

QUALITY ASSURANCE, RELIABILITY, MAINTAINABILITY AND SYSTEM SAFETY

SECTION 16

QUALITY ASSURANCE, RELIABILITY, MAINTAINABILITY, AND SYSTEM SAFETY

TABLE OF CONTENTS

SECTION 16

QUALITY ASSURANCE, RELIABILITY, MAINTAINABILITY, AND SYSTEM SAFETY

16.1 QUALITY ASSURANCE

This section contains the requirements for the Contractor's Quality Assurance Program (QAP) during the construction, qualification and delivery of the vehicles. The requirements of this section shall be applied to both the prime Contractor and Subcontractors. The content of the QAP shall be detailed in the Contractor's QA Manual, procedures, work instructions, and project-specific QA Plan and shall include such elements as identification of Contract requirements, control of the design, materials and manufacturing, record keeping, inspection and tests, and audits. This section includes the requirements for establishing and monitoring the development of the design in terms of reliability, maintainability and system safety requirements. The methods to be used to demonstrate compliance with the applicable criteria are defined in this section.

16.1.1 QAP Scope and Objectives

To provide a quality product to SCRRA, the Contractor shall have planned and established a documented QAP authorized by its chief executive or acceptable designee. The Contractor shall enforce the elements of the QAP within all parts of its organization and with all manufacturers, subcontractors, and suppliers performing Contract work.

This section defines the minimum project QA requirements. The objectives of the Contractor's QAP as it relates to this project shall be, to assure that design, materials, processes and workmanship comply with the Specification; and that its design and manufacturing documentation are approved by the Contractor, by SCRRA as required, and released in a timely manner. The Contractor's QAP for this work shall utilize training, internal auditing, and periodic management review as means to support, maintain, and improve effectiveness of its quality program and application to this work.

16.1.2 QA Manuals, Procedures, and Plans

The Contractor's QA Manual shall cover all requirements of this Specification. The manual shall establish and communicate the company's quality policy, which shall be a clear statement of top management's commitment and direction with regard to quality of its products and services. The manual must establish authority for QAP requirements and include or refer to all Contractor quality system procedures, explaining the hierarchy of quality system documents. Amendments may be included in the Contractor's QA Manual to fully comply with the QAP requirements of this SCRRA Contract.

The degree of quality system documentation required shall be consistent with the skills needed, methods used, and training resident among personnel performing contract work in accordance with the requirements of this Specification. The Contractor shall provide SCRRA access to quality assurance procedures required by this Specification upon SCRRA request.

The Contractor shall submit for the Engineer's approval, ninety (90) days after NTP, its proposed project Quality Assurance Plan. **[CDRL 16-001]** This Plan shall identify the controls, resources and skills the Contractor shall apply to satisfy project quality system requirements. For each specified quality system requirement, the Plan shall identify how it is satisfied; when, where, and by which job function. It must include a flow chart of the manufacturing sequence with all planned inspections indicated. The chart shall indicate entities participating in the inspections and if inspections are customer-witnessed or hold-point verifications. Necessary inspection equipment, extraordinary measurement requirements, required personnel certifications, workmanship acceptance standards, methods of inspection, and required quality records documentation shall be identified in the Plan. The Plan shall provide details responsive to requirements of the Quality Assurance Manual and may refer to supporting quality assurance procedures and/or include them. The Contractor's Quality Assurance Manual shall be submitted for the Engineer's approval with the project Quality Assurance Plan ninety (90) days after NTP. **[CDRL 16-002]** If there are review comments that result in Quality Assurance Manual changes, the changes may be addressed as project-specific amendments in the manual's appendix.

16.1.3 Management Responsibility for QAP

The Contractor shall assign to a member of its management the overall responsibility for implementing and maintaining its QAP throughout the Contract period. The interrelation of all Contractor personnel affecting the quality of this Contract's products and services shall appear on the company's organization chart. The Contractor shall provide for periodic reporting to management and management review of its quality system effectiveness, taking appropriate action whenever so indicated.

The Contractor shall provide adequate trained resources to perform verification activities. These activities include inspection, test witnessing, monitoring operations, participating in and supporting design reviews, and conducting internal quality audits.

16.1.4 Internal Quality Auditing

The Contractor shall establish and maintain procedures for internal quality system auditing. The Contractor shall schedule audits of its operations so that it assesses compliance with each Quality Assurance Manual section throughout its organization on a planned, periodic basis. Contractor auditors shall be independent of operations they audit and perform audits in accordance with established auditing procedures. Auditors shall communicate results to appropriate personnel. Auditors shall follow-up to verify and document that personnel have determined and applied effective corrective action with respect to identified deficiencies.

16.1.5 Contract Review

To ensure that SCRRA's needs are met throughout the performance of Contract work, SCRRA requires the Contractor to review and continually consider Contract requirements, both as work is planned and as it is carried out. The Contractor shall take steps necessary to ensure that all work reflects a thorough understanding of Contract provisions, and that any disagreements with Contract requirements are resolved through established channels for change control. Contract review shall also serve to assure that sufficient resources are available and applied to furnish products and services of the required quality. Scheduling, staffing and design control requirements are detailed in Section 19.

16.1.6 Design Control

The Contractor and suppliers shall establish and maintain documented procedures to control and verify design of products and services while ensuring compliance with all Contract requirements. Design tasks shall be assigned to qualified personnel provided with adequate resources. To this end the Contractor shall define, document, coordinate, and control sources of design input. This shall be accomplished by identifying interfaces between groups, both within, and outside of its organization; then reviewing and updating design input on a regular basis to assure designs are adequate for their intended applications and free from conflict.

Design output, including drawings, specifications, instructions, software and procedures shall be documented in such a way that it can be verified as meeting design input requirements. Design output documents shall contain or refer to acceptance criteria and identify any design characteristics that are crucial to safety. The Contractor shall subject all design output to a documented system of review and authorized approval prior to releasing designs for procurement or manufacturing. This shall also include prior SCRRA approval for design documentation so specified.

At appropriate times during processes of design development, manufacturing, and testing, the Contractor shall validate the design, confirming that it meets defined SCRRA requirements.

16.1.7 Document and Data Control

The Contractor shall establish and maintain procedures for controlling all project documents and data. The Contractor's procedures shall identify who is responsible to maintain its master listing of documents, revision levels, and status. The Contractor shall ensure that documents are reviewed and approved prior to their release, and that current versions are available where and when needed. Obsolete documents shall be controlled to prevent unintended use, and if retained, segregated and suitably identified as obsolete or superseded.

Changes to released documents and data shall be subject to review and approval by the same functions and organizations that performed the original review, whether internal or external, unless other arrangements are justified.

16.1.8 Control of Purchased Items and Services

The Contractor's shall establish and maintain procedures to ensure that products and services purchased to complete this work comply with Specification requirements. Procedures shall describe the Contractor's method of evaluating Subcontractors and suppliers on the basis of their ability to meet requirements, and establish methods of controlling Subcontractor and supplier activities and products to obtain that result. The Contractor's records of acceptable Subcontractors and suppliers for this Contract shall be available for SCRRA examination.

The Contractor shall ensure that purchasing documents describe clearly the products and services ordered, including the precise description of items, relevant data, and all applicable specification requirements, codes, and standards, including revision levels. Requirements for quality assurance documentation, testing, packaging and shipping shall also be included, as applicable. The Contractor's purchasing procedures shall require purchasing documents to be reviewed by appropriate personnel for adequacy in meeting specified requirements.

Refer to Section 16.1.17, below, for inspection verification requirements for purchased products.

16.1.9 Control of Customer-Supplied Products

The Contractor shall establish and maintain procedures for controlling any products, equipment, or services furnished or loaned to the Contractor by SCRRA. Procedures shall ensure that all such items are properly accounted for, stored, maintained, and protected from loss or damage. The Contractor shall report to SCRRA in writing any SCRRA-supplied items that may become lost, damaged or degraded, and any items or services that would not fulfill the Contractor's intended use.

16.1.10 Process Control

A significant part of the Contractor's quality program shall be to dedicated to preventing problems by controlling manufacturing processes, thereby lessening the demands on required inspection and correction activities. To this end, the Contractor shall identify and plan processing necessary to produce, under controlled conditions, products and services of the specified quality. Where necessary to accomplish this, the Contractor shall prepare documented instructions and workmanship criteria, and monitor and approve production processes. Production equipment and processes shall be maintained as necessary to ensure that products satisfy specified requirements.

16.1.11 Product Identification and Traceability

The Contractor shall establish and maintain procedures for identifying product, where appropriate, during all stages of production, installation, and delivery. To the extent possible, individual items or lots shall retain unique identification including their accepted, rejected, or un-inspected status.

16.1.12 Control of Inspection, Measuring, and Test Equipment

The Contractor shall establish and maintain procedures to control, calibrate and maintain inspection, measuring and test equipment. This shall require maintaining lists of serialized, calibrated items to support recall for recalibration before the due date shown on each item's calibration sticker. This system shall identify each item's calibration interval and standard, and assure control of the calibration procedures. Inspection, measuring and test equipment shall be calibrated to standards traceable to National Institute of Standards and Technology (NIST) or other recognized national standard.

Selection of calibrated equipment for specific uses shall be consistent with the required measurement accuracy. The capability of test software and hardware for inspection shall be checked periodically. This procedure shall include provisions for determining the validity of previous inspection and test results when measurement equipment is found out of calibration, and taking appropriate corrective action. Inspection, measuring, and test equipment shall be suitably stored to ensure continued accuracy and fitness for use.

16.1.13 Inspection and Test Status

The Contractor shall identify by suitable means, the inspection and test status of products throughout production and installation so that it uses only acceptable products. The Contractor's Quality Assurance Plan shall identify the inspection authority responsible for releasing product as conforming at each stage of production.

16.1.14 Controlling Nonconforming Products and Services

The Contractor shall establish and maintain a procedure to prevent the inadvertent use or installation of nonconforming product. Nonconforming products shall be marked and segregated from acceptable items. The Contractor shall be solely responsible for assuring against unauthorized use of nonconforming material.

The Contractor shall include a Material Review Board (MRB) in the Contractor's Quality Assurance Plan. The MRB shall meet monthly or at another mutually agreed upon regularly scheduled basis. The Material Review Board is a formal multidisciplinary group of individuals established to perform a material review. Membership usually consists minimally of representatives from the Authority, Purchasing, Engineering, Quality Assurance, and Manufacturing. This panel reviews, evaluates and either fixes in accordance to specification requirements or disposes of specific nonconforming materials and services. Important supportive responsibilities include the initiation and achievement of corrective action which precludes recurrence and provides feedback in a useful way to the manufacturing process.

16.1.15 Corrective and Preventive Action

The difference between *corrective* and *preventive* action shall be clearly expressed in the Contractor's Quality Assurance Manual. *Corrective Action* procedures shall address actual nonconformities that have occurred. *Preventive Action* procedures shall address the *potential* for nonconformity. The Contractor shall establish and maintain procedures for taking corrective and preventive actions that are appropriate to the magnitude of the problems they address and commensurate with the risks these problems present.

Corrective action procedures shall be effective in handling complaints from non-conformance reports and from all entities, including SCRRA. Methods shall include problem analysis, recording results, determining the most effective corrective action, and verifying that corrective actions are effective. Preventive Action procedures shall require use of all available information to eliminate potential sources of nonconformity. Methods shall include data and information analysis, determining the best approaches to prevent nonconformity, implementing and ensuring effective preventive action plans, and forwarding significant details of actions taken for review by management.

16.1.16 Use of Statistical Techniques

Specific needs for statistical techniques in controlling production processes shall be identified in the Contractor's Quality Assurance Plan for the Project. Statistical quality control applications used in acceptance of parts, materials, or processes by the Contractor or its suppliers shall be documented and based on generally recognized and accepted statistical quality control methods.

16.1.17 Inspections and Tests

The Contractor shall maintain and apply sufficient resources for inspection and testing verification. While production worker inspection of work in-process is strongly encouraged, planned inspection verification by trained Contractor and supplier inspectors who are independent of the means of production is required under this Contract. Inspections and tests are specified as means for the Contractor to demonstrate and document specification compliance to SCRRA. As such, inspections and tests are means to assess the quality of Contractor and supplier processes, which include in-process verification and validation.

16.1.17.1 General

The Contractor shall establish and maintain procedures for inspection verification activities listed below. Procedures shall be suitably documented to provide objective evidence that specified product requirements have been met.

16.1.17.2 First Article Inspection

A First Article Inspection (FAI) will be performed jointly by SCRRA and the Contractor on all major components and subassemblies listed in Section 1.9.7 and on the first fully assembled car of each type. Equipment shall be shipped from the point of manufacture only after an FAI has been offered and either passed, or waived by SCRRA. The Contractor shall perform an independent pre-FAI when necessary to ensure that the subcontractor is prepared, and provide an SCRRA with a monthly FAI schedule, confirming scheduled arrangements a minimum of ten (10) days before each FAI. **[CDRL 16-003]**

A First Article Inspection will evaluate component and system maintainability where possible. FAI will be performed on components built using approved production processes and tooling, and shall establish the quality of workmanship for the balance of like components. The level shall be established jointly by SCRRA and the Contractor.

First Article Inspection will not be conducted until the design drawings of the article have been conditionally approved or approved. If conditionally approved drawings are used, the conditions for approval shall be satisfied at the FAI and represented by the inspection article.
The FAI work space shall be a proper, well-lit environment for inspection of piece part, subassembly or car final assembly. When appropriate, the inspection article shall be displayed on a stand or table with all necessary inspection tools, go/no-go gauges, plug gauges and handling aids. Correct tools and labor to take mechanical or electrical measurements shall be provided, including tools and labor for disassembly and removal of covers.

Functional testing shall be performed in conjunction with the FAI when practical.

The Contractor shall submit its FAI reports to SCRRA for approval within ten (10) working days following each FAI, identifying each open item and agreed action. **[CDRL 16-004]** The Contractor shall inform SCRRA of steps it has taken or plans to take, to resolve each open item in the manner required by SCRRA and SCRRA will notify the Contractor in writing, when SCRRA determines that each item has been resolved to its satisfaction.

16.1.17.3 Receiving Inspection and Testing

The Contractor shall utilize Receiving Inspection process to verify that subcontractors and suppliers are meeting all requirements of the Contract Specification; and, that products and services received are as listed on purchasing documents. The Contractor's procedure for this activity shall prohibit use, including processing, of purchased items and materials until they have been inspected utilizing an approved procedure and verified to comply with requirements. The inspection status of items shall be positively marked and recorded to support recall and replacement of same, should that be necessary.

16.1.17.4 In-process Inspection and Testing

The Contractor shall ensure that all products are inspected and tested as required elsewhere in this Specification and the approved Master Test Plan. Products shall be withheld from release to the next stage of production or delivery until required inspections and tests have been completed and products accepted by the Contractor or supplier Quality Assurance functions.

16.1.17.5 Pre-shipment Inspection

Pre-shipment inspections shall be conducted for the subsystems and items listed in Section 1.9.7. The Contractor shall provide SCRRA with a monthly schedule of planned pre-shipment inspections and a minimum of ten (10) days notice for each inspection, including the agenda and list of items to be inspected. **[CDRL 16-005]** SCRRA will notify the Contractor of its plans to attend or not attend. The Contractor shall ensure that all necessary drawings, specifications, standards, tools and facilities are provided to support these inspections.

16.1.17.6 Final Inspection and Testing

The Contractor's Quality Assurance Plan shall identify all Final Inspections and Tests and the successful completion of such upon which the final release of vehicles and equipment are based. Products shall not be released for shipment to SCRRA until all final inspections and tests have been completed to SCRRA's satisfaction. The Contractor shall allow a minimum of two (2) full working days for SCRRA's final review of cars before shipment.

16.1.17.7 Inspection and Test Records

The Contractor shall establish and maintain records that indicate whether products have passed required inspections and tests. Any items that have failed inspection or test shall have such failure documented and processed per the Contractor's nonconformance and corrective action procedures. Inspection and Test Records shall identify the Contractor authority responsible for releasing inspected and tested products.

16.1.17.8 Contractor Provisions for SCRRA Product and Process Auditing

The Contractor shall extend to SCRRA its full cooperation and, at no additional cost to SCRRA, provide facilities at its car construction plants, including final assembly sites. These facilities shall enable convenient examination of materials, work, and equipment. There shall be provisions for separated, securable office space, desks, lockers, and file cabinets. Current copies of all drawings, diagrams, schedules, changes, deviations, and data shall also be furnished. Data shall be adequate to verify design, construction, assembly, installation, workmanship, clearance, tolerance, and functionality of the vehicles.

The Contractor shall provide SCRRA in-plant representatives with a heated, cooled, and adequately lighted private office for a minimum of three people at each location, with convenient access to restrooms. Three telephones with unrestricted, SCRRA-dedicated outside lines and a telefax machine shall be provided for use within this office. The Contractor shall furnish a copy machine with sorting capabilities and a suitable desktop computer with data/fax modem.

16.1.18 Handling, Storage, Preservation and Delivery

The Contractor shall establish and maintain procedures for handling, storage, packaging, preservation, and delivery of items furnished under this Contract. The Contractor and suppliers shall implement procedures that:

- Identify methods for preventing damage or deterioration,
- Provide for secure storage that includes documented receipt and dispatch,
- Control packaging, packing, and marking processes,
- Provide methods for preserving and segregating products in production, assembly, and storage, and
- Preserve product quality following final inspection and testing until delivered.

16.1.19 Control of Quality Records

The Contractor shall establish and maintain procedures for handling, maintaining, and disposing of quality records, including pertinent quality records of Subcontractors. Quality records may be maintained in paper, electronic files, or other media. All quality records shall be legible and traceable to the items they describe. Quality records shall be stored to prevent loss or damage, and shall be available for SCRRA examination upon request. The Contractor shall have established retention periods for quality records that are acceptable to SCRRA.

16.1.20 Quality Assurance Training

The Contractor shall establish and maintain procedures to identify training needs necessary to complete Work successfully under this Contract. The Contractor shall provide appropriate training to personnel performing activities that affect the quality of products and services. Records of training needs and completed training shall be maintained until the end of the warranty period.

16.1.21 Servicing

The Contractor shall establish and maintain procedures for servicing delivered products during the warranty period that include verification that warranty requirements are met. Procedures shall clarify the Contractor's servicing and warranty responsibilities in accordance with this Contract. Both Contractor and any subcontracted servicing and warranty activities shall be planned and supported by suitable instructions, documentation, and competent, trained personnel.

The Contractor's staff shall collect and feedback to responsible Departments any information during the warranty period that supports servicing, design, and product improvements necessary to fulfill Specification requirements reliably.

16.2 RELIABILITY PROGRAM

This section establishes criteria for development and implementation of a system assurance program to optimize the reliability characteristics of the vehicle systems. The vehicle shall be designed to provide a high degree of reliability and to minimize downtime during scheduled and corrective maintenance activities. Designs shall ensure that vehicles perform as required without excessive failures, delays, or interrupted service to passengers.

16.2.1 MDBF Requirements

Each component, assembly, subsystem, and system element shall be designed to perform its function under the specified design operating conditions without failure for the durations specified. The Contractor shall furnish equipment that meets the Mean Distance Between Failure (MDBF) requirements, considering all failure modes for components, assemblies, subsystems, and system elements. The combination of which shall result in realization of the following:

- Cab Car MDBF 20,000 miles
- Trailer Car MDBF 25,000 miles

Mean Distance Between Failure (MDBF): The MDBF at the vehicle level is the ratio of total operating distance accumulated by the total population of cars to the total number of relevant failures for the fleet.

The Contractor shall also furnish equipment that meets the MDBCF requirements.

Mean Distance Between Component Failure (MDBCF): The MDBCF of an item is the ratio of the total operating distance, *d*, accumulated by the total population of identical items to the total number of relevant failures, *F*, occurring within the population of identical items during the time, *t*. It is expressed by the following equation:

$$MDBCF = \frac{d}{F}$$

The term "failure" includes both the initial device failure and all consequential device failures caused by the initial failure.

The term "device" includes any component, subsystem, or system, whether electrical or mechanical.

The terms "restrictive" and "permissive" relate to potential system responses, which result in either a more-safe or less-safe condition, respectively, such as: stop vs. proceed, a lower speed vs. a higher speed, deceleration vs. acceleration, brakes applied vs. brakes released, actuation of alarm vs. no actuation of alarm.

Mean Time Between Component Failures (MTBCF): The MTBCF of an item is the ratio of the total operating time, *t*, accumulated by the total population of identical items to the total number of relevant failures, *F*, occurring within the population of identical items during time, *t*. It is expressed by the following equation:

$$MTBCF = \frac{t}{F}$$

Relevant Failure: A relevant failure of an item is an independent failure which results in a temporary or permanent loss of function of that item caused by either of the following:

a) A fault in the item while operating within its design and environmental Specification limits.
b) Improper operation, maintenance or testing of the item as a result of Contractor-supplied documentation.

At any time up to and including the completion of the warranty period, for any relevant failure, the Contractor shall review the failure and provide a failure analysis report. The following subsystem reliability goals are established for the systems and components of the vehicle, assuming routine maintenance is performed by SCRRA as recommended by the Contractor.

Subsystem Reliability Goals:

Cab Car	MDBCF (Miles)	Failure Rate
Coupler, Draft Gear, Trainline	3,500,000	2.857E-07
Side Entrance Doors and Controls	150,000	6.667E-06
Communication Systems	200,000	5.000E-06
▪ PA and Intercommunications	600,000	1.667E-06
▪ Train Radio	750,000	1.333E-06
▪ Destination Signs	600,000	1.667E-06
Lighting	1,000,000	1.000E-06
HVAC Equipment and Controls	250,000	4.000E-06
Auxiliary Power Supply and Apparatus	200,000	5.000E-06
Carbody and Appointments	215,000	4.651E-06
Truck and Suspension	750,000	1.333E-06
Friction Brake Equipment	200,000	5.000E-06
Traction/Brake Controls	200,000	5.000E-06
ATS, Event Recorder/Safety and Overspeed	200,000	5.000E-06
Microprocessor Controls	200,000	5.000E-06
Wheel Slide Detection/Correction	400,000	2.500E-06

Trailer Car	MDBCF (Miles)	Failure Rate
Coupler, Draft Gear, Trainline	3,500,000	2.857E-07
Side Entrance Doors and Controls	150,000	6.667E-06
Communication Systems	300,000	3.333E-06
▪ PA and Intercommunications	600,000	1.667E-06
▪ Destination Signs	600,000	1.667E-06
Lighting	1,200,000	8.333E-07
HVAC Equipment and Controls	250,000	4.000E-06
Auxiliary Power Supply and Apparatus	200,000	5.000E-06
Carbody and Appointments	215,000	4.651E-06
Truck and Suspension	750,000	1.333E-06
Friction Brake Equipment	200,000	5.000E-06
Microprocessor Controls	200,000	5.000E-06
Wheel Slide Detection/Correction	400,000	2.500E-06

The average train speed is determined to be 41 miles per hour. The value will be used to convert to and from Mean Distance Between Failures (MDBF) and Mean Time Between Failures (MTBF).

Any failures directly attributable to a microprocessor for a particular sub-system will be charged to microprocessor controls. There will be no double charging of relevant failures.

For the above, a chargeable failure shall be defined as any failure that requires repair or replacement of any subsystem or vehicle component. Chargeable failures shall also include intermittent failures, unverified failures and software failures. Chargeable failures shall exclude consumable items, except those which are not achieving their design. Other excluded failures shall include the following:

a) A failure in equipment of another subsystem, due to the primary failure,
b) A failure of the Contractor or SCRRA to perform the recommended preventive maintenance actions,
c) Vandalism or physical mistreatment at a human interface,
d) Operating or weather conditions of unusual aspect or severity beyond those noted in Section 2.1.3, or
e) Due to an accident.

The term "unusual aspect or severity" shall be understood to mean a condition that does not occur on the SCRRA "rail lines" more often than once in ten (10) years. The time, place or type of service in which the car was being operated at the time of a failure shall not be of any consequence. The data collection shall be made throughout the warranty period. MDBCF shall be based on a period of twelve (12) months following initial burn-in, but no less than three (3) months following any design change, for the affected system.

16.2.2 Reliability and Failure Analysis

The Contractor shall submit reliability predictions, which demonstrates that the specified MDBF and MDBCF requirements shall be achievable. **[CDRL 16-006]** If certified field data is unavailable for a particular component, the reliability predictions shall use the MIL-HDBK-217F part stress method for the "ground mobile" environment for electronic components and NPRD-95 for non-electronic components.

The Contractor shall perform and submit to the engineer for review and approval a Failure Modes and Effects Analysis (FMEA) to identify weaknesses in safety critical system hardware and software design, and to analyze the modes and effects of failures whenever these details are not established by historical records of equipment operation. **[CDRL 16-007]** The FMEA shall provide input to system designs and to the safety analyses for theoretical circuit behavior, random component failures, electrical interference, systematic component failures, and software errors in software-based logic. FMEA and reliability prediction shall be updated throughout vehicle design development. A schedule of milestones which includes submittal of both the reliability prediction and FMEA shall be identified in the Reliability Program Plan.

The Contractor shall develop reliability block diagrams which show each equipment element that is essential to the successful performance of the system, including element interrelationships. Block diagrams shall be kept current with design iterations.

16.2.3 Reliability Program Plan

The Contractor's Reliability Program Plan shall be submitted to the Engineer for review and approval within sixty (60) days after NTP. **[CDRL 16-008]** The plan shall address, to SCRRA's satisfaction, applicable elements of MIL-STD-785 B; including, but not limited to: Monitoring/Control of Subcontractors and Suppliers; Program Review; Failure Reporting, Analysis, and Corrective Action System (FRACAS); Failure Review Board; Reliability Modeling; Reliability Allocations; Reliability Predictions; Part De-rating; Thermal Reliability; and Reliability

Development/Growth Testing. In addition, the Program plan shall address:

a) Reliability program objectives,
b) Reliability program schedule, which identifies specific tasks, with start and completion dates, and explains how these tasks are coordinated and integrated with major program milestones for design, manufacturing, and testing,
c) Methodology whereby the Contractor shall predict compliance with the reliability requirements,
d) Organization of personnel responsible for managing the reliability program,
e) Controls for activities of Subcontractors and equipment suppliers, to assure their compliance with reliability program methods and objectives, and
f) Demonstration testing plans for verification of compliance with reliability requirements when calculations and analyses are inconclusive, or when past performance records are incomplete or unavailable.

Reliability progress reporting which details implementation of the approved reliability program, shall be submitted to SCRRA on a monthly basis.

16.2.4 Reliability Demonstration Plan

The Contractor shall submit to the Engineer, for review and approval, a Reliability Demonstration Plan (RDP) no later than ninety (90) days before delivery of the first Unit. **[CDRL 16-009]** The plan shall address the following to illustrate compliance with the specified MDBF and MDBCF requirements:

a) Demonstration schedule,
b) Reliability demonstration procedures and forms for recording and submitting data,
c) Success-failure criteria for measuring MDBF and MDBCF values for individual equipment items and subsystems under demonstration,
d) Failure analysis of reported failures to identify the cause and need for corrective action. The Contractor shall establish a Failure Review Board (compromised of Contractor and at least one SCRRA personnel) to meet with SCRRA, as required, to determine the need and depth of failure analyses,
e) Change control procedures for implementing design changes during the demonstration program, and
f) Format and location of test records, test logs, and data records.

The Contractor shall furnish onsite, for the entire demonstration, a qualified reliability engineer to oversee associated activities. The Contractor proposed reliability engineer shall be subject to SCRRA approval.
If, at the end of the demonstration, Contractor is unable to substantiate SCRRA's satisfaction that the equipment has met the reliability requirements, the Contractor shall redesign the equipment as

needed to achieve acceptable reliability. Acceptable MDBF data shall be obtained by another demonstration, and the Contractor shall bear all costs associated with the redesign effort, including any required vehicle modifications.

16.2.5 Reliability Demonstration Procedures

The Contractor shall provide a minimum of the following requirements in its reliability demonstration procedures:

a) All equipment failures reported during reliability testing shall be classified as relevant or non-relevant failures by the Failure Review Board (FRB). Failures shall include all failures, whether or not occurring in revenue service.

b) The plan shall describe the details of the burn-in period for each vehicle. All equipment failures during the burn-in shall be reported and recorded, but not counted in establishing MDBF values.

c) A proposed plan for corrective action shall be developed and forwarded to SCRRA for approval. The plan shall include proposed 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 unless approved by SCRRA.

d) Preventive maintenance procedures specified for the equipment during normal operation shall be performed by SCRRA during the reliability demonstration.

e) A monthly Reliability Report shall be maintained which contains all the information necessary to calculate MTBF, MTBCF, MDBF and MDBCF values for the vehicle and major systems, and to verify successful demonstration of the reliability requirements. The failure record shall be provided to SCRRA in hard copy and electronically. **[CDRL 16-010]**

The Contractor shall provide a detailed discussion of the reliability demonstration procedures in the Reliability Demonstration Plan.

16.3 MAINTAINABILITY PROGRAM

The vehicle shall incorporate design standards which minimize Mean Time to Repair (MTTR) and costs throughout its intended useful life. The objectives of the maintainability program, including corrective and scheduled maintenance, shall provide for enhanced vehicle availability and minimization of maintenance costs.

16.3.1 MTTR Requirements

The quantitative maintainability requirement for SCRRA's vehicle shall result in a MTTR of no greater than 1.8 hours. This shall be the weighted average of the MTTR of the key system elements as listed below.

System Element	MTTR (hours)
Auxiliary Electrical Equipment	1.50
HVAC	2.00
Trucks	1.60
Passenger Doors	1.00
Brakes	2.00
Communications	1.00
Monitoring	1.00
Windows	0.50
Locomotive Controls	1.00
Water System	1.00
Coupler and Draft Gear	1.00

Compliance with requirements shall be illustrated during the Maintainability Demonstration.

16.3.2 Maintainability Program Plan

The Contractor's Maintainability Program Plan shall be submitted within ninety (90) days after NTP and shall include a detailed plan outlining all schedules and activities for vehicle corrective and preventive maintenance. **[CDRL 16-011]** This plan, along with the proposed maintenance manuals and associated drawings, shall be included in the Master Program Schedule. The plan shall outline each maintenance task, time schedules, recommended tools, personnel, and skill levels required. These recommendations shall be based upon those of the Contractor and of the equipment suppliers. The weighted average of the component MTTR shall illustrate compliance with the overall MTTR requirements. This plan shall be coordinated with the maintenance manuals and agree with them.

16.3.3 Maintainability Demonstration Procedures

Each equipment FAI shall include evaluations of maintainability. At the car level, a formal demonstration shall be performed based on MIL-STD-471 and a minimum sample size of one (1) Unit. As part of the training program for maintenance personnel, selected servicing, preventive maintenance, troubleshooting, change-out of components, corrective maintenance, and use of special tools shall be demonstrated where special emphasis, instruction, or proficiency is needed. Demonstration shall use production Units on SCRRA property, which shall be documented by videotape and submitted to SCRRA. Actions necessary to enable train movement under disabling conditions shall also be demonstrated. The Contractor shall submit a Maintainability Demonstration Procedure **[CDRL 16-012]** no later than ninety (90) days before delivery of the first Unit. The Contractor shall videotape or digitally record all demonstrations and deliver as part of training aids.

16.3.4 Scheduled Preventive Maintenance

Scheduled preventative maintenance shall comprise all tasks that are performed to service the car and those recommended by equipment suppliers to defer or prevent failures and maximize equipment life.

Monitoring of equipment performance by SCRRA shall commence and be applicable three (3) months after acceptance of the first car. This delay period exists to enable the Contractor to ensure that all maintenance requirements for the car equipment have been effectively established by its operating and maintenance training programs and manual publications.

16.4 REGULATORY REQUIREMENTS

SCRRA's car shall be designed and constructed to be safe to passengers, persons near the vehicle, and employees, both under normal operating conditions and in the event of equipment failure. The Contractor shall ensure that all systems' safety aspects are considered for each individual system and for systems as integrated to complete the vehicle design.

Conflicts between performance and safety requirements will be addressed on a case-by-case basis.

The guidelines for resolution of conflicts will be as follows:

a) Applications, which in accordance with the requirements of this section are determined to have a significant impact on passenger safety, will conform to applicable safety requirements. Requirements for other material characteristics or properties will conform to that of materials typically used for the application that are available at the time of award of contract. Typical examples of this application are materials used in the interior of the car body.

b) Applications which do not meet the criteria described in the previous paragraph will require conformance to all operational, performance, service, and maintenance requirements.

16.4.1 Industry Codes and Standards

All equipment shall comply with applicable codes, standards, and regulations cited in this Specification. Where conflicts exist between standards, the more restrictive, as determined by SCRRA, shall apply.

16.4.2 Governmental Rules and Regulations

All equipment shall comply with applicable federal, state, and local rules and regulations. These include, but are not limited to, the following:

a) Code of Federal Regulations, Title 49, Part 609: "Transportation of Elderly and Handicapped Persons." (FTA).

b) Code of Federal Regulations, Title 49, Parts 27 and 37: "Transportation for Individuals with Disabilities." (U.S. Dept. of Transportation).

c) Military Standard, MIL-STD-882: "System Safety Program Requirements." (U.S. Dept. of Defense).

Deviations from, and substitutions of, specified standards shall be made only if previously approved by SCRRA. The Contractor shall submit a detailed comparison of the alternative criteria, the rationale for the alternative, and whether the proposed code or standard meets or exceeds the existing standard.

16.5 SYSTEM SAFETY PROGRAM

16.5.1 System Safety Program Plan

Contractor shall develop, implement, and maintain a comprehensive System Safety Program Plan (SSPP) **[CDRL 16-013]** conforming to the guidelines and requirements of MIL-STD-882, latest revision, Section 4 and all tasks within Sections 100 and 200. SCRRA will use the implementation guidelines of Appendices A and B of MIL-STD-882 as the basis for determining acceptability of the Contractor's SSPP. The System Safety Program shall be in accordance with the SSPP and shall address 49 CFR 238.105 requirements.

The SSPP shall identify all hazards related to the vehicle and impose design requirements and management controls, which prevent mishaps by eliminating hazards or reducing risk to levels acceptable to SCRRA. The SSPP shall be developed in the earliest phases of the Contract and shall be continuously maintained throughout as design and construction evolves. Safety requirements shall be incorporated into the SSPP and the Contractor's designs.

16.5.2 General Design Requirements

Hazards shall be resolved according to the precedence rules listed in Paragraph 4.4 in MIL-STD-882, with the restriction that hazards with Category I and II severity (as defined in MIL-STD-882) shall be resolved only by methods 4.3a or 4.3b.

The general safety design requirements of Paragraph 4.3 in MIL-STD-882, and the guidelines listed below, shall be incorporated into the design of all vehicle systems affecting safety:

a) Only components with high reliability and which have been proven in conditions similar to the projected service shall be utilized.

b) All devices not guaranteed fail-safe shall be assumed capable of failing in permissive modes.

c) All electronic circuits and software shall be assumed capable of failing in permissive modes.

d) 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.

e) All vital circuits not wholly within the system apparatus enclosure shall be double-wire, and double-break, with the exception of connections to non-vital circuits, which may be single-wire, and single-break.

f) 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 percent of the release value of any safety device in the circuit.

g) Commands that result in permissive conditions shall be propagated by no less than two (2) 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.

h) Systems controlled by variable level signals shall be arranged such that zero signal level results in the most restrictive condition. At least one (1) 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.

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

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

k) Systems subject to wear shall not wear to permissive states within a period less than three (3) times the overhaul period under the worst-case combination of duty cycle, environment, and all other influences. Such devices shall be clearly indicated as SAFETY CRITICAL in the maintenance manuals.

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

m) All locks, catches, and similar devices affecting safety shall be either self-engaging without application of power, or, if engaged by application of power, shall remain fully and safely engaged in the absence of power.

n) All systems shall function safely under all combinations of supply voltages, fluid pressures, shock, vibration, dirt accumulation, and SCRRA's environment.

o) All safety related systems, and devices within those systems, shall be clearly identified as SAFETY CRITICAL in all maintenance manuals, procedures, and training materials.

16.5.3 Failure-Induced Hazards

Vehicle equipment and systems shall be designed and constructed to revert to safe modes under failure conditions. The Contractor shall employ high quality components, proven systems, redundancy, checking devices, and other techniques to accomplish this goal.

Vehicle systems whose failure could result in hazards of Category I or II severity shall conform to both of the following design principals, and shall be validated per Unit Qualification Test.

- The failure of a single device shall not result in a permissive condition, and
- An undetected failure of any device shall not permit a subsequent device failure to result in a permissive condition.

Systems shall conform to the safety design principals by one or both of the following methods:

- The utilization of fail-safe devices, that is, devices with known, guaranteed-by-the-manufacturer failure modes, such as signal-grade relays, and
- Independent channels with independent checking of each. All channels shall indicate a permissive state in order that the controlled system may achieve a permissive state. Failure in any channel shall not affect any other channel, or force the system into a permissive state. Lack of correspondence between channels shall be alarmed and shall force a restrictive state on the system. Checking equipment invariably requires devices conforming to this method.

Failures in equipment which result in an indication of danger, whether or not actual danger exists, shall be considered to have occurred in a safe manner. Conversely, a failure which results in an indication of safety, when in fact a dangerous condition may exist, shall not be considered safe.

16.5.4 Friction Brake System

The friction brake system shall control service and emergency brake applications on a per car basis with the wheel slide detection/correction being controlled on a per truck basis. Each is permitted to have independent permissive failure modes.

16.5.5 Fire and Life Safety

All vehicle components, subsystems, and systems shall be designed for the prevention of fire and protection of the public, employees, and emergency response personnel from injury due to fire, smoke, explosion, or panic due to fire, and protection of system elements from damage by fire or explosion.

Design shall provide for equipment to be located outside of the passenger compartment, whenever practical, in order to isolate potential ignition sources from combustible materials. Vehicle end-caps and the floor shall be designed to prevent propagation of an underfloor fire to the vehicle interior. Fire-stops shall be provided at floor and roof penetrations. Enclosures for control and other critical equipment shall be located to provide protection against environmental contamination and mechanical damage.

The Contractor shall submit to the Engineer for review and approval a Fire Safety Report addressing materials, certifications, fire safety analysis and inspection, testing and maintenance procedures in compliance with the requirements of 49 CFR 238.103. **[CDRL 16-014]**

16.5.6 Safety under Normal Operating Conditions

The vehicle shall present a safe, hazard-free environment to passengers and the operating and maintenance personnel.

Passengers shall not be exposed to tripping hazards, sharp points and edges, lethal or injurious voltages, toxic materials, abrupt or unexpected accelerations, or similar hazards. Location, illumination levels, colors, graphics, and surface finishes shall be selected to maximize visibility of step edges, windscreens, controls, and other objects with which the passengers must interface.

Normal and emergency equipment and controls which passengers may operate shall be clearly identified, and operating procedures shall be presented in both printed and graphic formats.

Maintenance manuals, procedures, and training shall indicate the proper handling, storage, and disposal of hazardous materials. Exposure of maintenance personnel to lethal or injurious voltages shall be minimized through compartmentalization, interlocks, and similar measures. All equipment shall be free from sharp points and edges. All equipment enclosures containing hazardous materials, lethal or injurious voltages, or other risks shall be clearly labeled on both the outside and inside of the equipment enclosures.

Maintenance, operating, training, and other manuals shall clearly identify all hazardous materials and equipment. All maintenance procedures involving hazards shall contain clear identification of the hazard and instructions to minimize or eliminate the hazards during the procedure.

16.5.7 Human Error and Other External Influences

The Contractor may wish to use MIL-STD-882 and MIL-STD-782 for guidance. All systems shall minimize unsafe conditions resulting from human error. No sequence of operations, or the simultaneous activation of any controls, shall result in unsafe conditions. Where conflicting commands, such as simultaneous power and brake, are requested, the more restrictive shall result.

Maintenance of safety-related equipment shall be arranged such that the effects of errors are minimized. Methods such as limitation of adjustment ranges, unalterable software, non-interchangeable parts, and visible wear indicators shall be employed.

16.5.8 Hazards Identification

The Contractor shall identify all failure-induced and normal operating (non-failure condition) hazards falling into severity Categories I, II, and III. Hazards shall be compiled into lists and submitted to SCRRA for approval.

As required by MIL-STD-882, hazard lists shall be organized into a Preliminary Hazard List (PHL) **[CDRL 16-015]**, Subsystem Hazard List (SSHL) **[CDRL 16-016]**, and System Hazard List (SHL) **[CDRL 16-017]** as described in Tasks 201, 203, and 204, respectively.

In addition to those hazards identified by the Contractor, the following hazards shall be included in the listings and shall be considered hazards of Category I or II severity:

a) Emergency brakes fail to apply when requested,
b) Service brakes fail to apply when requested,
c) Propulsion fails to cease when requested,
d) No-motion detection system indicates no-motion when vehicle is not at zero speed,
e) Excessive currents or overheated equipment cause fire hazard,
f) Indication of uncoupled when vehicles are coupled,
g) Indication of coupled when vehicles are uncoupled,
h) Vehicle moves in wrong direction,
i) Vehicle speed and track curvature combine in such a manner as to cause a train to derail or a vehicle to overturn,
j) Onboard equipment causing EMI affecting wayside signaling system or other onboard systems,
k) Wayside equipment causing EMI affecting wayside signaling system through vehicle or onboard systems,
l) Emergency brake fails to stop at required distance(s) per Specification, and
m) Service brake fails to provide requested braking rate.

16.5.9 Hazards Analysis

Contractor shall perform hazard analyses on all identified hazards. Per-hour failure rates shall be established for each hazard severity category. Analyses shall demonstrate that the vehicle conforms to the requirements of this Specification and that all identified hazards are either eliminated, or reduced to levels of risk acceptable to SCRRA.

All hazard analyses shall be adjusted or amended as the vehicle design and construction progresses.

The analysis methods shall be selected by the Contractor as appropriate for the system under evaluation and the Category of hazard severity. Hazards of Category I and II severity shall receive analyses sufficiently rigorous to demonstrate that the hazard cannot occur under any reasonable conditions. The Contractor shall be prepared to demonstrate by test the validity of any portion of all analyses of Category I or II severity hazards. Failure rate for Category I and II hazards must be less than 10^{-7} per hour of operation. Failure rate for Category III hazards must be less than 10^{-5} per hour of operation.

Standard failure and safety analysis methods, and published failure rates for components, shall be utilized wherever possible. Failure mode for all electrical circuits shall be fully analyzed using Failure Mode Effects and Criticality Analysis, Operator and Safety Hazards Analysis, Preliminary Hazards Analysis, and Fault Tree method as approved by the Engineer to address the prevention, detection, and elimination of hazardous conditions. Methods used shall be submitted for review and approval by the Engineer.

Existing hazard analyses of subsystems may be submitted provided the analyzed subsystem is identical in all respects to that proposed, including the operating environment, and the analysis method is sufficiently rigorous. Analyses or tests required by other Sections of this Specification, such as structural analyses or fire penetration tests, may also be submitted for consideration by SCRRA where appropriate.

Analyses shall examine the vehicle in all possible configurations, and shall include circuit faults within the coupler electrical circuits.

Analyses shall identify all maintenance errors that could result in unsafe conditions, such as incorrect adjustment of sensors, and incorrect adjustments of the door obstruction sensing system to cite two, but not all, examples. Analyses shall also include design errors that could produce unsafe conditions, such as improper breaker type or rating and temperature or environmental dependence on proper operation for use in checking designs.

End of Section

Contract Deliverables Requirement List

CDRL No.	Title	Car Type	Reference Paragraph
16-001	Quality Assurance Plan	All	16.1.2
16-002	Quality Assurance Manual	All	16.1.2
16-003	FAI Schedule	All	16.1.17.2
16-004	FAI Reports	All	16.1.17.2
16-005	Pre-shipment Inspection Schedule	All	16.1.17.5
16-006	Reliability Predictions	All	16.2.2
16-007	Failure Modes and Effects Analysis	All	16.2.2
16-008	Reliability Program Plan	All	16.2.3
16-009	Reliability Demonstration Plan	All	16.2.4
16-010	Monthly Reliability Report	All	16.2.5
16-011	Maintainability Program Plan	All	16.3.2
16-012	Maintainability Demonstration Procedure	All	16.3.3
16-013	System Safety Program Plan (SSPP)	All	16.5.1
16-014	Fire Safety Report	All	16.5.5
16-015	Preliminary Hazard List (PHL)	All	16.5.8
16-016	Subsystem Hazard List (SSHL)	All	16.5.8
16-017	System Hazard List (SHL)	All	16.5.8

SECTION 17

TESTING AND ANALYSIS

SECTION 17

TESTING AND ANALYSIS

TABLE OF CONTENTS

SECTION 17

TESTING AND ANALYSIS

17.1 GENERAL REQUIREMENTS

Each car and its associated equipment shall be subjected to a comprehensive test program to validate that the design and performance meet Technical Specifications, to assure operational compatibility with existing systems and existing cars, and, to establish the service lives of systems and components for optimum reliability and maintainability. Three (3) basic types of tests have been identified: qualification, production conformance/predelivery and acceptance. Qualification tests ("proof of design" tests) on first articles, Specification compliance tests, and routine acceptance tests on all items shall be required. Components or systems shall be built to the approved production configuration as tested in this Section. Components and subsystems that are not the approved production configuration shall not be used for production or spares.

The Contractor shall provide at least fifteen (15) working days notice to the Engineer prior to the start of any test referred to herein. All the tests, specified in this or any other Section of this Specification, will be conducted by the Contractor and at the Contractor's expense. This expense shall include all the costs of test equipment and test personnel required to conduct the tests. For dynamic tests to be conducted on SCRRA property, SCRRA will supply the test train operating crew and other individuals required by SCRRA policies for the conduct of such tests at no charge to the Contractor. Should the results of the dynamic tests indicate that the equipment does not comply with the requirements of the Technical Specification; the Contractor shall reimburse SCRRA for all SCRRA costs for retesting, including but not limited to, test train operating crew and other individuals required by SCRRA policies. These tests shall be conducted at such times and on such portions of SCRRA lines as mutually determined by the Engineer and Contractor.

SCRRA reserves the right to perform, at its own expense, additional operating tests of each car separately or in trains of up to 10 cars to verify the acceptability of the cars. These additional tests will be conducted within thirty (30) days of the completion of Contractor acceptance testing. The Contractor may be required to participate and furnish technical assistance for such tests. If the result of the testing indicates that the vehicle was non-compliant with the Technical Specification (in line with the stated purpose of the testing), the cars in question shall be returned to the Contractor for correction and resubmitted to SCRRA. SCRRA will have an additional thirty (30) days to retest.

All expenses and costs incurred in the removal of cars from the designated delivery point for correction of defects shall be borne by the Contractor. Definitions and specific requirements and costs of test crews are defined in the Terms and Conditions of the Contract.

No later than two hundred-seventy (270) days after NTP or sooner if required by Master Program Schedule, the Contractor shall submit a detailed plan and schedule for conducting all tests to the Engineer for review and approval. **[CDRL 17-001]** The Submittal shall include classification of the type of test, the location where each test will be conducted and the system/equipment to be tested.

17.1.1 Required Tests

The required tests and adjustments shall be performed on the cars supplied under this Contract and are grouped into three (3) classifications:

- Qualification
- Production (routine) and Pre-Delivery
- Acceptance

Packaged components and assemblies, which do not receive testing as parts of a system, shall be tested at the point of manufacture as part of the quality assurance program. Test results shall be available for the Engineer's inspection.

17.1.2 Instrumentation Calibration

The Contractor shall provide all instrumentation, testing equipment, tools, diagnostic equipment, spare parts, and all other equipment and supplies necessary for the testing. Accuracy and response of the instrumentation used for testing shall be sufficient to determine the degree of compliance with the Specification and design data. All instrument calibrations shall be current prior to start of tests. The Contractor shall demonstrate the calibration of any instrument upon request from the Engineer or his representatives during the tests.

17.1.3 Design Qualification Tests

Qualification Tests (see Sections 17.4, 17.5, 17.6) encompass components, systems, and car tests to be performed at the manufacturer, Contractor, and SCRRA facilities to demonstrate conformance of the component, system, or car design with the Technical Specification requirements.

Qualification tests shall be organized into three (3) sub-categories:

- Component / Subsystems
- Static Vehicle
- Dynamic Vehicle

Each component shall be wired, piped, and assembled with auxiliaries, as necessary, to allow for complete component conformance tests, which shall be run in conjunction with the First Article Inspection. Components shall pass each test in acceptable condition. Tests are to be witnessed by the Engineer or designee.

17.1.4 Production and Pre-Delivery Tests

Production (routine) Tests (see Sections 17.6, 17.7) encompass all components, systems, and car tests to be performed on an on-going, routine basis at the manufacturer's or Contractor's facility on a specified number of components, systems, and cars to demonstrate proper operation and conformance with Technical Specification requirements.

Pre-Delivery Tests encompass all components, systems, and car tests to be performed on an on-going, routine basis at the manufacturer's or Contractor's facility on each component, system and car to demonstrate proper operation and conformance with Technical Specification requirements prior to delivery.

17.1.5 Contractor Acceptance Tests

Vehicle Acceptance Tests (see Section17.8) encompass all car tests to be performed by the Contractor on each car at a SCRRA or other specified site to demonstrate the conformance of the car to the performance requirements of the Technical Specifications as a Condition of Acceptance of each car.

17.2 TEST PROCEDURES AND REPORTS

17.2.1 General

The Contractor shall ensure that all test procedures and reports are formally reviewed and approved for validity and reliability by its Engineering Department prior to their submittal to the Engineer. Each procedure and report shall include a sign-off block that includes the name and signature of the Contractor's responsible engineer: date the review was completed and approved by the Engineer. Whenever test requirements overlap, the more restrictive requirement shall take precedence.

Test procedure and report requirements shall also apply to tests included in the Contractor's approved test plan and schedule required by Section 17.1.

A written procedure and report for all tests performed shall be submitted to the Engineer for approval prior to performance of the tests. The report pertaining to routine acceptance tests on cars and equipment shall be included in the "Car History Book" (See Section 19.7) for that car. A separate procedure and report for each shall be submitted. All procedures shall be submitted at least sixty (60) days prior to the scheduled test date, and shall be approved by the Engineer, prior to the conduct of any test. The Contractor shall assign one or more engineers who shall perform the tests, render the installed equipment fully operational and demonstrate that the equipment properly interfaces with other systems installed in the cars. No test will be considered complete until a test report has been received and approved by the Engineer.

17.2.2 Test Procedure Requirements

The Contractor shall prepare a detailed test procedure for each test described herein and for any other tests conducted by the Contractor in connection with his own quality assurance program. Each test procedure shall be submitted to the Engineer for review and approval, prior to conducting any test. **[CDRL 17-002]** As a minimum, each procedure shall state the following:

a) Scope, objectives, pass/fail criteria, and applicable Section of the Technical Specification.

b) Operational parameters and responsibilities, including environment, equipment, personnel, services, setup sketches, diagram, schematics, and photographs.

c) Prerequisite tests and activities.

d) Test equipment and test instruments including description model numbers, serial number, and calibration dates.

e) Microprocessor software test procedures and test cases designed to uncover software errors, if appropriate.

f) Test constraints, including equipment, personnel, and support required from subcontractors, if appropriate.

g) Operation monitoring requirements including instructions for performing the test, permissible adjustments during the test, and representative test data sheets with instructions.

h) Provision for retest in cases of test failure or modification of the tested item.

i) Means of updating test procedures based upon results of other tests.

The procedures for these tests shall be updated as required. The basis for changes to these procedures shall be the feedback from both the Contractor and the Engineer. The procedures may be expanded to include checkpoints in areas, which have proven to be troublesome. All test procedure revisions shall be subject to the Engineer's approval.

Each detailed Test Procedure shall be submitted to the Engineer for review (at least sixty (60) days prior to test date). It shall allow the Engineer at least thirty (30) working days for initial review and comment or approval of the procedure, and with sufficient remaining time for the Contractor to modify a rejected procedure and resubmit it for review and approval, a minimum of fifteen (15) working days prior to conducting the test covered by the procedure.

17.2.3 Test Report Requirements

The Contractor shall submit a written report of each test, including copies of all test data, to the Engineer for review and approval. **[CDRL 17-003]** For tests, which are performed on all cars or components, the reports of those tests shall be included in the appropriate Car History Book or equivalent database. As a minimum, every report shall include a description of the test, detailed physical description of test specimen (serial number, length, width, height, weight material, etc.), all raw data collected in the test, all data reduction forms, calibration dates of equipment, photographs, physical and chemical characteristics of the test specimen (as appropriate to the test being performed), appendices, and any other data necessary to support the test results, and a summary of the results in a manner that can be directly compared to the Specification without further calculations. Any deviations from the test procedures, discrepancies in test results, and corrective actions employed shall be documented and discussed in detail in the test report. Test procedures and reports provided by a Supplier are to be approved by the Contractor, prior to the Contractor's submittal, of such, to the Engineer.

Should the Test Procedure and/or Report be inadequate and not meet the requirements of the Technical Specification, the Engineer reserves the right to require additional plans, procedures, analyses, details, and schedules to assure that the test program or report is adequate and that the component, subsystem or car does meet the Specification requirements. The approval of the Engineer does not in any way relieve the Contractor of responsibility for ensuring the adequacy of the Test Program within the scope of this Technical Specification.

17.2.4 Corrective Action Plan

In the event of a failure to meet the Technical Specification requirements in any test, necessary corrective action is to be taken by the Contractor, subject to the approval of the Engineer, at the Contractor's expense, and the failed test component, subsystem, or car, shall be retested in its entirety at the Contractor's expense. If further corrections or modifications affecting the item under test are instituted, the Contractor shall perform a complete system retest at his expense to demonstrate compliance with the Specification requirements.

17.3 COMPONENT DESIGN QUALIFICATION TESTS

17.3.1 Fire Safety

All materials, used in the construction of the cars, shall be tested and analyzed in accordance with the requirements of Section 15.23 and 49 CFR 238.103. All materials shall be tested at a recognized, Engineer approved, independent testing laboratory. All materials tested shall be selected from production material used in the actual car construction unless otherwise approved by the Engineer.

17.3.2 Door Panel

One (1) door panel of each type shall be tested to demonstrate proper strength and rigidity as required by Section 4.9.1.2.

17.3.3 Windows

Cab windshields, left side windshields, standard passenger side windows, emergency exit passenger side windows, cab sliding windows, cab partition door windows, end-of-car door windows, and passenger side door windows shall be tested in accordance with requirements of Section 4.8.1 and 49 CFR 238.221. The qualification speed for these cars is 110 mph.

17.3.4 Seat Assemblies

One (1) of each configuration of seat shall be tested to demonstrate compliance with the requirements of Section 4. For purposes of seat configuration, it includes all components that are permanently attached to the seat structure.

17.3.5 Ballasts

Two (2) lighting ballasts of each type used in the car shall be tested to demonstrate compliance with the specified requirements.

17.3.6 Motors - AC and DC Power

Each type of motor supplied shall be “type” tested by the manufacturer in accordance with IEEE-11 with electrical characteristics per IEEE-112, IEC-349-2, or NEMA MG-1 (1998), Section II, Part 12, as appropriate for the motor application. The first motor produced in each production lot, and an additional motor for every 100 motors produced in each production lot or portion thereof, shall be tested. The motors to be tested, in addition to the first production unit, shall be selected at random by the Engineer from the production run.

All DC-powered motors shall be tested in accordance with NEMA MG-1, Part 12 (for DC motors). All AC-powered motors shall be tested in accordance with NEMA MG-1, Part 12 (for AC motors), with one (1) motor of each type tested for temperature rise in accordance with IEEE-112.

17.3.7 Battery, LVPS, and PA/IC/Radio Power Supply

A test of the battery per Section 10.3.1; of the low voltage power supply and battery charger per Section 10.4; and, of the PA, intercom, radio power supply per Section 13.1, shall be performed to demonstrate compliance with the Specification. Any other power supplies and battery chargers used for different vehicle systems shall also be tested to demonstrate compliance with specified requirements. Power supplies shall be tested with actual loads applied or simulated loads as approved by the Engineer.

The qualification testing for the low voltage power supply shall include, as a minimum:

- A continuous heat run at rated input voltage and rated output voltage and current. The heat run shall be of sufficient duration to allow all critical elements to stabilize in temperature. Temperature rise over ambient shall be within the Contractor’s limits as set forth in the test plan.
- The unit under test shall be operated for 1 hour at an input voltage 1 volt below the upper limit of the specified operating range and at rated output current and voltage.
- The unit shall be operated for 1 hour at an input voltage 1 volt above the lower limit of the specified input range for which rated output voltage and current are to be delivered.
- The unit shall be cycled off and on into rated load by interruption of the source voltage supply external to the power supply. Rate of cycling shall be approximately 1 second on, 1/2 second off, and shall proceed for 2 minutes.
- The unit shall be started into an open circuit five (5) times in succession.

- The unit shall be started into a short circuit (as nearly representative of a "bolted fault" as the test setup allows) five (5) times in succession.
- The unit shall be started into an overload (approximately 120 percent of rating). The overload shall then be removed, and the unit shall automatically provide rated output voltage.
- Noise measurements shall be taken sufficient to demonstrate compliance with the specified requirements.
- At all operating points representing deliverance of rated output voltage or routine current limit operation, voltage wave forms shall be monitored by an oscilloscope to determine compliance with the specified levels of ripple. Similarly, output voltage, during normal operation at various operation points shall be monitored for compliance with the voltage regulation requirement.

The qualification testing for the communication system, PA, intercom, radio, and sign system power supplies shall include as a minimum:

- A continuous heat run tested at rated input voltage and rated output voltage and current. The heat run shall be of sufficient duration to allow all critical elements to stabilize in temperature. Temperature rises over ambient shall be within Contractor's limits as set forth in the test plan.
- The unit under test shall be operated for 1hour at an input voltage just below the upper limit of the specified operating range and at rated output current and voltage.
- The unit shall be operated for 1- hour at an input voltage just above the lower limit of the specified input range for which rated output voltage and current are to be delivered.
- Noise measurements shall be taken sufficient to demonstrate compliance with the Specifications.

17.3.8 Truck

17.3.8.1 General

Each truck frame and bolster type shall be tested to verify that the maximum allowable stresses, specified in Section 11.4 under an AW3 load, are not exceeded. The first production unit of each type shall be used unless otherwise specifically approved by the Engineer.

Not less than seventy-five (75) strain gauges shall be applied to locations on the truck as agreed to by the Contractor and the Engineer, the Engineer shall determine the locations in the event of a disagreement. The locations on which to place strain gauges shall be determined by analysis and by a preliminary static test to determine the location and direction of stresses using brittle lacquer or other indicators. If the Contractor elects to use analytical methods in lieu of brittle lacquer or other indicators, then the Contractor shall apply not less than 100 rosette strain gauges to the truck at locations of expected high stress and areas of interest as agreed to by the Contractor and the Engineer. **[CDRL 17-004]** The Engineer shall determine the locations in the event of a disagreement. There shall be no less than two (2) locations where there are a sufficient number of gauges to encircle the side frames, and two (2) locations that encircle the bolster, to appraise the cross sectional stress distribution.

17.3.8.2 Static Load Test

The routine static load test shall be repeated twice with a complete release between applications, and shall be performed with the suspension elements replaced by solid blocking.

Routine Static Load Test

Truck	
Vertical	50% x (Carbody at AW3)
Lateral	25% x (vertical load) applied at cg
Longitudinal	Equivalent to AW3 emergency braking, but not less than 15% of vertical load applied at cg
Tread Brake Unit (TBU)	
Horizontal	Max Horizontal Reaction, AW3 Emergency
Vertical	Max Vertical Reaction, AW3 Emergency, plus six (6) times the TBU weight
Disc Brake Unit (DBU)	
Horizontal	Max Horizontal Reaction, AW3 Emergency
Vertical	Max Vertical Reaction, AW3 Emergency, plus six (6) times the DBU weight
Dampers	Maximum possible damper force

The stress results of the two (2) load applications shall be compared with the calculated stresses, and the higher shall be less than the allowable stresses, as specified in Section 11.4. Manual calculations may be required in areas of high stress gradient or near welds, to extrapolate the test results to determine the critical stresses. If the stress exceeds the allowable stresses, the truck design shall be corrected to bring the test stress to less than the allowable stress. The redesigned truck shall be retested at the expense of the Contractor, and all trucks previously installed in the cars shall be modified to be in accordance with the corrected design.

Prior to the test, a magnetic particle or dye penetrant inspection of the truck for cracks shall be performed in the presence of the Engineer. If cracks are detected, the design shall be corrected and re-inspected before testing.

To demonstrate that the truck has adequate strength to sustain a maximum load in the presence of a combination of minor manufacturing defects, it shall be overloaded statically once as follows:

Overload Test Loads

Truck		
	Vertical	50% x (Carbody at AW3)
	Lateral	Vehicle overturning applied to cg
	Longitudinal	Equivalent to Main Reservoir Pressure in brake cylinder with maximum shoe wheel friction, and perfect wheel rail adhesion
Tread Brake Unit (TBU)		
	Horizontal	Equivalent to Main Reservoir Pressure in brake cylinder with maximum shoe wheel friction, and perfect wheel rail adhesion.
	Vertical	Equivalent to Main Reservoir Pressure in brake cylinder with maximum shoe wheel friction, and perfect wheel rail adhesion
Disc Brake Unit (DBU)		
	Horizontal	Equivalent to Main Reservoir Pressure in brake cylinder with maximum shoe wheel friction, and perfect wheel rail adhesion.
	Vertical	Equivalent to Main Reservoir Pressure in brake cylinder with maximum shoe wheel friction, and perfect wheel rail adhesion.
Dampers		Maximum possible damper force

Unit stresses at critical locations and dimensional measurements using dial indicators shall be taken before and after the test between representative points on the truck as approved by the Engineer. **[CDRL 17-005]** There shall be no permanent deformation as determined from strain gauge or dial indicator readings.

17.3.8.3 Fatigue Test

To demonstrate that each truck type has adequate fatigue strength under dynamic loading, each tested truck frame and bolster type shall be subjected to a minimum six million cycles of combined loading. Each tested unit shall be the unit previously tested in Section 17.3.8.2. The loads specified are minimum values. Each test truck frame and bolster shall be tested as a unit with the suspension elements replaced by approved solid blocking.

The vertical load shall be 50 percent of the AW2 car body weight with a ± 20 percent augment. The lateral load shall be applied first in one lateral direction and then in the opposite lateral direction. The longitudinal load as indicated below shall be applied first forward and then rearward. Both lateral and longitudinal loads shall act as if applied at the center of gravity of the car body at AW2 load with resulting vertical loading, due to transferring the loads from the center of gravity to the truck bolster, applied to the bolster. Accessory loads shall vary between plus and minus 100 percent of their maximum steady state values; brake unit under full cylinder pressure with not less than 20 percent adhesion.

Fatigue Test Loads - Range

Truck	
Vertical	50% x Carbody at AW2 ± 20%
Lateral	±15% x (Carbody at AW2)
Longitudinal	±15% x (Carbody at AW2 or full service braking whichever is greater)
Tread Brake Unit (TBU)	
Horizontal	0 to Max Horizontal Reaction
Vertical	± Max Vertical Reaction + 6 x TBU Weight
Disc Brake Unit (DBU)	
Horizontal	± AW3 Full Service Horizontal Reaction
Vertical	± AW3 Full Service Vertical Reaction plus 6 x DBU Weight
Dampers	± Maximum expected load

Note: The "±" symbol means that the load applied in the direction indicated, and then 180 degrees from that direction.

The phasing of loads shall result in maximum combined stresses at the critical locations. All tests shall result in maximum combined stresses at the critical locations that do not exceed those required in Section 11.4. The designation, by the Contractor, of critical locations is subject to the approval of the Engineer. **[CDRL 17-006]** The frequency of the load cycling shall not exceed 3 Hz, and load phasing shall remain within 5 degrees of theoretical, or as otherwise agreed to by the Engineer. During the fatigue test, the truck shall be inspected regularly using magnetic particle or dye penetrant to detect any crack initiation and progression. At the conclusion of the fatigue test, a magnetic particle or dye penetrant inspection for cracks shall be conducted in the presence of the Engineer. Cracks will be considered critical, if they have a definite direction and a minimum length of ¼ inch. A crack will be considered a failure once it has progressed ¼ inch after initial recognition. If evidence of progressive cracking or failure is found, the cause of such shall be assessed by the Contractor, an appropriate correction established, the truck retested at the expense of the Contractor, and all trucks installed under the cars shall be modified to be in accordance with the corrected design. The corrected design is to be approved by the Engineer. The correction and test shall be repeated until successful.

Cast trucks will be submitted to a 6,000,000 cycle fatigue test using the above specified fatigue test load ranges for the first 2,000,000 cycles. At the conclusion of the fatigue test, a magnetic particle or dye penetrant inspection for cracks shall be conducted in the presence of the Engineer.

Upon completion of the 2,000,000 cycle test, the frame and bolster used in that test shall be subject to fatigue loading, as tabulated below:

- 2,000,000 cycles with loads increased by 10 percent over fatigue test loads, then
- 2,000,000 cycles with loads increased by 20 percent over fatigue test loads

At the conclusion of the extended fatigue test either by failure or at 6,000,000 cycles, a magnetic particle or dye penetrant inspection for cracks shall be conducted in the presence of the Engineer. If a crack is found, the condition is to be assessed by the Engineer and the Contractor to determine if a design change is required.

Fabricated trucks will be submitted to a minimum 6,000,000 cycle fatigue test using the above specified fatigue test load ranges. The number of cycles will be increased beyond 6,000,000, if required, to ensure that the most severe fatigue strength weld detail has been exposed to the full endurance limit as defined by the American Welding Society Structural Welding Code D1.1 as detailed in APTA RP-M-009-98. At the conclusion of the fatigue test, a magnetic particle or dye penetrant inspection for cracks shall be conducted in the presence of the Engineer. Cracks will be considered as a cause for failure as detailed above.

17.3.8.4 Primary Suspension Test

A load deflection test shall be performed to demonstrate that the spring rates of the primary suspension system in all axes are within the design limits of the car. This test shall demonstrate that the primary suspension system responds as predicted and will not result in excessive deflection, prevent desired axle alignment in curving, or decrease truck clearance above top of rail to less than the minimum prescribed in Section 2.3.1.

17.3.8.5 Equalization Test

To verify the equalization provided by the truck design, one (1) of the cars, with air springs inflated, shall have one (1) wheel jacked up, and then lowered 2-1/2 inches. Contact between the other three (3) wheel treads and the rails shall be verified. Alternately, one (1) wheel may be run up on a wedge to obtain 2-1/2 inches of elevation, the other wheels remaining on level track.

Also one (1) of the cars, with air springs inflated, shall have one (1) wheel raised and then lowered two (2) inches and suitable instrumentation provided to measure the load carried on the other wheels. The load changes shall be less than 55 percent of the initial weight on any wheel.

Weight measurements shall be recorded for all wheels of the test truck; prior to raising the test wheel, when the test wheel is raised to the specified height, when the test wheel is lowered to the track, when the test wheel is lowered to the specified height, and when the test wheel is returned to track level.

For a truck/suspension design which does not have previous operating history on SCRRA, an equalization test will be made at 5 mph on a 250 foot radius yard track, supplied by SCRRA, with a 3 inch cusp tamped in. The cusp will be to the parameters in Section 7.6.1 of the 2003 NUCARS Users Manual, with C1 equal to 8.0 feet, and C2 equal to 39.0 feet. Either a low joint on the outside rail or a high joint on the inside rail may be simulated. The actual cusp geometry shall be reviewed before the test and approved by the Engineer. The test will be run on both inflated and deflated air bags. The test will be run on clean dry rail with a minimum rail temperature of 10 degrees F above the atmospheric dew point. For the equipment to pass the test, there must be no derailment, the instrumented wheelsets must not unload to less than 10 percent of the static vertical wheel load, and single wheel L/V ratio shall be less than the safety limit calculated for a 69 degree wheel flange angle using the Nadal criteria with theoretical friction of 0.5.

In the event that suitable equalization is not attained as indicated by the tests, the truck design shall be corrected, the truck retested at the expense of the Contractor, and all trucks installed under the cars shall be modified to be in accordance with the corrected design.

To verify the car stability provided by the truck design, the first car with simulated crush load shall be run up on a rail or blocking on one side to simulate 7 inches of super-elevation. Lateral displacement and roll angle of the car body shall be measured. In the event that the degree of motion restriction required is not attained as indicated by the test, the truck design shall be altered, and the car retested.

17.3.8.6 Alignment in Curves Analysis

An analysis shall be performed to demonstrate the yaw angle (angle of attack, AOA) of the lead axle in curves from 1 to 10 degrees curvature, in 1 degree increments, at balance speed. Wheel-sets with the ratio of AOA to degree of curvature of approximately 1.0 or less will have an acceptable radial alignment and are expected to produce only a nominal amount of wheel flange/rail gage face wear in curves.

17.3.8.7 Radiographic Inspection

Qualification shall require 100 percent radiographic inspection for all welds used for either construction or repair, and all critical areas of all castings, in those areas where radiographic inspection is possible. If not possible, ultrasonic inspection methods shall be used. Radiographs shall be made in accordance with American Welding Society (AWS) D1.1. Inspection quality level shall be selected by the truck manufacturer consistent with the truck design, but shall not be of lesser quality than that required by AWS D1.1. If the first truck fails the radiographic or UT inspection, then the second shall be inspected, and 100 percent process shall continue until a truck passes the inspection with no repairs. Production variables for the succeeding trucks shall duplicate those for the truck that passes the radiographic inspection. Critical welds shall continue to be inspected by radiography on 10 percent of the trucks chosen at random. Critical areas of castings will be subject to radiographic inspection. A method is to be provided by the truck manufacturer to positively identify the work of each welder.

Critical areas of the casting shall be as identified by the truck manufacturer and approved by Engineer **[CDRL 17-007]**, and shall include, as a minimum, all assembly welds and welds or portions of welds which, based on the results of the stress analysis and/or truck tests, have a fatigue stress is excess of 70 percent of the F_{TH} stress in Table 2.4 of AWS D1.1, 2002. Critical areas of castings shall be identified in a similar fashion.

Per Section 15.5.4, all exposed welds and entire castings of any steel castings used for trucks shall be subjected to magnetic particle or dye penetrant inspection. Magnetic particle inspection shall be in accordance with ASTM E 709 or approved equal. Ultrasonic inspection, if approved, shall be performed in accordance with AWS D1.1-002, Section 6.

17.3.9 Trainlines, Coupler, and Draft Gear

The coupler at both ends of a car and the car-to-car electric jumper cables shall be mocked-up in the same configuration they are to be installed and supported on the car. The electric cables shall be given a 100,000 cycle flexing test equivalent to the motions the cables would experience with the cars negotiating the “worst case” conditions of vertical and horizontal curves and minimum turnouts.

Coupler and draft gear qualification tests shall include tests pertaining to the performance and capabilities of the equipment and shall, at a minimum, include the following:

- Coupler draft and buff loading
- Coupler assembly within minimum and maximum initiation loads
- Coupler assembly minimum energy absorption
- Coupler assembly minimum compression stroke
- Draft gear deflection and uncoupling mechanism
- Anchor-casting static loading

All applicable inspections and verifications defined in APTA SS-M-003-98. In addition, the couplers set up at the manufacturer’s plant and on the cars or other car, as approved by the Engineer, shall be tested to determine that they have a sufficient gathering range and rotation as approved by the Engineer, to operate properly under the simulated worst case conditions of the specified vertical and horizontal curves, wheel wear, deflated and fully inflated air bags, static and dynamic spring deflections, as specified in Section 2.3.1.

17.3.10 Equipment Noise Tests

The Contractor shall conduct a noise and vibration analysis of the car, which shall include the predicted contribution of individual equipment and the effect of vibration dampening and sound deadening provided by the subassemblies. Equipment and subassembly noise and vibration tests shall be conducted prior to installation to demonstrate the accuracy of the Contractor's noise and vibration model. The subassemblies, (i.e., roof, side, floor) shall be tested as defined in ASTM E90-85 for measurement of sound transmission losses. Equipment and subassemblies shall be tested in accordance with the requirements of IEC-61373 Railway Applications Rolling Stock Equipment Shock and Vibration Tests. The equipment and subassemblies when installed on the cars shall comply with the requirements of Section 2.5.2.

Noise produced by the individual operation of all undercar and overhead ceiling/roof-mounted equipment and equipment mounted in lockers, which normally operates (except equipment that only operates occasionally, such as a circuit breaker or pneumatic venting device) shall not exceed the requirements of Section 2.5.2. This equipment includes motors, generators, blowers, brakes, compressors, valves, and other noise generating components.

The Contractor shall perform noise and vibration tests on the completed car to demonstrate compliance with the requirements of Section 2.5.2.

17.4 SYSTEM DESIGN QUALIFICATION TESTS

17.4.1 Control Systems

One (1) of each type of microprocessor based control unit shall receive performance and functional tests that simulate all normal and abnormal inputs and verifies all outputs. All microprocessor based control units shall receive a burn-in test in accordance with Section 15.27.4 while cycling the temperature over the specified temperature range.

17.4.2 Communication System

The complete communications system shall be tested on a one-time basis to demonstrate compliance with the requirements of the Technical Specification including Sections 13 and 15 and all applicable FCC, FRA, APTA and AAR requirements. It is emphasized that the entire system shall be tested in a laboratory bench setting in which each and every device shall be connected and functional. It shall be possible to exercise, use, and identify any and all devices including indicators, buttons, microphones, speakers, and switches of the communication system. All components shall be of the production configuration. Prior to the test, a complete test procedure shall be provided, which shall include a concise, step-by-step process of systematically verifying all requirements of the system.

17.4.3 Friction Brake System

Friction Brake System qualification tests including wheel slide detection/correction system shall include the following tests on one of the first three (3) complete car sets of production units to determine the following characteristics. As a minimum, the Contractor shall record speed versus time, stop distances, average V/T, and wheel and disc temperatures for all dynamometer tests.

17.4.3.1 Response

The friction brake system shall be tested to verify the response to all control inputs.

17.4.3.2 Linearity

Dynamometer test runs shall be made for simulated car weight AW0, AW2 and AW3 from each of the entry speeds of 20, 50, 80, and 100 mph. For each entry speed, 25 percent, 50 percent, 75 percent and 100 percent of full service braking effort and emergency braking effort shall be applied. Results shall be plotted to show the relationship between input signal and output braking effort over the speed and weight range.

17.4.3.3 Brake System Capacity

The system shall be tested on a dynamometer or flywheel to verify the brake system capacity with both hot and cold initial brake disc or wheel conditions. The brake disc and pad or wheel and shoe surface temperature shall be measured and recorded throughout the test. At the completion of this test, the brake unit shall remain in an undamaged, fully operable condition.

17.4.3.4 Pressure Test

All pneumatic brake system components shall be tested at 180 psi or the compressor safety valve operating pressure, whichever is greater. No component damage shall occur.

17.4.3.5 System Endurance Test

A complete friction brake system, including the electronic control unit but excluding the master controller, shall be subjected to an endurance test of one-half million cycles of normal apply and release applications under conditions as stated in Section 2 and Section 12. Brake reaction forces shall be simulated on the actuators.

17.4.3.6 System Environmental Test

A test setup in an approved environmental laboratory shall be prepared to simulate the climatic conditions to be encountered. The test setup shall include conditions of high humidity with rapid temperature fluctuation cycles between 110°F and -20°F. If it is impractical to test a complete braking system, parts of the system may be simulated. During environmental tests, system function ambient temperature and humidity shall be recorded.

The test schedule shall start with overnight 8 hour minimum) soak at the high temperature limit with power on. The equipment shall then be tested. After which the equipment shall be subject to 8 temperature and humidity cycles between high and low temperature limits with each cycle lasting 12 hours, including holding at the high and low temperature limits for a minimum of 1 hour during each cycle.

During the 1 hour hold period, the brake system shall be operated to apply and release the brakes at least once every 5 minutes. The brake operation shall be cycled between full application and full release with the brake application held on for 1 minute. There shall be at least two (2) emergency applications. All applications shall simulate full passenger load conditions. The wheel slide correction control shall also be cycled during each application.

The system will be considered acceptable if no system component or part fails or malfunctions. A complete disassembly and parts inspection shall be conducted following completion of the test to verify compliance.

17.4.3.7 Wet Braking Rate Test

A series of brake dynamometer tests shall be conducted to compare the braking rates achievable with wet wheels and shoes and wet brake discs and pads.

A series of stops with dry wheels and shoes and dry brake discs and pads shall be simulated at 25 percent, 50 percent, 75 percent, and 100 percent of AW3 full-service brake pressure and AW3 Emergency Brake pressure, with entry at each pressure under both hot-wheel and disc and cold-wheel and disc conditions. The average braking rate (V/T) for each stop shall be recorded.

The same series of stops shall be simulated with wet brake conditions. Water shall be sprayed onto the wheel and disc at the wheel-shoe and disc-pad interface. The water spray apparatus, pattern, and flow rate shall conform to UIC 541-4, Appendix 4, if tread brakes are used and UIC 541-3, Appendix 4, if disc brakes are used. The spray apparatus shall be oriented to spray the disc/pad interface if disc brakes are used and the wheel/shoe interface if tread brakes are used.

The average braking rate under wet conditions shall not decrease by more than 15 percent nor increase by more than 10 percent from the dry-stop conditions.

17.4.4 Door System

Door, door operator, and control, system design qualification tests shall include an accelerated life test of 1.5 million cycles for the complete door system. These tests shall be completed without failure before the first car is ready for final assembly. Door speed and noise tests shall be performed at the beginning, mid-point, and end of the life test for comparative evaluation. Door testing shall include the effects of wind and ventilation system car body pressurization.

The life test shall include temperature variations, temperature extremes, and simulated dirt contamination. All parameters of the life test are to be approved by the Engineer. **[CDRL 17-008]** Failures recorded during testing must correlate within specified reliability values.

17.4.5 Air Conditioning System

17.4.5.1 General

One (1) complete air conditioning module and its controls shall be tested in a laboratory climate room by the air conditioning manufacturer to verify the functioning of the system at all conditions specified in Section 8. Tests may be performed in an independent laboratory, approved by the Engineer. **[CDRL 17-009]** The test shall be performed according to ASHRAE Standard 37, “Methods of Testing for Rating Unitary Air Conditioning and Heat Pump Equipment”. The secondary applicable test method is to be selected by the Contractor from Table 1 of Standard 37. The instrumentation and required test data shall meet the requirements of the Standard. This test shall be successfully completed before conducting the pre-delivery tests.

The system shall be installed in a suitable test fixture to separate exterior and car interior conditions using appropriate equipment. Temperature and humidity controls shall be used to maintain the conditions as specified in Section 8 in the exterior and interior sections of the test chamber for the duration of the test period. All equipment, normally mounted on the car roof, exposed to ambient conditions, shall be installed in the “exterior” area. The resistance of the air flow circuit, external to the evaporator-blower-heater unit and its associated ducting and filters, similar in design and function to actual car installation, shall be established by an approved method during testing. The tested unit shall be installed such that the quantity of entering air can be measured and regulated to the design volume. Electrical data, motor RPM, and system static pressures shall be recorded. The evaporator air pressure drop measurements shall be compared with the manufacturer’s coil curves in terms of cfm, RPM, and static pressure.

All data, except as otherwise indicated, shall be continuously recorded by a digital data acquisition system using appropriate transducers and sensors. The instruments and transducers/sensors shall have been calibrated before the test, and calibration certificates for all the instruments shall be available for inspection by the Engineer or approved by the Engineer on the day prior to the commencement of the test. Copies of these certificates shall be included in the test report. The Contractor may propose alternate methods of instrumentation to the Engineer for consideration and approval.

Air side pressure drops and motor speeds may be recorded manually, as required. Prior to the test, the air conditioning unit shall be evacuated and dehydrated to 50 microns or fewer; the system pressure shall not rise above 300 microns after 1 hour, when the vacuum pump is isolated.

The unit used for qualification testing and the units installed on the vehicle climate-room test car shall have the following test fittings:

- Pressure tap fittings in each suction header adjacent to the expansion valve equalizer connections.
- Liquid line pressure tap fitting.

17.4.5.2 Data Requirements

The following data shall be taken during each test run:

1. Air temperatures

- Evaporator °FDB and °FWB inlet
- Evaporator °FDB and °FWB outlet
- Condenser °FDB air inlet(s) and outlet(s)
- Exterior area °FDB and °FWB
- Interior area °FDB and °FWB

2. All fan motor winding temperatures

3. Refrigerant temperatures

- Compressor suction
- Compressor discharge
- Condenser outlet
- Evaporator inlet
- Evaporator outlet

4. Pressures

- Compressor suction
- Compressor discharge
- Evaporator inlet
- Evaporator outlet
- Evaporator air pressure drop across the coil
- Condenser air pressure drop across the coil

5. Electrical

- Compressor(s) voltage, current, RPM
- Blower voltage, current, RPM
- Condenser Fan(s), voltage, current, RPM

6. Air Flow

- Fresh air intake

- Evaporator outlet
- Return air

17.4.5.3 Tests that are to be Conducted for Air Conditioning System

For each test, continuous readings shall be taken during the test period. The tests listed in this section shall be conducted.

17.4.5.3 (a) Refrigerant Charge Determination

The system shall be leak-tested, evacuated, and dehydrated prior to the refrigerant charge determination test.

The Climate Room "interior" and "exterior" temperatures shall be maintained to simulate the design conditions of Section 8.1.1

The following criteria shall constitute correct system refrigerant charge:

- 10°F superheat at evaporator outlets,
- Minimum 10°F liquid sub-cooling at condenser or heat exchanger (if the last provided) outlet,
- Receiver bottom sight glass approximately ½ full of liquid,
- Compressor sight glass approximately ½ full of oil,
- Compressor crankcase oil not foaming,
- Compressor fully loaded (all cylinders), and
- No bubbles in liquid lines at 115°F and 125°F ambient.

The exact recorded refrigerant charge weight shall be applied to all remaining units.

17.4.5.3 (b) Capacity Test

The capacity test shall be performed in accordance with ANSI/ASHRAE 37 Standard.

- At design conditions listed in Section 8.1.1.
- At design conditions listed above, but with the ambient at 125°FDB, 85°FWB.

17.4.5.3 (c) High Ambient Test

A demonstration of the pressure modulation capability and compressor unloading at 125°F dry bulb (°FDB), 85° wet bulb (°FWB) air delivered to the condenser and fresh air intakes shall be included in the test. A successful condenser high ambient test shall consist of continuous operation of the system for at least 3 hours without shutdown due to high pressure, circuit breaker trip, compressor motor overload, or device failure. A shutdown, while operating at the high ambient temperature, for any reason, shall constitute a failure of the test. At the end of the 3-hour operation, the system shall be momentarily stopped and restarted. The system shall continue to function properly with all components safe from malfunction.

17.4.5.3 (d) Temperature Control Test (Scan Test)

The temperature control components shall be exposed to the operational environment by installation in their proper locations and energized during the capacity tests; although they will not function to control the system during these demonstrations (the mixture temperatures used are higher than the thermostat set points).

Following the capacity tests, the “interior” temperature load shall be reduced until it is low enough for the thermostats to control the system. The interior and exterior temperatures shall be varied such that the thermostats operate the system through the full control range on rising and falling “interior” and “exterior” temperatures including heating and ventilating modes of the thermostatic control. The use of substitute switches shall not be permitted. During this demonstration, temperature, pressure and electrical data as recorded for the other tests shall be recorded at each control step.

17.4.5.3 (e) Control Stability Test

The “interior” and “exterior” area shall be held at the design conditions specified in Section 8.1.1. The system shall be operated with the thermostat in control. Control voltage shall be held at 72 VDC. When stable operation is reached, the control voltage shall be varied between the limits required by Section 2.2.3 to show the effect of such a change. The same data, as that recorded for the temperature control operational test, shall be recorded. Additionally, any changes noted in the mode of system operation shall be recorded as the control voltage is changed.

17.4.5.3 (f) Condensate Carry-Over Test

Under the design “interior” conditions and 80° FDB/75°FWB “exterior”, the air conditioning system shall be operated for 6 hours to verify that there is no carry-over of condensate into the air ducts, and that the condensate drain pan and drain piping operates properly. The evaporator assembly shall be elevated to simulate conditions of acceleration, deceleration, grade and super elevation of the track, as approved by the Engineer. During the test, no condensed water shall drop, run, or blow-off from the unit casing and drain pan. Coil surfaces shall be in the as-manufactured condition without special wetting agents applied or any other surface coating that is not part of the production configuration approved by the Engineer.

17.4.5.3 (g) Low Temperature Operation Test

This test shall be performed at the following conditions:

At 50° FDB/40°FWB, return air and ambient temperature. After establishment of specified conditions, the unit shall be operated continuously for a period of four (4) hours. During the entire test, the air conditioner shall operate without damage to the equipment; evaporator air quantity shall not drop more than 25 percent from the manufacturer’s rating.

17.4.5.3 (h) Abnormal Heating Condition with Restricted Air

Unit ambient temperature shall be maintained at approximately, 70°FDB. Mixed inlet air shall be restricted slowly, such that heater unit temperature rises not faster than 2°F per minute, until the high limit switch cycles-off. The restriction shall then be backed- off to the point where the high limit switch closes and remains closed. The heating test shall be continued, simulating a dirty filter condition. The system shall be operated until a steady state is reached. Temperature readings shall be taken every 5 minutes. Acceptance criteria shall be as follows:

- The fusible link or shunt trip shall not open during these tests.
- The temperature inside the unit shall not cause damage to the equipment and components.
- The high limit switch shall open at design set point +/-10°F.

17.4.5.3 (i) Abnormal Heating Conditions without Air Circulation

The unit ambient temperature shall be maintained at approximately 70°FDB. Power shall be applied to the heaters with no air blowing over them. The system shall be operated as the high limit switch cycles.

The acceptance criteria for the restricted air-flow test shall apply to this test. The test shall be performed at the nominal voltage and at limits required by Section 2.2.1.

17.4.5.3 (j) Backup Protection Device Test

The backup protection device (fusible link or shunt trip circuit breaker), located at the overhead heater, shall be tested at conditions listed below:

The air conditioning system shall be shut down and the “interior” area brought to an ambient temperature of approximately 70° FDB. With the evaporator fans shut down, the overhead heat shall be turned on using suitable jumpers. The high limit switch and duct temperature control thermostat shall be overridden using jumpers. During this testing, the following data shall be recorded continuously from the time of power “on” until 30 minutes after the backup protection device:

- Temperature
- Air inside the evaporator unit measured as close to the backup protection device as possible.
- Ambient air at the intake to the evaporator coil.
- Electrical
- Voltage and current to the heater.
- Time

The operating temperature of the backup protection device shall be high enough to allow it to operate only in the event of a failure of the primary protective devices, while still preventing damage to the equipment and any carbody components.

The test shall be performed at the nominal voltage and at the limits specified in Section 2.2.1.

17.4.6 Destination Sign and Interior Message Display

One (1) complete destination sign interior message display system shall be tested to demonstrate conformance to the Specification. This test shall organize all displays, signs, and operating equipment as designed for actual car installation. The test shall include trainline capability for software download and upload verification, diagnostics verification, and verification that all other car and trainline system tests are compatible with the destination sign system. The test shall include display of actual messages and demonstrate changing messages.

17.4.7 Toilet Room and Water System

The complete toilet room and water system shall be tested to demonstrate Specification compliance. The entire integrated system shall be tested to confirm proper operations of toilet, lavatory, soap dispenser, ventilation, tank filling, draining, and cleaning. A pressure test of all piping tanks and fittings shall be performed.

17.5 VEHICLE LEVEL QUALIFICATION TESTS

17.5.1 Carbody Structural Tests

17.5.1.1 General

Requirements for static load testing of the car body structure are given in sections below through 17.5.1.13. Requirements for CEM element testing are in 17.5.1.14.

One of the first four (4) cab carbodies shall be tested by the Contractor to confirm that the FEA is sufficiently accurate to ensure that the carbody structure complies with this Specification. If there are no major structural differences between the car shell types and the test results are comparable with the FEA, one (1) cab car shell shall be tested. The tests shall be performed at an Engineer-approved facility. To be acceptable the test facility must have documentation showing calibration of all instrumentation, have qualified personnel with experience in conducting similar tests, and have the necessary equipment, instrumentation and control equipment to conduct the test. **[CDRL 17-0010]** The tests shall not begin until the carbody stress and energy absorption analyses have been submitted and approved by the Engineer.

The test carshell shall be completely inspected and any non-conformances corrected. All inspection, test, rework, repair and corrective action reports shall be available for review. Particular attention shall be given to recording flatness and straightness.

The test carshell shall be structurally complete, including all structural parts and fiberglass ends (if part of the design), but excluding such items as exterior and interior trim, windows, doors, seats, lights, interior lining, or other parts that would obscure any structural member from view, or that would interfere with the performance of the test. The test shell shall have no paint, primer, sound damping coating, or insulation. The weight of underfloor and above floor compartment-mounted equipment and heavy roof-mounted equipment shall be simulated by equivalent weights at their respective locations. All structural tests shall be conducted on the same carshell.

The carshell shall be weighed and the weight recorded prior to installation of any test equipment. For the tests, the car shall be supported on the trucks or equivalent supports to allow longitudinal movement.

All gauges and instruments shall be in current calibration and remain so for the duration of the test. The methods of calibration and time periods for recalibration shall be in accordance with the test laboratory's national standard or ISO standards. The laboratory shall have on file a current certification of calibration traceable to the laboratory's national standard or ISO Standards.

The Contractor may conduct preliminary tests, but all critical dimensions and flatness shall be verified after the Contractor tests and before the official test begins. The test of record is to be witnessed by the Engineer. A copy of all recorded data shall be given to the Engineer at the conclusion of each test.

Where practical, all gauges shall have an electric output suitable for recording on electronic (magnetic) media. A data acquisition system shall be provided to permanently record all gauge outputs at each load step. At the end of each load step, a printout of all strain gauge readings in proper engineering units (micro-strains) and a plot of load vs. gauge reading for critical gauge locations shall be given to the Engineer or his representative for review. The Contractor shall obtain approval of the Engineer or his representative after every load step before proceeding with the next step. The Contractor shall not break down the test fixtures until the Engineer or his representative has reviewed and accepted all data.

The Contractor shall prepare a color photographic record of the test. This record shall include photographs of the car in the several test fixtures, installation of critical strain gauges, repairs or modifications, deviations from the drawings, and any areas found to be non-compliant.

The entire procedure shall be video recorded by the Contractor with a sound-equipped VHS color video camera. The camera shall rove to view and record key areas. All videotapes taken during this test shall become the property of SCRRA.

SCRRA reserves the right to test a second car of each type during the construction period. Should such a test be ordered, it shall be at the expense of SCRRA unless such tests prove the design is non-compliant in any structural area, in which case, the Contractor shall be responsible for the test expense and for all of SCRRA costs, and the cost of modifications necessary for the car and all other cars to be made compliant with the Specification. The Contractor (at its expense) shall also perform a complete set of structural tests to qualify the modified car.

17.5.1.2 Test Procedure

A procedure shall be prepared for each test. The procedure shall include a description of the test, its purpose, how and with what equipment the specimen is to be loaded and the load increments, the type and location of strain gauges, the location of deflection gauges, a complete description of all fixtures, instruments and gauges, and a detailed description of the data acquisition system. Annotated copies of catalogue cuts may be used to provide parts of the description. An explanation of the accuracy of the instrumentation shall be provided. Drawings and sketches shall be included to clarify the text. The test procedure shall provide a step by step instruction describing how the load is to be applied, the load at each step, when data is to be recorded, a space for the signature of the test supervisor and a space for recording the authorization to proceed obtained from the Engineer or his representative. Test procedures shall be submitted not less than sixty (60) days in advance of the proposed test date; approvals of the test procedure and stress analysis are prerequisites for the start of testing.

The test procedure shall include a copy of the current calibration certification for each instrument and gauge to be used for the test. Typical logging sheets, print-outs, plotting forms, and examples of any other data sheets for the test or in the final report shall also be submitted as part of the test procedure.

Tables shall be included to give the maximum allowable reading for each gauge and loading condition. Other tables shall be included to provide the requirements for all other test criteria.

Each test procedure shall contain a table of predicted strain (or stress) and deflection at selected gauge locations. This table shall list the strain or deflection gauge number, the location of the gauge, the predicted strain (or stress) or deflection from the stress analysis, spaces to enter the actual gauge readings, and a space to enter the calculated percent difference, defined as:

$$\%\ \text{difference} = \frac{\text{Actual} - \text{Predicted}}{\text{Actual}}\ x\,100$$

17.5.1.3 Strain Gauges

A minimum of 240 strain gauges shall be applied to the car structure for each of the compression, vertical load, and diagonal jacking tests. Some gauges may be used for more than one (1) test if their location on the structure is appropriate for other tests, but readings from at least 240 strain gauges in locations shall be obtained for each test. The location of the strain gauges shall be based on the Contractor’s experience, the stress analysis, and the Engineer’s recommendations.

In order to appraise the stress distribution in the carbody at these cross sections, there shall be no less than three (3) locations where there are a sufficient number of gauges to encircle the carbody. One (1) location shall be outboard of the bolster, one (1) shall be between the bolster and the transition to the upper and lower levels, and one (1) shall be at the center of the car. Gauges shall be placed, for example, on all four (4) sides of the side sill and body sills, on the side framing, along the cantrail, on the cross members, and at the center line of the car.

For each post load test, there shall be a minimum of 100 strain gauges applied to the post and car structure in the vicinity of the post. Some of the gauges may be for more than one (1) test if their location on the structure is appropriate for other tests, but readings from at least 100 strain gauges in locations where the stress may be critical shall be obtained for each test.

Drawings and sketches showing the location of each strain gauge shall be prepared by the Contractor and submitted for approval as part of the test procedure. These drawings shall dimension the location of each gauge, showing their distances from edges, connections, and bends. Their locations on the upper or lower, inner or outer surface, shall be noted on these drawings.

The strain gauges shall be bonded resistance (SR-4) type or other approved gauges suitable for the application. The gauges shall be calibrated in accordance with the manufacturer's instructions for the material being measured. The gauges shall be compensated for temperature.

17.5.1.4 Deflection Gauges

Vertical deflection of the carbody shall be measured along both side sills at each load step during all tests. At least eleven (11) gauges per side shall be used. Gauges shall be located at the end sills, at the bolsters, and at the mid point between the bolsters. The remaining gauges shall be evenly spaced between the five (5) locations. Measurements shall be taken to the nearest 0.01 inch, and the deflections shall be considered as the average of the readings recorded on both sides of the car.

To measure the longitudinal deflection of the car during compression testing, additional deflection gauges shall be applied at the end sill, near the ram, and at the opposite end sill, near the reaction.

For the diagonal jacking test, an additional deflection gauge shall be applied at the jack that is lowered or raised to measure the vertical movement at jack location.

During the vertical load test, the change in carbody width due to bending shall be measured and recorded at the belt rail in the center of the car. Two (2) additional deflection gauges shall be applied in one (1) of the side door openings closest to the center of the car to measure the change in the diagonal dimensions of the opening during the tests.

To measure the bending of the collision and corner posts during the post tests, deflection gauges shall be applied at a minimum of seven (7) locations on each post being tested: top, bottom, middle, load application point, between the load application point and the bottom, between the load application point and the center, and between the center and the top. These gauges shall be mounted to measure the deflection of the post in the direction of the applied force.

Deflection gauges shall be mounted on rigid stands separate from the carbody and its fixtures. The contact surface on the car shall have a smooth, polished, low-friction surface plate mounted perpendicular to the axis of the deflection gauge. If, during a test, the deflection gauge moves off of this surface plate or contacts the test carshell or the fixtures, the test shall be terminated. The gauges shall be readjusted and the test repeated from the beginning.

The deflection gauges shall have electrical outputs compatible with the data logging apparatus used with the strain gauges. All deflections shall be recorded simultaneously with the strain gauge recordings.

In addition to the above electronic recordings, dial indicators (mechanical) of sufficient stroke shall be employed. Two (2) shall measure the vertical deflection at the center of both side sills during all tests. During the compression tests, dial indicators shall be employed to measure the longitudinal deflection at the end sill next to the ram and next to the reaction at the opposite end of the car. An indicator shall be located next to the lowering jack during the diagonal jacking test. A dial indicator shall be mounted at the center of the post during each post tested. These dial indicators shall be read and manually recorded at each load step.

All deflection gauges shall have sufficient stroke capacity to measure the maximum deflection expected in the test without the need for resetting any gauge during the test.

17.5.1.5 Load Cells

In order to verify the accuracy of the applied loads and reactions, load cells shall be provided at the appropriate locations for each test. Each load cell shall be calibrated to 1.0 percent accuracy and certified within one (1) year before commencement of the tests over the full range of 1.5 times the maximum load to which the load cell will be subjected during these tests. The Contractor shall provide records of calibration results prior to commencing these tests. The load cells shall have electrical outputs compatible with the data logging apparatus used with the strain gauges. All loads shall be recorded simultaneously with the strain gauge recordings.

Load cells shall be placed at the end of the ram and at the reaction point for the compression test. A load cell shall be placed at each secondary spring location for the vertical test and at each ram if the load is applied hydraulically. A load cell shall be placed at each jack location for the diagonal jacking test. A load cell shall be placed at the end of the ram for each post test. Load cell readings shall be taken and recorded at each step of load application and removal process.

17.5.1.6 Vertical Load Test

17.5.1.6 (a) Test Description

The carbody supported on trucks or simulation thereof, shall be subjected to a vertical load test. A test load equal to the static vertical operating load specified in Section 3, shall be applied to the specimen. The load shall be applied in four (4) approximately equal increments resulting in a total of five (5) vertical load increments. One (1) of these increments shall be equivalent to a ready-to-run carbody weight plus a passenger load of AW3. The test load may be applied by means of weights or jacks, but shall be distributed in proportion to the distribution of weight in the finished car. The specimen shall be unloaded in the increments in which it was loaded. Strain gauge, deflection and load cell readings shall be taken at each load increment.

17.5.1.6 (b) Test Criteria

The car shall be considered compliant with this Specification if all of the following conditions are met:

- Stresses are in accordance with the requirements of Section 3.
- Vertical deflection readings plotted against load do not vary by more than +/-five (5) percent from a straight line (linear) deflection curve, with one (1) end point at the origin (no load) and the other at that point which represents the measured deflection for maximum vertical load.
- Strain readings plotted against load do not vary by more than +/-five (5) percent from a straight line (linear) deflection curve, with one (1) end point at the origin (no load) and the other at the point which represents the measured deflection at maximum load.
- Maximum stresses calculated from strain readings in any structural element do not exceed the allowable stresses approved prior to starting the test program as part of the stress analysis.
- Recorded residual vertical deflection between bolsters following removal of the maximum vertical test loading does not exceed 0.01 inch.
- Recorded residual car transverse width and/or opening diagonal dimensions following removal of the maximum vertical test load do not exceed 0.01 inch.
- Indicated residual strains at strain gauges on principal structural elements following removal of the maximum vertical loading do not exceed the maximum error resulting from the accuracy of the instrumentation.
- Carbody deflection, as measured during the vertical load tests under a load equal to the passenger load of AW3, is not more than the design camber in the side sill at any point between the carbody bolsters.
- There are no permanent deformations, fractures, cracks, or separations in the car structure. Broken welds resulting from the test are to be inspected jointly by the Contractor and SCRRA to determine if the failure is the result of weld quality or stress.
- The flatness and straightness of structural members meet the requirements of Section 3.3.5.

17.5.1.7 End Sill Compression Load Test

17.5.1.7 (a) Test Description

A compression test load as defined in Section 3.3.2.1 is to be applied to the end sill assembly in the underframe of the test specimen by means of a ram. This load shall be applied horizontally at the horizontal centerline of the carbody.

During the compression test, the carshell shall be supported on trucks or simulations thereof to allow free longitudinal movement. The carshell shall be loaded with sufficient dead weight to bring the total body weight of the test specimen to that of an AW0 loaded car. This loading shall be distributed in proportion to the distribution of weight in the finished car.

The compression test load shall be applied by means of a controlled hydraulic ram, and the force measured by a means independent of those producing the force. The force shall be measured at the ram and at the reaction at the opposite end of the car. The ram shall be supported at the car end, but shall remain free to move longitudinally with respect to the car end.

17.5.1.7 (b) Test Criteria

The car shall be compliant with this Specification if all of the following conditions are met:

- Stresses are in accordance with the requirements of Section 3.3.2.
- The vertical deflection of each side of the test structure is within +/-10 percent of the value determined by the analysis.
- The force measured at the reaction load cell is within 1.0 percent of the force applied at the ram.
- Maximum stresses calculated from strain readings in any structural element do not exceed the allowable stresses approved prior to starting the test program as part of the stress analysis.
- Indicated residual strains at strain gauges on principal structural elements following removal of the maximum vertical loading do not exceed the maximum error resulting from the accuracy of the instrumentation.
- There are no permanent deformations, fractures, cracks, or separations in the car structure. Broken welds are to be jointly inspected by the Contractor and SCRRA to determine if the failure is the result of weld quality or stress.

17.5.1.8 Compression Load Test at the Draft Stop

17.5.1.8 (a) Test Description

A compression test load, as defined in Section 3.3.2.1 (a test load of 800,000 pounds.), shall be applied to the rear draft stop in the draft gear housing. This load shall be applied at the car transverse centerline and vertically at centerline of draft. No allowance shall be made for the camber of the carbody.

A fixture, which simulates the regular draft gear and carrier, shall be installed.

During the compression test, the carshell shall be supported on trucks, or a simulation thereof to allow free longitudinal movement. The carshell shall be loaded with sufficient dead weight to bring the total body weight of the test specimen to that of an AW0 loaded car. This loading shall be distributed in proportion to the distribution of weight in the finished car.

The compression test load shall be applied by means of a controlled hydraulic ram, and the force measured by a means independent of those producing the force. The force shall be measured at the ram and at the reaction at the opposite end of the car. The load shall be applied in increments of 25, 50, 75, 87.5, and 100 percent of full load. After each load increment is applied, the load shall be reduced to not more than 2 percent of full load. Strain gauge, deflection, and load readings shall be taken at each load increment and at each relaxation of load. The ram may be supported at the car end, but shall remain free to rotate at its contact with the car end.

17.5.1.8 (b) Test Criteria

The car shall be compliant with this Specification if all of the following conditions are met:

- Stresses are in accordance with the requirements of Section 3.3.2.
- The vertical deflection of each side of the test structure is within +/- 10 percent of the value determined by the analysis.
- The force measured at the reaction load cell is within 1.0 percent of the force applied at the ram.
- Vertical deflection readings plotted against load do not vary by more than +/- 5 percent from a straight line (linear) deflection curve, with one (1) end point at the origin (no load) and the other at the point which represents the measured deflection at maximum load.
- Strain readings plotted against load do not vary by more than +/- 5 percent from a straight line (linear) deflection curve, with one (1) end point at the origin (no load) and the other at the point, which represents the measured deflection, at maximum load.
- Maximum stresses calculated from strain readings in any structural element do not exceed the allowable stresses approved prior to starting the test program as part of the stress analysis.
- Recorded residual vertical deflection between bolsters following removal of the maximum vertical test load does not exceed 0.01 inch.
- The residual horizontal deflection between ends following removal of the maximum load does not exceed 0.04 inch.
- Indicated residual strains at strain gauges on principal structural elements following removal of the maximum vertical loading do not exceed the maximum error resulting from the accuracy of the instrumentation.
- There are no permanent deformations, fractures, cracks, or separations in the car structure. Broken welds are to be jointly inspected by the Contractor and SCRRA to determine if the failure is the result of weld quality or stress.
- The flatness and straightness of structural members meet the requirements of Section 3.3.5.

17.5.1.9 Diagonal Jacking Test

17.5.1.9 (a) Test Description

The carshell shall be loaded to its AW0 weight, with trucks, or equivalent weight, hanging from the body bolsters. The carshell shall be supported symmetrically at the jack pads at the four corners of the car. One of the jacks shall be lowered in five equal increments until the load on the jack is 10 percent of its original load. All gauges shall be recorded at each increment of jack position. The procedure shall be reversed until the load on the jack is returned to its original level.

17.5.1.9 (b) Test Criteria

The car shall be compliant with this Specification if all of the following conditions are met:

- Maximum stresses calculated from strain readings in any structural element do not exceed the allowable stresses approved prior to the start of the test program as part of the stress analysis.
- Strain readings plotted against load do not vary by more than +/-5 percent from a straight line (linear) deflection curve, with one end point at the origin (no load) and the other at the point that represents the measured deflection at maximum load.
- Indicated residual strains at strain gauges following return to original level do not exceed the maximum error resulting from the accuracy of the instrumentation.
- There are no permanent deformations, fractures, cracks or separations in the car structure. Broken welds are to be jointly inspected by the Contractor and SCRRA to determine if the failure is the result of weld quality or stress.
- The flatness and straightness of structural members do not exceed the requirements of Section 3.3.5.

17.5.1.10 Collision Post Elastic Test

17.5.1.10 (a) Test Description

The ability of the carbody structure to resist the collision post longitudinal loads specified in Section 3.3.6.1 shall be tested.

During the collision post test, the carshell shall be supported on trucks or simulations thereof to allow free longitudinal movement. The post-applied load shall be reacted at the coupler. The carshell shall be loaded with sufficient dead weight to bring the total carbody weight of the test specimen to that of an AW0 loaded carbody. This loading shall be distributed in proportion to the distribution of weight in the finished car.

The specimen shall be instrumented as required for the car and collision post per Section 3.3.6.1. The strain gauges and deflection gauges shall be installed at the same places at some locations so that the structural equivalence of the model to the carbody can be determined.

A longitudinal test load as specified in Section 3.3.6.1 shall be applied to, and centered on, the collision post at an elevation 18 inches above the top of the underframe. This load shall be distributed over an area not to exceed the width of the collision post by 6 inches in height.

The test load shall be applied by means of a controlled hydraulic ram, and the force measured by a means independent of that producing the force. A fixture and means of cushioning, such as lead sheets, shall be provided to assure uniform bearing and to prevent crippling around the area of force application. This fixture and cushion shall not be attached to the post. The test load shall be applied horizontally parallel to the car longitudinal centerline. The load shall be applied in increments of 25, 50, 75, 87.5 and 100 percent of full load. The load shall be reduced to not more than 2 percent of full load after each step. Strain gauge and deflection readings shall be taken at each load increment and at each relaxation of load. The ram shall be supported at the car end, but shall remain free to move longitudinally with respect to the car end.

17.5.1.10 (b) Test Criteria

The car shall be compliant with this Specification if all of the following conditions are met:

- Deflection readings plotted against load do not vary by more than +/- 5 percent from a straight line (linear) deflection curve, with one (1) end point at the origin (no load) and the other at the point that represents the measured deflection at maximum load.
- Strain readings plotted against load do not vary by more than +/- 5 percent from a straight line (linear) deflection curve, with one end point at the origin (no load) and the other at the point which represents the measured deflection at maximum load.
- Maximum stresses calculated from strain readings in any structural element do not exceed the allowable stresses approved prior to starting the test program as part of the stress analysis.
- Indicated residual strains at strain gauges on principal structural elements following removal of the maximum loading do not exceed the maximum error resulting from the accuracy of the instrumentation.
- There is no permanent deformation, fractures, cracks, or separations in the car structure. Broken welds are to be jointly inspected by the Contractor and SCRRA to determine if the failure is the result of weld quality or stress.

17.5.1.11 Corner Post Longitudinal Load Test

17.5.1.11 (a) Test Description

The ability of the carbody structure to resist the primary side corner post longitudinal compressive loads specified in Section 3.3.2.3 cab cars and Trailer cars shall be tested.

During the corner post longitudinal test, the carshell shall be supported on trucks or simulations thereof to allow free longitudinal movement. The post applied load shall be reacted at the coupler. The carshell shall be loaded with sufficient dead weight to bring the total carbody weight of the test specimen to that of an AW0 loaded carbody. This loading shall be distributed in proportion to the distribution of weight in the finished car.

The specimen shall be instrumented as required for the car and corner post in Section 3.3.2.3. The strain gauges and deflection gauges shall be installed at the same places at some locations so that the structural equivalence of the model to the carbody can be determined.

Longitudinal test loads shall be applied to, and centered on, the corner post at an elevation of 18 and 30 inches above the top of the underframe as specified in Section 3.3.2.3. The magnitudes of the loads shall be limited to values that approach the yield strength of the past as predicted by the approved FEA. These loads shall be distributed over an area not to exceed the width of the collision post and not to exceed 6 inches in height.

The test load shall be applied by means of a controlled hydraulic ram, and the force measured by a means independent of that producing the force. A fixture and means of cushioning, such as lead sheets, shall be provided to assure uniform bearing and prevent crippling around the area of force application. This fixture and cushion shall not be attached to the post. The test load shall be applied horizontally parallel to the car longitudinal centerline. The load shall be applied in increments of 25, 50, 75, 87.5, and 100 percent of full load. The load shall be reduced to not more than 2 percent of full load after each step. Strain gauge and deflection readings shall be taken at each load increment and at each relaxation of load. The ram shall be supported at the car end but shall remain free to move longitudinally with respect to the car end.

17.5.1.11 (b) Test Criteria

The car shall be compliant with this Specification if all of the following conditions are met:

- Deflection readings plotted against load do not vary by more than +/- 5 percent from a straight line (linear) deflection curve, with one (1) end point at the origin (no load) and the other at the point which represents the measured deflection at maximum load.
- Strain readings plotted against load do not vary by more than +/- 5 percent from a straight line (linear) deflection curve, with one (1) end point at the origin (no load) and the other at the point which represents the measured deflection at maximum load.
- Maximum stresses calculated from strain readings in any structural element do not exceed the allowable stresses approved prior to starting the test program as part of the stress analysis.
- Indicated residual strains at strain gauges on principal structural elements following removal of the maximum loading do not exceed the maximum error resulting from the accuracy of the instrumentation.
- There is no permanent deformation, fractures, cracks, or separations in the car structure. Broken welds shall be jointly inspected by the Contractor and the SCRRA to determine if the failure is the result of weld quality or stress.

17.5.1.12 Corner Post Transverse Load Test

17.5.1.12 (a) Test Description

The ability of the carbody structure to resist the corner post transverse load specified in Section 3.3.2.3 shall be tested.

During the corner post test, the carshell shall be supported on trucks or simulations thereof. Transverse restraint shall be at the lateral stops between the carbody bolsters and truck frame. The carshell shall be loaded with sufficient dead weight to bring the total body weight of the test specimen to that of an AW0 loaded carbody. This loading shall be distributed in proportion to the distribution of weight in the finished car.

The specimen shall be instrumented as required for the car and corner post in Section 3.3.2.3. The strain gauges and deflection gauges shall be installed at the same places at some locations so that the structural equivalence of the model to the carbody can be determined.

Longitudinal test loads as specified in Section 3.3.2.3 shall be applied to and centered on the corner post at an elevation of 18 inches above the top of the underframe. This load shall be distributed over an area not to exceed the width of the corner post and not to exceed 6 inches in height.

The test load shall be applied by means of a controlled hydraulic ram, and the force measured by a means independent of that producing the force. A fixture and means of cushioning, such as lead sheets, shall be provided to assure uniform bearing and prevent crippling around the area of force application. This fixture and cushion shall not be attached to the post. The test load shall be applied horizontally perpendicular to the car longitudinal centerline. The load shall be applied in increments of 25, 50, 75, 87.5, and 100 percent of full load. The load shall be reduced to not more than 2 percent of full load after each step. Strain gauge and deflection readings shall be taken at each load increment and at each relaxation of load. The ram shall be supported at the car end but shall remain free to move transversely with respect to the car end.

17.5.1.12 (b) Test Criteria

The car shall be compliant with this Specification if all of the following conditions are met:

- Deflection readings plotted against load do not vary by more than +/- 5 percent from a straight line (linear) deflection curve, with one (1) end point at the origin (no load) and the other at the point which represents the measured deflection at maximum load.
- Strain readings plotted against load do not vary by more than +/- 5 percent from a straight line (linear) deflection curve, with one end point at the origin (no load) and the other at the point which represents the measured deflection at maximum load.
- Maximum stresses calculated from strain readings in any structural element do not exceed the allowable stresses approved prior to starting the test program as part of the stress analysis.

- Indicated residual strains at strain gauges on principal structural elements following removal of the maximum loading do not exceed the maximum error resulting from the accuracy of the instrumentation.
- There is no permanent deformation, fractures, cracks, or separations in the car structure. Broken welds are to be jointly inspected by the Contractor and SCRRA to determine if the failure is the result of weld quality or stress.

17.5.1.13 Collision Post Elastic-Plastic Test

17.5.1.13 (a) Test Description

The ability of the connections between the collision posts and the carbody structure to withstand a longitudinal load equal to the ultimate load carrying capacity of the post as specified in Section 3.3.6.1 shall be tested.

The test specimen shall be a full-scale structural model of the cab end of a car. The structural model shall include all structural elements required to support the collision posts including the end underframe and roof between the forward end of the end frame and the bolster. All connections shall be identical to those of production cars. The bolster end of the model shall be attached to a rigid fixture so that the stresses in the post and its supporting structure shall be the same as those in a car subjected to the same load.

The specimen shall be instrumented in the same manner in which it was instrumented in the collision post elastic test Section 3.3.6.1 except that instruments of greater capacity may be needed for this test. The strain gauges and deflection gauges shall be installed in the same locations so that the structural equivalence of the specimen to the carbody can be determined.

Longitudinal test loads shall be applied to and centered on the collision post at an elevation of 30 inches above the top of the underframe. This load shall be distributed over an area not to exceed the width of the collision post and not to exceed by 6 inches in height.

The compression test load shall be applied by means of a controlled hydraulic ram, and the force measured by a means independent of that producing the force. A fixture and means of cushioning, such as lead sheets, shall be provided to assure uniform bearing and prevent crippling around the area of force application. This fixture and cushion shall not be attached to the post. The test load shall be applied horizontally parallel to the car longitudinal centerline. The initial load shall be applied in increments of the same magnitude as those used during the collision post elastic load test, Section 3.3.6.1. The load shall be reduced to not more than 2 percent of full load after each step. Strain gauge and deflection readings shall be taken at each load increment and at each relaxation of load.

The strain gauge readings and deflections measured during this test shall be within 5.0 percent of the gauge readings for the same load and location measured during the collision post elastic test. If difference between the two (2) test results, the fixture and/or the model shall be corrected until agreement within 5.0 percent between the two tests is obtained.

After agreement between the two (2) tests is demonstrated, the collision post shall continue to be loaded in stroke increments of 20 percent of the full depth of the collision post until the load carrying capacity of the collision post is obtained. At each 20 percent load increment, all load cell(s), strain gauges, and deflection gauges shall be recorded. The load need not be relaxed after each step.

The ultimate load carrying capacity of the post shall be defined as the condition where the post cannot support an increased load or the center of the post has deflected more than its full depth. This deflection shall be measured at the middle of the post from a string connected between the top and bottom of the post.

17.5.1.13 (b) Test Criteria

The collision post shall be compliant with this Specification if all of the following conditions are met:

- All strain gauges and deflection gauges have the same readings within +/- 5 percent for the same loads at the same locations as the collision post elastic load test for 0 to 100 percent as tested in Section 3.3.6.1.
- The connections between the collision post and all other structural members are not completely broken.

17.5.1.14 Crash Energy Management

17.5.1.14 (a) General

A series of tests shall be conducted to validate the CEM design. This shall include one dynamic or quasi-static test 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.

17.5.1.14 (b) CEM Test Plan

A1 CEM system design validation shall be provided according to separate CEM System Tests Plan that shall be integrated into the Carbody and Truck Stress Analyses and Tests Plan of Section 3.4.2. The Contractor shall provide a CEM System Tests Plan for review and approval by the Engineer. **[CDRL 17-011]** The CEM System Tests Plan shall include as a minimum the tests included in Section **17.5.1.14** and Table 17-1 CEM System Test Matrix. A1

Table 17-1
CEM System Test Matrix

Test	Spec	Type	Car End	Level	Input Parameter	Criterion
PEAM Energy Absorption	3.10.7	Dynamic	Both	Component	Energy Absorption	Minimum Target Value
PEAM Initiation Load	3.10.7	Dynamic or Quasi-Static	Both	Component	Initiation Load	Within Target Range
CM Energy Absorbed	5.3.1 & 17.3.9	Dynamic	Both	Component	Energy Absorption	Minimum Target Value
CM Initiation Load	5.3.1 & 17.3.9	Dynamic or Quasi-Static	Both	Component	Initiation Load	Within Target Range
Cab End LDM/LTM Deformation	3.10.6	Dynamic or Quasi-Static	Cab	Component	Maximum Design Stroke	No Material Failure as defined by Section 3.10.6
Cab End LDM/LTM Geometry	3.10.6	Static Dimensional Inspection	Cab	Car	Location/Size	Within Specified Dimensions

PEAM – Principal Energy Absorption Mechanism
CM – Coupling Mechanism
LDM – Load Distribution Mechanism
LTM – Load Transfer Mechanism

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.

17.5.1.14 (c) 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.

17.5.1.14 (d) 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, strains, and accelerations. Each dynamic test shall be documented with high-speed cameras. The record of the test shall be provided digitally on optical media, CD-ROM or DVD, or may be provided on video tape formatted for VHS-North America.

17.5.1.14 (e) 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, strains, and accelerations shall also be compared.

17.5.1.14 (f) Test Pass-Fail Criteria

The values specified in the following are the difference between test and analytical result with the former as the base:

- Peak force, ±P%,
- Average force, ±A%,
- Force and displacement vs. time, ±T% at any particular time, and
- Modes of crush as predicted by analysis.

The Contractor shall provide meaningful and realistic pass/fail criteria for P%, A%, and T% for review and acceptance by the Engineer. That criteria must be based on state-of-the-art analysis and testing techniques. The basis of that criteria must be defined by the Contractor and supported by established pass/fail criteria of other CEM designs that have been analyzed and tested.

Strain and acceleration results are for information.

In case pass-fail criteria are not achieved, the Contractor shall modify the design and model, and repeat the analysis. If discrepancies are due to model features (parameters or characteristics of the element inaccurately modeled, or not included, as examples), such model features shall be modified to obtain agreement of the model predictions with the test results within the specified pass-fail criteria. The model thus revised shall be used to evaluate the behavior of the cars according to the Evaluation Scenario of Section 3.10.2.

17.5.1.15 Structural Changes

Any structural changes or modifications performed during any test or during construction and assembly shall be subjected to the entire test series. All cars constructed prior to and subsequent to these tests shall incorporate the same structural changes or modifications. These tests and modifications shall be at the expense of the Contractor.

17.5.1.16 Test Report

The Contractor shall prepare and submit a final test report for each test within thirty, (30) days after successful completion of the structural tests. Approval of the test report shall constitute acceptance of the car structural tests. In addition to the requirements of Section 17.2.3, the test report shall include:

- A table of contents.
- All pages numbered, including the appendices and data sheets.

- The test procedure (with all appendices).
- A narrative describing the performance of the test.
- Tables showing stresses and deflections that were 80 percent or more of the allowable.
- Description and explanation of any value that exceeded the test criteria.
- Appendices containing all data, *i.e.*, output from each gauge for each load step. These data shall be clearly identified and include the date that they were recorded.
- Record photographs mounted on pages the same size as the report pages.
- Video record of the tests formatted for VHS-North America or digital and on CD.
- Side sill deflection curve for each load step.
- Stress (or strain) vs. load curves for the ten (10) locations of greatest tensile stress and the ten (10) location greatest compressive stress for each series.
- Tables comparing the stresses computed in the analyses with stresses computed from the strain gauge readings for each test. The tables shall be annotated to explain differences between the predicted and test values.
- The report shall be in compliance with Section 17.2.3.

17.5.2 Ventilation Duct Watertightness

All car fresh air intake ducts with blowers connected and operating at maximum speed shall be tested, the first car of each type, to determine the effectiveness of the water excluding features. This shall be done operating the car at 110 mph through simulated heavy rain, by operating the car at 5 mph through a simulated car washer, and by operating the car at 110 mph through a simulated snowstorm as a test of snow plugging resistance. If ducts are the same for each car type, the test shall be required for only one (1) car.

17.5.3 Air Leakage

To assure positive internal car body pressurization, the first car body shall be given an air leak smoke bomb test with the interior pressurization to a minimum of 0.50 inches of water (120 Pa). All openings related to ventilation shall be sealed during this test. All leaks shall be investigated and the car design changed as required. If the carshell is the same for each car type, the test shall be required for only one (1) car.

17.5.4 Door Operation

Before delivery, all of the passenger doors and controls of the first car of each type shall be operated for 25,000 continuous, trouble-free cycles each. The car shall be equally loaded throughout the passenger compartment to AW3 loading. No adjustments or maintenance shall be allowed during the test. Any door or door control failure occurring prior to completion of the test shall nullify the test, and the test shall be restarted. If door system is the same for each car type, the test shall be required for only one (1) car. If the carshell is the same for each car type, the test, shall be required for only one (1) car.

17.5.5 Climate Room Test

The purpose of the air conditioning climate room test is to demonstrate that the performance of the Ventilating and Air Conditioning system of a completely assembled car is in compliance with all Technical Specification requirements. The climate room test car shall not be removed from the climate room chamber until the conduct of all tests has been confirmed as successfully completed and the results have been found acceptable by the Engineer. The climate room test car shall be the fully assembled and completed Pilot Car. The test facility must be approved by the Engineer.

17.5.5.1 General Requirements

The tests described in the following Sections shall be conducted in an approved Climate Room capable of heating and cooling to maintain specific ambient temperatures between 20°F and 125°F and relative humidity levels between 25 percent and 90 percent. **[CDRL 17-012]**

The temperature in the climate room shall not vary by more than 5°F from 2 feet above top of rail to 2 feet above the car roof, and from end to end of the car.

Care shall be taken to assure that the localized heat rejection from the condenser and the condenser air-flow does not unduly influence the test results. In no case shall the distance from the highest point of the car to the ceiling of the climate room be less than the minimum clearance existing on any SCRRA line.

Engineer approved equipment shall be provided inside the car to simulate the latent and sensible heat loads required by the specification.

The Climate Room shall be equipped to supply sufficient wayside electrical power at the nominal car voltage defined in Section 2.2.1 to the car power trainline. All vehicle equipment shall be powered from the car borne power conditioning and distribution equipment.

17.5.5.2 Instrumentation and Data Requirements

17.5.5.2 (a) Instrumentation

All test data shall be recorded by a computer based data acquisition system with sufficient input channels to record the required data. Multiplexing of data shall not be allowed. If multiple recorders are necessary to obtain the required number of channels, they shall be time synchronized. The data sampling rate shall be adjustable, with the minimum time being not more than one (1) sample per second. Each sample shall be time and date-stamped. Real time display of test data and trending shall be possible. Real time calculation and display of information such as the average of several channels, difference between selected channels, or minimum and maximum of a group shall be possible. All real time display data and recorded data shall be in engineering units and, if possible, selectable between I-P and SI units. Recorded data shall be capable of being exported to normally available spreadsheet programs such as MS Excel.

The data acquisition system shall be capable of recording both analog data streams and digital (on/off) events. It is preferred that digital events be recorded on an uninterrupted basis.

For temperature measurements, the range shall be adequate as required by the environmental conditions listed in the Specification. Temperature measurements shall be at a resolution of 0.1°F, and with the total accuracy (including thermocouples, thermocouple wires, signal processing, and conversion) not to exceed ±1.0°F.

The climate room shall be equipped with the following instrumentation:

Thermocouples (temperature sensors) with ± 0.5°F accuracy. Thermocouples shall be in accordance with ASHRAE Standard 41.1.

- Psychrometers in accordance with ASHRAE Standard 41.6.
- Ammeter.
- Recording ammeters.
- Voltmeter.
- Recording voltmeters.
- Manometers.
- Thermometers.
- Hand-held hygrometer.
- Flowhood as manufactured by Shortridge Instruments, Inc., or approved equal.
- Vane anemometer with the ability to calculate and display average velocity recorded over a selected period of time.
- Electronic manometer.
- Refrigerant cylinder.
- Refrigerant recovery unit.
- Refrigerant scale.

Additional instruments shall be provided to perform specific tests as described herein. All instruments shall demonstrate satisfactory compliance with approved calibration standards and the requirements of this specification. All instruments and measurements shall meet the requirements of the latest edition of the ASHRAE Standards 41.1 and 41.6.

In addition to the instrumentation requirements of this Specification, the instrumentation described in Section 17.5.2 shall also be provided for all cooling equipment testing.

The Event Recorder shall be used to record the same parameters recorded for the Scan Test described in Section 17.4.5.3.

The Temperature Recorder shall be used to record temperatures in predetermined locations throughout the car and the Climate Room as proposed by the Contractor and approved by the Engineer. A minimum of fifty (50) thermocouples (channels) shall be located in the car (including the cab) and a minimum of five (5) thermocouples (channels) in the Climate Room.

The Voltage Recorder shall record all voltages applied to the car.

The Electric Current Recorder shall be used to record the current drawn by the following equipment:

- Each Compressor Motor
- Each Condenser Fan Motor
- Each Evaporator Blower Motor
- Each Overhead Heater

17.5.5.2 (b) Test Data

The data acquisition system shall record the following data, as necessary for the individual tests:

- Names and affiliations of observers.
- Dates and times.
- Barometric pressure in inches of Hg.
- Nameplate data of all test equipment.
- Instrumentation calibration records.
- Input power to all equipment.
- Applied voltage.
- Frequency, Hz.
- Fan speeds, RPM.
- Ambient air dry-bulb temperature, °F.
- Ambient air wet bulb temperature, °F.
- Dry bulb temperature of conditioned air leaving car ceiling diffusers, °F.
- Wet bulb temperature of conditioned air leaving car ceiling diffusers, °F.
- Car interior temperatures, °F, in locations approved by the Engineer in cab, upper, lower, and intermediate areas.
- Each evaporator fan motor winding temperature, °F.
- Each condenser fan motor winding temperature, °F.
- Each compressor motor parameters.
- Each condenser fan motor operation.

- Each evaporator blower motor operation.
- Each liquid line solenoid valve operation.
- Each modulation solenoid valve operation.
- Overhead heat operation.
- Floor heat operation.
- Each high pressure limit switch operation.
- Each compressor crankcase heater operation.
- Time delay relay operation.
- Overload relay operation.
- Line and control voltage and current demand of all equipment.

Additional data shall be recorded for certain other tests as described herein. All instruments and transducers used for the Climate Room tests shall have been calibrated within one (1) year of the test, or as otherwise required by the Specification. Calibration certificates for all the instruments and transducers shall be available for inspection by the Engineer on the day prior to the commencement of the test. Copies of these certificates shall be included in the test reports.

17.5.5.3 Air Balance and Car Pressurization Test

17.5.5.3 (a) Purpose

The purpose of the Air Balance Test is to demonstrate conformance with interior ventilation, air-flow, and pressurization requirements. The test shall also demonstrate adequate air distribution and circulation throughout the entire car.

17.5.5.3 (b) System Conditions

This test shall be performed with only the evaporator blowers operating at an ambient temperature of approximately 70°F.

17.5.5.3 (c) Miscellaneous Parameters

During the air balance test, the Contractor shall measure and record the following:

- Line voltage,
- Blower motor voltage (at each blower motor),
- Blower motor current (at each blower motor), and

17.5.5.3 (d) Air Volumes

Air volumes shall be measured by the Flowhood, using the hood size appropriate to the duct openings to be monitored. "Standard" hoods provided by the flow meter manufacturer shall be used to the extent possible, without additional adaptors. If "standard" hoods cannot provide a leak-free seal, additional ducting or adapters may be used between the Flowhood and the carbody grilles and/or louvers, depending on their configuration.

The following air volumes shall be measured:

- Fresh air volume;
- Conditioned air flow into the car interior at the diffusers;
- Re-circulated air volume
- Car Pressurization;
- Diffuser Discharge Velocity.

17.5.5.4 Cooling System Tests

17.5.5.4 (a) Refrigerant Charge Determination/Verification

The purpose of this test is to determine or verify the proper quantity of refrigerant required by the air conditioning system to satisfy the design requirement under all applicable conditions.

This test shall be a verification of the HVAC unit refrigerant charge determined by the HVAC supplier at the unit qualification testing. During the car climate room test, the correct charge shall be verified by comparing system pressures, and sub-cooling and super-heat functions at operating conditions identical to those of the unit qualification test.

The HVAC systems shall be leak-tested, evacuated, and charged at the manufacturer's factory per a procedure approved by the Engineer.

All refrigeration system work shall be performed according to the EPA and other applicable governmental agencies' rules currently in effect. The refrigerant charge shall be determined by the following:

If the refrigerant level is incorrect, the amount of refrigerant in the unit shall be adjusted, and the test repeated.

17.5.5.4 (b) Scan Test

The purpose of this test is to demonstrate that the HVAC control performs in accordance with the specified sequence and parameters. The data acquisition system shall record data parameters for the following system elements:

- Each compressor motor
- Each condenser motor
- Each evaporator blower motor
- Each liquid line solenoid valve
- Each modulation solenoid valve

- Overhead heat
- Each compressor crankcase heater
- Time,
- Climate Room ambient temperature and humidity
- Each return air temperature in car (independent from the HVAC unit's return air sensors)
- HVAC unit return air sensor readings
- Average interior temperature and humidity for upper, lower and intermediate areas

The sequence of the Scan Test shall be arranged to ensure that all control points for rising and falling temperatures are included and tested. The test sequence shall be such that all temperatures that affect system control are tested individually. The Scan Test shall be satisfactorily completed before proceeding to further climate room testing.

In the event of any control failure, appropriate adjustments shall be made and the entire scan test shall be repeated until all system controls perform in accordance with the specified requirements.

17.5.5.4 (c) Pull-Down

The objective of this test is to determine the temperature pull-down time after the air conditioning system is energized and to measure cycling periods and air temperature stratification after stabilization. The pull down test shall be performed in accordance with the following:

- Prior to this test, the car shall be "soaked" in the climate room for at least 6 hours at 110°FDB with the car doors and windows closed with the maximum solar load applied. Climate room conditions shall be maintained constant during the entire test.
- After completing the "soak" period, all electrical circuits, including car lights, shall be energized, and the air conditioning system shall be turned ON with all car doors and windows closed. Fresh air intakes shall be open.
- The time required for the system to reduce the interior air temperature to the Specification required value shall be recorded.
- The time required to stabilize the car interior temperature shall be recorded. The car interior temperature shall be considered stabilized when the average interior temperature swing is less than 3°F in any 5 minute period. All temperature and pressure measurements shall be taken at 1 minute intervals.
- After initial temperature stabilization is attained, the test operation shall be continued for 30 minutes with temperatures and pressures recorded at 1-minute intervals in order to evaluate temperature variations as the controls and equipment cycle.

17.5.5.4 (d) Steady State Operation at Design Conditions

The pull-down test shall have been satisfactorily completed prior to this test. The steady state operation test shall be performed in accordance with the following steps:

The following conditions shall be established and maintained during the steady state operation test:

- Simulated load of passengers per Section 8.1.1
- Simulated solar load per Section 8.1.1
- All lights and electrical components ON
- Fresh air inlets open
- Climate Room ambient temperature maintained at 101°FDB, 70°FWB
- The air conditioning system shall be operated until conditions stabilize. Stabilization shall be considered the condition at which average interior temperature changes no more than 2°F during three (3) consecutive recordings at 5 minute intervals.
- After stabilization is attained, all temperatures and pressures shall be recorded at one (1) minute intervals for a period of 30 minutes. The interior conditions of Section 8.1.4 shall be met.

17.5.5.4 (e) Door Cycling Test -Cooling

The purpose of this test is to verify that the system capacity is sufficient to recover from temperature variations caused by door openings at station stops within the specified time.

With the same conditions as the steady state operation test, cycle the doors on one side of the car as defined in below:

- The average car temperature (within the intermediate, lower or upper areas evaluated individually) shall recover within 2°F of the required interior car conditions within 2 minutes maximum following a 30-second door opening. It shall be demonstrated that this requirement can be met during one hour of continuous door cycling of thirty seconds open and 2.5 minutes closed at design conditions in both air conditioning and heating modes at the climate room test conditions specified in this section.

17.5.5.4 (f) Condensate Carry-Over

The objective of this test is to demonstrate that no water (condensate) is carried from the evaporator into the supply-air discharge plenum. The condensate carry-over test shall be performed in accordance with the following steps:

- The air conditioning system shall be operated continuously for a period of 4 hours with the climate room ambient air temperature 80°FDB/75°FWB.
- Interior loads shall be adjusted during the test to maintain system operation in cooling mode. The system shall not enter ventilation mode during the test period. Any adjustments to internal loads must hold the interior sensible heat ratio constant at the design value.

- At the end of the test, all heater coils, evaporator blower compartments (in draw-through units), supply-air discharge plenums, air ducts, and diffusers shall be examined for the presence of water.
- The test shall be considered successful if, during the test, no condensed water is blown from any evaporator unit casing and/or its drain pan, and is carried in the air stream to any heater coil, evaporator blower, supply-air discharge plenum, air duct, or diffuser. All overhead heater elements shall remain dry.

17.5.5.4 (g) Maximum Operating Conditions

The objective of this test is to demonstrate air conditioning system operation at the maximum specified interior and exterior load conditions. The steady state operation test shall have been satisfactorily completed prior to this test. The following conditions shall be maintained for the duration of the test:

- Climate Room Ambient Temperature 110°FDB 84°FWB.
- Simulated passenger load as defined in Section 8.1.1
- Solar Load as defined in Section 8.1.1
- All Lights Turned ON.
- Fresh Air Intakes OPEN.

The maximum operating conditions test shall be performed in accordance with the following steps:

- The system shall be operated continuously for a period of 1 hour. During the entire test, the system shall not shut down due to high pressure, modulation, circuit breaker trip, compressor motor overload, or failure of any device. There are no capacity requirements to be met.
- After 1 hour of operation, the power input to the system shall be removed for minimum of 2 seconds, and then reapplied. The system shall recover from the power interruption and restart. After restart, the system shall function properly with all components free from malfunction. The removal of power simulates a power gap or phase break. The exact method of power removal, and duration may be modified as agreed to and approved by the Engineer.

17.5.5.4 (h) High Ambient Temperature Operation

The objective of this test is to demonstrate air conditioning system operation and control function at extremely high ambient temperature conditions. The high ambient test shall be performed in accordance with the following steps:

- All load requirements described for the Maximum Operating Conditions test shall apply for this test, except that the Climate Room ambient temperature shall be between 110°FDB to 115°FDB; exact temperature to be approved by the Engineer.

- The system continuously for a period of 1 hour. As the condenser pressure changes, the proper operation of the modulation switch and compressor un-loader (or other capacity reduction method as approved by the Engineer) shall be demonstrated. The system shall not shutdown due to high pressure, circuit breaker trip, compressor motor overload, or failure of any device. There are no capacity requirements to be met.
- The event recorder shall be used to monitor the modulation solenoid valve operation.

17.5.5.4 (i) High Pressure Switch Test

After successful completion of the High Ambient Test, increase the climate room temperature until the High Pressure Switch is actuated. After actuation, the system must restart as dictated by the control system.

17.5.5.4 (j) Low Ambient Temperature Operation

The objective of this test is to demonstrate successful air conditioning system operation and control function at low ambient temperatures with minimum passenger load, with adequate oil return to the compressor, and without freezing of evaporator coils. The following conditions shall be maintained for the duration of the test:

- Climate Room Ambient Temperature 50°FDB, 40°FWB
- All Lights ON
- Fresh Air Intakes OPEN

The low ambient test is to be performed by operating the system continuously for a period of 4 hours. Internal loads shall be adjusted such that the system operates at its minimum cooling capacity for the entire 4-hour period. Latent loads shall be sufficient to ensure that condensation forms on the cooling coil. During the entire test, the system shall operate without damage to the equipment and the evaporator airflow shall not drop more than 15 percent from the manufacturer’s design point. Interior car temperature shall not fall below 65°F.

17.5.5.5 Heating System Tests

17.5.5.5 (a) Vehicle Heat Transfer (UA)

The purpose of this test is to demonstrate that the overall carbody heat transmission does not exceed the specified limits.

The following conditions shall be maintained during this test:

Floor Heat	Operable
Ventilation Blowers	Inoperable
Overhead Heat	Inoperable
Cab Heat	Inoperable
Lights	Inoperable
All Auxiliary Equipment	Inoperable
Doors (side and end)	Closed
Fresh Air Intakes	Sealed

The heat transfer test shall be performed in accordance with the following steps:

- The fresh air intakes shall be sealed to eliminate the “chimney” effect. Door seals shall be maintained in their normal closed condition.
- Lower the Climate Room ambient temperature to 25°FDB, or as approved by the Engineer, and maintain this temperature throughout the test.
- Turn ON the floor heat. Allow the car interior temperature to stabilize.
- Record the interior temperature throughout the car at locations approved by the Engineer and the ambient temperature throughout the climate room at locations approved by the Engineer at 3 minute intervals for a period of 1-hour (producing twenty (20) sets of data).
- Calculate the average car interior and climate room ambient temperatures for each of the twenty (20) sets of data.

At the conclusion of the test, calculate the average car interior and climate room ambient temperatures for the entire test period.

Calculate the “UA” value using the following formula:

$$UA = \frac{3.413\,W}{(T_2 - T_1)} \quad \text{Units = Btu/(hour °F)}$$

where:

W = total heat applied to the car in watts

T_2 = average car interior temperature

T_1 = average Climate Room ambient temperature.

The Heat Transfer test shall be satisfactorily completed before proceeding to further testing in the Climate Room.

In the event the Heat Transfer test is failed, appropriate changes to the carbody insulation system shall be made, the test shall be repeated, and this process shall continue until the referenced Specification requirements are met.

17.5.5.5 (b) Layover

The purpose of this test is to demonstrate that the temperature control system can maintain the interior and cab temperature within the specified layover temperature range during changing ambient conditions, and at the minimum ambient temperature. Summary of Test Conditions is:

Climate room temperature:	25°FDB
Car voltage supply:	Nominal
Internal loads:	None

Maintain the ambient at the specified minimum for 8 hours. The average interior temperature must remain within the allowed layover temperature range for the entire 8-hour period.

17.5.5.5 (c) Warm-Up from Stable Layover Condition

The purpose of this test is to demonstrate that the heating system can raise the interior temperature of the car and cab from a stabilized layover condition to the specified design interior temperature within the specified time. During this test, the surface temperatures of the heater guards shall be verified and must not exceed the specified maximum. Summary of Test Conditions is:

Climate room temperature:	25°FDB
Car voltage supply:	Nominal
Internal loads:	None, except lighting

The warm-up from layover test shall be performed in accordance with the following steps:

- At the conclusion of the 8-hour layover test, defined in Section 17.5.5.6.1, energize the car and turn on the lights and all auxiliary circuits.
- The time required to raise the average interior temperature to the specified level without the benefit of solar or passenger loads shall be recorded.
- The time required to reach a stable interior temperature within the specified range of 67°FDB and 70°FDB. This time shall not exceed 30 minutes.
- The temperature of the heater guards in the passenger area and in the cab shall be recorded. The surface temperature must not exceed 125°F at any time during the test.

17.5.5.5 (d) Warm-Up from Dead-Cold Condition

The purpose of this test is to demonstrate that the heating system can raise the interior temperature of the car and cab from a cold soaked condition to the design interior temperature within the specified time. Summary of Test Conditions is:

Climate room temperature:	25°FDB
Car voltage supply:	Nominal
Internal loads:	None, except lighting

The dead-cold warm-up layover test shall be performed in accordance with the following steps:

- Prior to this test, the car shall be "soaked" in the climate room for at least 8 hours at the specified temperature with all doors open, lights and electrical circuits OFF, and with no passenger or solar load.
- Climate Room conditions shall be maintained constant temperature as much as possible during the entire test.
- After the complete "soak" period, the heating system shall be turned ON. All other electrical circuits including car lights shall be de-energized. All car doors and windows shall be closed and fresh air intakes shall be open.
- The time required for the average interior temperature to reach the minimum specified design dry bulb temperature.
- The time required to stabilize the car's interior temperature. The car interior temperature is to be considered to be stabilized when the average interior temperature swing is less than 2° F over any 5-minute period.
- During the entire pull-up period, monitor the surface temperature of the heater guards. Heater guard surface temperature must not exceed the specified maximum.

17.5.5.5 (e) Steady State at Design Conditions (minimum ambient, no passengers)

The purpose of this test is to demonstrate that the heating system capacity is sufficient to maintain the car and cab interior conditions at the specified design temperature with the ambient temperature at the specified minimum. The test also shall demonstrate the ability of the temperature control system to maintain interior temperature control within the specified limits, and that the required interior temperature uniformity can be met. Heater guard temperatures shall also be monitored. Summary of Test Conditions is:

Climate room temperature:	25°FDB
Car voltage supply:	Nominal
Internal loads:	None, except lighting

After the average interior temperature has stabilized following the warm-up test defined above, continue to record all data at 1-minute intervals for a minimum of 30 minutes. Average interior temperature shall remain within the specified design conditions. The required temperature uniformity conditions defined in Section 8.1.5 shall be established. The system's return air sensors shall not exhibit undue influence from the incoming fresh air. Heater guard temperatures shall not exceed the specified maximum.

17.5.5.5 (f) Door Cycling - Heating

The purpose of this test is to demonstrate that the heating system has sufficient capacity to restore the average interior temperature to the specified design conditions within the specified time with periodic door operation simulating station stops. Summary of Test Conditions is:

Climate room temperature:	25°FDB
Car voltage supply:	Nominal
Internal loads:	None, except lighting

After successful completion of the steady state test defined above and keeping conditions the same as defined therein, begin operating the doors on only one side of the car at the open-closed cycle defined for Door Cycling – Cooling test for a period of 1 hour. The doors on the opposite side of the car shall remain closed during the test. Average interior temperature shall recover as defined in Section 17.5.5.4(e).

17.5.5.5 (g) Steady State (minimum ambient, no passengers, and minimum voltage)

The purpose of this test is to document the stabilized interior temperature that the system can maintain at the specified minimum car supply voltage. Control stability and temperature uniformity must also be demonstrated. Summary of Test Conditions is:

Climate room temperature:	25°FDB
Car voltage supply:	Nominal
Internal loads:	None, except lighting

After successful completion of the steady state test defined above, the voltage supplied to the car shall be reduced to the specified minimum. The doors shall be opened and the interior temperature to drop to at least 10°F below the required interior temperature. After door closure, the interior temperature shall stabilize. After stabilization has been reached, all data shall be recorded at 1-minute intervals for a minimum of 30 minutes. It shall not be necessary for the average interior temperature to meet the specified conditions, however the interior temperature uniformity requirements of Section 8.1.5 shall be met.

17.5.5.5 (h) Steady State (design passenger load and minimum ambient)

The purpose of this test is to demonstrate control stability and temperature uniformity at the given test conditions. Summary of Test Conditions is:

Climate room temperature:	25°FDB
Car voltage supply:	Nominal
Internal loads:	Design passenger load, no solar load.

After successful completion of the steady state test defined above, the supply voltage shall be restored to the nominal value and design passenger sensible and latent internal loads shall be introduced. After stabilization, all data shall be recorded at 1-minute intervals for a minimum of 30 minutes.

The average interior temperature shall remain within the specified limits. The interior temperature uniformity requirements of Section 8.1.4 shall be met.

17.5.5.5 (i) Steady State (design passenger load, minimum ambient and high voltage)

The purpose of this test is to demonstrate that the average interior temperature is maintained within the specified limits, temperature control is maintained without excessive cycling of system components, and temperature uniformity is maintained within the specified limits. Summary of Test Conditions is:

Climate room temperature:	25°FDB
Car voltage supply:	Specified high limit
Internal loads:	Design passenger load, no solar load.

After successful completion of the steady state test defined above, the supply voltage to the car shall be increased to the specified maximum value and the car interior conditions shall stabilize. After stabilization, all data shall be recorded at 1-minute intervals for a minimum of 30 minutes. The average interior temperature shall remain within the specified limits. The interior temperature uniformity requirements of Section 8.1.5 shall be met.

17.5.5.5 (j) Abnormal Heating Conditions with Air Flow Restricted

The objective of this test is to demonstrate that first stage overheat protection device operates properly, the set point of the first stage overheat protection devices is appropriate, the first and second stage overheat protection devices are properly coordinated, and the variations in the overhead heat power caused by variations in the wayside supply voltage do not adversely affect the satisfactory operation of the first stage overhead protection device.

Climate room temperature:	Approximately 70°FDB
Car voltage supply:	Nominal, specified minimum and maximum
Internal loads:	None

The abnormal heating test shall be performed in accordance with the following steps:

- Return air inlet shall be gradually restricted at a rate such that heater unit temperature rise is less than 2°F per minute. The restriction shall be topped when the first stage overheating protection devices trips. The restriction shall be backed-off to the point where the device resets.
- Temperature readings shall be taken at 5-minute intervals.
- Heating system shall continue to operate until a steady stat is attained. A steady state shall be the condition at which three (3) consecutive temperature readings indicate no temperature rise.

The test shall be considered satisfactorily completed if the following conditions are met:

- Backup overheat protection device does not actuate,
- Temperature inside the unit does not cause damage to any equipment or components,
- No smoke or odors are detected,
- High limit switch opens at design set point $\pm 10^\circ$F.

Procedure shall be at the specified maximum and minimum supply voltages.

17.5.5.5 (k) Abnormal Heating Conditions with No Air Flow

The objective of this test is to demonstrate safe operation of heating system with no air-flow through the evaporator unit. This test shall be performed only after satisfactory completion of the restricted airflow test described above. Summary of Test Conditions is:

Climate room temperature:	Approximately 70°FDB
Car voltage supply:	Nominal, specified minimum and maximum
Internal loads:	None

The abnormal heating test shall be performed in accordance with the following steps:

- Evaporator blowers shall be turned off. Heating system shall cycle on an off safely under the control of the high limit switch.
- Temperature reading shall be taken at a rate approved by the Engineer.

- The system shall operate under these conditions until the peak temperature seen during the cycle does not increase for three (3) consecutive cycles.

The test will be considered satisfactorily completed if the following conditions are met:

- Backup overheat protection device does not actuate,
- Temperature inside the unit does not cause damage to any equipment or components,
- No smoke or odors are detected,
- High limit switch opens and closes at design set point ± 10°F.

The test shall be repeated with the wayside power supply at the specified minimum and maximum values.

17.5.5.5 (l) Back-up Overhead Heat Overheat Protection

The purpose of this test is to demonstrate that the backup overheat protective device functions correctly and that the set point of the back-up overheat protective device is satisfactory. Summary of Test Conditions is:

Climate room temperature:	Approximately 70°FDB
Car voltage supply:	Nominal, specified minimum and maximum
Internal loads:	None

The back-up heating test shall be performed in accordance with the following steps:

The first stage overheat protective device shall be bypassed/jumpered.

- Evaporator blowers shall be turned off.
- The overhead heat shall be turned on.
- Temperature readings shall be taken at a rate approved by the Engineer.

The test will be considered satisfactorily completed if the following conditions are met:

- Temperature inside the unit does not cause damage to any equipment or components,
- No smoke or odors are detected,
- The backup overheat device actuates at a temperature high enough to allow it to activate only in the event of failure of the primary protective devices.
- After the functioning of the device, temperature measurement records shall be continued at not greater than 30-second intervals until steady temperature fall is observed.

The test shall be repeated with the wayside power at the specified minimum and maximum values.

17.5.5.5 (m) Windshield Defrosting and Demisting Test

The objective of this test is to demonstrate operation of the Operator's cab windshield defroster/demister. The following measurements shall be recorded:

- Heater element voltage, current, and power,
- Climate room ambient temperature, and
- Cab temperature at locations approved by the Engineer.

At stable climate room conditions as specified in Section 8.2.2 and with ice applied to the windshield according to the requirements of standard SAE J381M, time required to clear the windshield shall not exceed 15 minutes. If the heated windshield is used, the windshield temperature shall not exceed 125°F.

17.5.6 Light Intensity

The intensity of the lighting shall be measured in one of each car type to verify the levels specified in Section 9.1.2.

17.5.7 Weight Distribution

Weight distribution tests shall be performed on one completed car of each type to verify compliance with the requirements of Section 2.4.3.

17.5.8 Clearance

The Contractor shall perform complete dimensional and clearance measurements of the car and car-mounted equipment on the first of each car type. **[CDRL 17-013]**

The cars shall be measured by the Contractor for proper truck, coupler and cable and hose clearance on the minimum radius horizontal and vertical curves, reverse curves, crossovers on minimum track centers, wheel truing machine allowances, vehicle outline and combination thereof, as specified in Section 2. The trucks shall be measured for proper swing and for clearance from carbody and undercar components. All cables and hoses shall be measured for clearance, stretching and chafing. These tests shall be performed at both AW0 and AW3 car weight. Tests shall also be carried out with one AW3 weight car with deflated air springs and simulated fully worn wheels coupled to another car at an AW0 weight with new wheels at simulated maximum upwards dynamic air spring extension. A test shall be made with air bags at one (1) end fully deflated and air bags at the other end of the car inflated to maximum pressure (each end to be tested at both full and deflated pressures).

Truck clearances, coupler clearances, and operation shall be measured by moving a train of the consist listed in Section 2.5 over a curve and a crossover duplicating the most restricting track work and car condition specified in Section 2.7. These tests shall be repeated two (2) additional times on production cars selected at random by the Engineer. This test shall demonstrate that no interference occurs under all conditions.

The carbody clearances, including trucks and couplers, shall be measured by moving a train comprised of the cars, with temporary templates installed at all locations representing the worst-case dynamic clearance envelope of the car, over the entire right of way. The test cars shall be configured to simulate AW3 passenger loads. Template design, template locations, and test methodology shall be subject to approval by the Engineer. **[CDRL 17-014]**

17.5.9 Trainline and Compatibility with Existing Vehicles

The cars shall be tested using suitable apparatus to demonstrate that all trainline functions including HEP trainlines perform satisfactorily under the control of the cab car and under control of the locomotive. All cab and interface functions shall be tested. This test shall be performed at the Contractor's facility prior to delivery. Any modifications required as a result of these tests shall be incorporated into all cars.

One (1) car of each type shall be tested with another car of each type furnished under this Contract to demonstrate that all trainline functions perform satisfactorily from control cabs of each car when cars are coupled together. These tests shall include running as well as static tests. Trainline verification tests shall be performed, as a minimum, for the following vehicle combinations:

- Both Ends Cab Car,
- Both Ends Trailer Car,
- Locomotive to Cab Car,
- Locomotive to Trailer Car,
- Existing Trailer and Locomotive to Cab Car, and
- Existing Cab and Locomotive to Trailer Car.

These tests shall be performed at the Contractor's facility prior to delivery of the first car except for those trainline tests requiring the use of the existing cars, and/or locomotive equipment, which shall be performed on SCRRA property. Any modifications required as a result of these tests shall be incorporated into all cars prior to delivery.

These trainline tests shall include all signals that may be transmitted to and from the cab car, the trailer, the locomotive, the car level processing unit, the cab message display, and all data loggers. This shall include all normal and abnormal conditions, such as faults, which may be simulated as approved by the Engineer. **[CDRL 17-015]** Proper cab message display, storage (including data loggers), and transmission (including radio) of data shall be demonstrated.

17.5.10 Friction Brake Thermal Capacity

Prior to the start of the Test Program, a series of "Shake-Down" tests, as approved by the Engineer **[CDRL 17-016]**, shall be conducted to determine the equipment settings and calibrations to be used.

Using the data from the shake down tests, characteristic car performance parameters and curves shall be generated for the evaluation of the test results of the production cars. These parameters shall include all air pressures, voltages, and currents.

A group of plots (at various speeds passenger loads and wheel temperatures) of brake cylinder pressure versus braking effort (derived from deceleration recordings and known loadings, less known drift rates of the corresponding speed) shall be developed. All pertinent data from each test at each loading shall be represented on a single graph.

If the cars or any of their equipment fails to satisfy the specified performance and design criteria, the cars shall have the necessary adjustments made and be retested at the Contractor's expense.

The friction brake system shall be tested on the cars to demonstrate that it meets the requirements of Section 12. The brake disc and brake pad or wheel and brake shoe temperatures shall not exceed the limits specified by the manufacturer(s). These limits shall be included in the test procedure for this test. Brake disc or wheel temperatures shall be measured and recorded in a manner approved by the Engineer such that the measurements can be compared directly to the manufacturer's specified limits during the testing without need for additional calculation. The brake disc or wheel manufacturer shall also approve the brake disc or wheel temperature measurement method employed by the Contractor for these tests. Successful completion of all of the preceding tests and acceptance of the test results by the Engineer shall be required for final approval of the friction brake system. Prior to testing, pads or shoes shall be fully seated.

Conformance or proof-of-design tests shall be performed on the cars on a SCRRA line prior to acceptance. These tests shall be more inclusive than the performance and acceptance tests of the balance of the cars so as to demonstrate not only that the cars are properly adjusted, but also that the design of the cars is correct in all respects and in compliance with the performance standards specified. The Contractor shall develop, a list of tests to be performed and shall submit the same to the Engineer for approval. **[CDRL 17-017]**

All static tests shall be performed on a Cab Car and all of the road tests shall be performed at the same location that the existing cars were tested.

As a minimum, two (2) runs in the same direction shall be made for each road test condition listed in Section 17.5.10.1 with the locomotive leading and again with cab car loading. This series of tests shall be used to determine the brake equipment settings and calibrations to be used for the car acceptance program.

After the successful completion of the test program, each car used in the test train shall be restored to its original configuration.

All recorded data shall be corrected for grade as part of the Contractor's test report. Test reports shall be forwarded to the Engineer, and become the property of SCRRA.

If any car, or any equipment, fails to satisfy the specified performance and design criteria, the cars, with the necessary adjustments, shall be retested at the Contractor's expense.

Any modifications deemed necessary shall be submitted to the Engineer for review and approval. Modifications shall be verified by appropriate test(s) approved by the Engineer and effected on a fleet wide basis.

Multiple-channel ink or thermal pen recorders (Gould Brush 2800 series recorders or equal) or Digital Data acquisition system are to be provided by the Contractor, to produce a permanent test record. The Contractor shall supply all recorders, sensors, pickups, and wiring. This instrumentation shall use the cars' 120 VAC supply. Internal combustion engine driven generators shall not be permitted. The equipment shall not be damaged by the conditions specified in Section 2. Isolation amplifiers and voltage dividers shall be provided as part of the instrumentation package to isolate the inside car instrumentation wiring and equipment from high voltages; no exposed terminals with potential differences greater than 50 volts shall be permitted. The accuracy and response of the instrumentation shall be sufficient to determine the degree of compliance with the Specification and design data.

For these tests, the following channel assignments shall be permanently recorded simultaneously.

Static Tests:

- Time,
- Brake Valve Handle Movement,
- Load Weigh Pressure,
- Equalizing Reservoir Pressure,
- Brake Pipe Pressure,
- Brake Cylinder Control Pressure, and
- Brake Cylinder Pressure.

Road Tests:

- Time,
- Brake Valve Handle Movement,
- Load Weigh Pressure of Cab Car,
- Accelerometer of Cab Car,
- Brake Pipe Pressure of Cab Car,
- Brake Cylinder Pressure of Locomotive,
- Brake Cylinder Pressure of Each Truck of Each Car,
- Speed of Each Axle on Each Car, and
- Distance (Pulses).

As a minimum, the following tests shall be performed on a train consisting of five (5) multi-level cars with at least one (1) multi-level cab car and a locomotive, except as otherwise required:

17.5.10.1 Braking Kinematic Tests

17.5.10.1 (a) Static Tests

The static tests simulated passenger load shall be zero. The test shall be performed on one multi-level Cab Car and shall include the following response time tests from time of brake valve handle movement in the following sequence:

- Brake Pipe Reduction Time to 85 psi
- Brake Cylinder Build-up Time to 95% of maximum
- Brake Cylinder Release Time to 5 psi
- Emergency
- Brake Pipe Reduction Time to 0 psi
- Brake Cylinder Build-Up Time to 95% of maximum

The static test shall include brake shoe and brake pad force test. This test shall determine actual force developed at each shoe and pad. The brake pipe pressure shall be reduced in 5psig increments from fully charged to 0 psig. At each increment the force at each shoe and pad shall be recorded. A full service pressure and again at emergency pressure the hand brake shall be applied. The test shall be conducted at AW0 and AW3 conditions.17.5.10.1 (b) Road Tests

The simulated passenger load in each car shall be zero (0). For each run, the wheel temperature shall not exceed 200 degrees F before initiation of any test. Performance requirements shall be as in Section 12.3.

Full service stops from 100, 80, 60, 40, and 20 mph with the braking provided by the multi-level cars only with locomotive brakes bailed-off.

Emergency stops from 100, 80, 60, 40, and 20 mph. For safety, the locomotive brakes shall not be bailed-off for these tests.

17.5.10.1 (c) Wheel Slide Tests

During the Braking Road Tests, axle speed and brake cylinder pressure of each test car shall be monitored and recorded to indicate the wheel slide system operation and the ability of the car to withstand numerous wheel slide corrections without emergency application. If no slide activity is recorded during the tests, additional tests shall be performed to create slide condition artificially.

17.5.10.2 Dynamic Wet Braking

The cars shall be dynamically tested under wet braking conditions. This test shall be performed by the Contractor on SCRRA's property as selected by the Engineer.

The Contractor shall provide water spray equipment capable of spraying water at each and every wheel-to-shoe interface and/or disc-to-pad interface of the cars. All water spray equipment, spray pattern and spray flow shall be in accordance with UIC 541-3, Appendix 4, if tread brakes are used or UIC 541-4, Appendix 4, if disc brakes are used. Water spray equipment and method of directing water to the brake system are to be approved by the Engineer.

17.5.11 Handbrake

A test of the adequacy of the design of the handbrake shall be made (using first new, and then fully worn brake shoes) by measuring with a scale the force needed to move the car with the handbrake applied per Section 12.16.1 and 12.16.2. The handbrake interlocking circuitry, including the applied indicator described in Section 12.16.1, shall also be tested.

The handbrake arrangement shall be tested separately with AW3 emergency brake application to demonstrate compliance with requirement of Section 12.16.1

17.5.12 Ride Quality

To verify conformance with the ride quality requirements of Sections 2.5.3 and 11.3, and 49 CFR 238.227, the cars shall be subjected to Ride Quality Tests at SCRRA following delivery. Ride Quality Tests shall be conducted on each type. As part of the Ride Quality Tests, the same tests shall be conducted on one (1) SCRRA third generation car for comparison. The existing car is to be selected by the Engineer. The test track shall be on SCRRA track, as selected, and tests shall be conducted at the same speed and in the same direction for all cars. Ballast used in simulating the seated load, as well as the labor for loading and unloading, shall be provided by the Contractor at his expense.

Ride quality shall be evaluated according to ISO 2631-1:1997(E). The RMS acceleration values for each measurement point shall not exceed 0.315 m/sec^2 for seated and standing passengers. Also, the vibration total value (root sum of squares summation) for each measurement point shall be calculated, and shall not exceed 0.5 m/sec^2. Where appropriate, frequency weighting W_b shall be used instead of W_k . Acceleration data shall be evaluated over the range of 0.5 Hz to 80 Hz. For seated passengers, the evaluation shall be made over all six (6) axes on the seat pan and the three (3) translational axes at the seat back and floor. For standing passengers, the acceleration data shall be evaluated in the three (3) translational axes of the floor. Representative seat and floor positions shall be proposed by the Contractor and approved by the Engineer. Ride quality shall also be calculated from the same data per ISO 2631-1:1985 for vertical and horizontal directions, and submitted to the Engineer for information only.

Ride quality shall be evaluated for AW0 and AW3 load conditions and at all normal vehicle acceleration, deceleration, and speed conditions. As a minimum, the Ride Quality Tests shall consist of operating the cars at speeds of 50, 75, and 100 miles per hour. The test shall be conducted on the class track appropriate for the test speeds. The vehicle shall be evaluated with new wheels on tie and ballast track, welded and jointed rail, and turnouts with non-corrugated welded rail. Riding qualities of the car at all speeds up to 75 mph shall be equal to or superior to those of an SCRRA third generation car. There shall be not a dangerous buildup of oscillations or excessive lean, sway, or yaw, which could cause the car to violate the dynamic clearance limits. The cars shall also be tested with deflated air springs to confirm safe train operation under those conditions at AW0 and AW3. With deflated air springs, ride quality shall not exceed 0.62 m/sec^2 for seated and standing passengers and total value (root sum of squares summation) for each measurement point shall not exceed 1.0 m/sec^2.

Instrumentation capable of measuring and charting (for permanent record) the magnitude and frequency of the vertical, longitudinal, and lateral shocks expected, up to 2.0 g and 150 Hertz, shall be provided and operated by the Contractor, who shall reduce the raw data for presentation to the Engineer. Sensing units shall be located on the car floor above the intersection of the car longitudinal center-line and each truck transverse center-line or other locations as approved by the Engineer. Provision shall be made for recording vertical, lateral, and longitudinal shocks (vibrations) concurrently, speed and distance in 100 feet increments, and to allow entry of event markers on recorded data for these tests.

In the event that the dynamic behavior of the cars is inferior in any respect to the Technical Specification requirements, the Contractor shall submit to the Engineer, within sixty (60) days, a program containing mathematical analysis of the problem and a course of action for its correction. If the Engineer approves the analysis and corrective measures, those corrective measures shall be made effective on the cars within ninety (90) days at the expense of the Contractor, the cars shall be retested, and if the measures are successful, they shall be applied to all the cars. If not, the analysis and correction steps shall be repeated, submitted, and retested until successful.

The Contractor shall demonstrate compliance with the requirements of 49 CFR 238.227 as part of the Ride Quality Tests. Hunting shall be evaluated by recording data from lateral sensing accelerometers mounted on the truck frame adjacent to the journal bearing housings. The measurements shall be processed through a filter having a pass band of 0.5 to 10 Hz. There shall be no sustained cyclic oscillations in excess of 0.32 g root mean square (mean removed) for 2 seconds.

17.5.13 Noise and Vibration

The interior and exterior noise and vibration levels of the cars shall be measured to assure compliance with the requirements of Section 2.5.2, 40 CFR Part 201, 49 CFR Part 210, and 49 CFR 229.121. Vibration tests and noise measurements tests shall be performed with all car systems in operation while the car is at a stand still and while operating from a stand still to 90 MPH and back to a stand still using full service braking. All tests shall be performed with the car on level tangent track in an open area. The sound level meter shall conform, at a minimum, to the requirements of ANSI S1.4, Type 2, set to the A-weighted slow response, or an audio dosimeter of equivalent accuracy and precision may be used. Vibration and shock tests shall conform to requirements of IEC-61373 Railway Applications Rolling Stock Equipment Shock and Vibration Tests.

In conducting sound level measurements in the interior of the cabs and passenger compartments with a sound level meter, the microphone shall be oriented vertically and positioned approximately 15 centimeters from, and on the axis of, a seated passenger or the Operator’s ear.

Measurements with an audio dosimeter shall be conducted in accordance with manufacturer's procedures as to microphone placement and orientation.

Measurement of the sound levels of the horns shall be made using a sound level meter conforming, at a minimum, to the requirements of ANSI S1.4, Type 2, and set to the A-weighted slow response. With the cars on level tangent track, the microphone shall be positioned four (4) feet above the ground at the center-line of the track, 100 feet from the end of each car, and shall be oriented with respect to the sound source in accordance with the manufacturer's recommendations. Sound level measurements shall be tape recorded in the event further analysis is required.

For the preceding tests, completed test reports shall comply with requirements of Section 17.3.1 and include the following:

- Description of noise or vibration source being measured, including pertinent statistical information;
- Description of the environment where noise or vibration source is measured, including a sketch showing source position;
- Operating conditions of noise or vibration source during measurements;
- Pertinent meteorological data, if applicable;
- Locations and orientations of microphones with respect to noise source;
- Equipment used for making measurements;
- Description and measurement of ambient noises;
- Data obtained, including range of variation;
- Instrumentation, settings, corrections and calibration results; and
- Summary of results and conclusions.

17.5.14 Horn and Bell

The horn and bell, as mounted on the completed car, shall be tested for conformance to the requirements of Section 7.

17.5.15 Miscellaneous Tests and Adjustments

Other equipment not listed in the previous subsections shall also be tested to ensure compliance with this Specification and manufacturer's standards. The Contractor shall identify each of these tests in test plan. **[Part of CDRL 17-001]**

17.5.16 Coupling Test

Couplers shall be tested to verify the specified gathering range and centering. The first two cars shall also be tested to demonstrate coupling compatibility with the existing SCRRA cars and locomotives.

17.5.17 EMI Tests

An electromagnetic compatibility test shall be performed on the cars for compliance with those requirements and for compatibility with SCRRA signal and communications systems. During these tests, confirmation of emissions limits specified in this section shall be conducted by monitoring signal and communication systems function.

17.5.17.1 General

As requirement to ensure EMI, all vehicle electronic systems, which are potential EMI emitters or victims, are to be tested separately by a qualified laboratory.

These tests shall include the following specific requirements:

- IEC 61000-4-2 Electrostatic discharge Immunity test. Test level 4 is required.
- IEC 61000-4-3 Radiated, radio frequency, electromagnetic field immunity test. This test shall be done at a field-strength of 20 V/m. The range from 80 MHz to 6 GHz shall be tested. Test result class A shall be required for all safety critical systems. Test result Class B shall be required for all other systems.
- IEC-6100-4-4 Electrical fast transient / burst immunity test. Test Level 4 is required.
- IEC-6100-4-5 Surge immunity test. Test Level 4 is required.
- IEC-6100-4-6 Immunity to conducted disturbances, induced by radio-frequency fields test.
- Level 3 is required from 150 kHz to 80 MHz.
- Radiated Emissions per FCC part 15, class A levels from 30 MHz to 1 GHz.
- Conducted Emissions per FCC part 15, class A levels from 0.15 MHz to 30 MHz.

A vehicle level radio frequency immunity test shall be conducted using hand-held radios of the same type used by SCRRA and various types of cellular phones. The test shall include interior and exterior of vehicle. The contractor shall submit a test plan and test procedure for review and approval of SCRRA prior to any testing.

The Contractor shall demonstrate through specified electromagnetic compatibility, inductive, and radiated emissions tests that the worst-case emissions of a ten (10) car train are electromagnetically compatible with all SCRRA systems.

To determine the worst-case emissions, the Contractor shall perform the specified tests for normal, abnormal, and failed operating conditions, and in the full range of all applicable operating modes, speeds, voltages, train lengths, and loading. The Contractor shall test all operating modes including appropriate combinations of HVAC and all auxiliaries including light ballast and Destination Signs at maximum and minimum power, and under failure conditions. Failure conditions shall include failures of all EMI control components or subsystems, all EMI detection components and subsystems, all EMI sources that affect amplitude or frequency, and all failures identified in the safety analysis.

For each test below, the Contractor shall develop and submit a test procedure to the Engineer for review and approval. The Contractor shall perform the tests to the satisfaction of the Engineer. In each case, the Contractor shall document the test and submit a test report for review and approval. Laboratory tests shall be conducted as part of the subsystem qualification tests. Field tests shall be conducted as part of the qualification tests. Note that both single-rail and double-rail track circuits may be present.

17.5.17.2 Compatibility Testing

The Contractor shall conduct vehicle EMC tests to ensure that all systems operate correctly without interference. Testing shall be performed with systems operating in all modes under normal and abnormal operating conditions.

In addition, combined testing with each type of existing SCRRA passenger car and locomotive shall be performed to ensure EMC between the locomotives and the passenger cars.

17.5.17.3 Inductive Emissions

17.5.17.3 (a) Laboratory Inductive EMI Tests

The Contractor shall perform Laboratory Inductive EMI Tests. The Contractor shall perform a test for each power unit with a rating greater than 10 kW, including auxiliary electric converters and any others such as the HVAC motor inverter.

The Contractor shall submit a Laboratory Test Procedure for each power unit for review and approval. **[CDRL 17-018]** The Laboratory Test Procedure shall be compatible with Method RT/IE01A in UMTA-MA-06-0153-85-8, Inductive Interference in Rapid Transit Signaling Systems - Volume II Suggested Test Procedures, March 1987, adapted for laboratory operation. The draft procedure shall be available at the Preliminary Design Review.

17.5.17.3 (b) Field Inductive EMI Test

The Contractor shall perform a Field Inductive EMI Test.

The Field Test Procedure shall be compatible with Method RT/IE01A in UMTA-MA-06-0153-85-8, Inductive Interference in Rapid Transit Signaling Systems - Volume II Suggested Test Procedures, March 1987.

The Contractor shall submit a Field Inductive EMI test procedure to the Engineer for review and approval. **[CDRL 17-019]** The draft procedure shall be available at the Preliminary Design Review.

17.5.17.3 (c) Inductive Emission Limits

The per car emission limits in the following table shall not be exceeded:

Frequency (Hz)	Most Sensitive Relay Pickup Level (mV)	Emission Limit (mV)
20 to 30	220 RMS	55 RMS
50 to 70	220	55
90 to 110	200	50
500 to 10 k	80	20
10 kHz to 20 kHz	40	10

At other frequencies, train emissions shall be limited to values that do not result in interference with other systems and apparatus.

The Contractor shall document the Inductive Emission Test results in a report that shall be submitted for review and approval. The report shall identify the source of all narrow band emissions from 20 Hz to 20 kHz.

17.5.17.4 Radiated Emissions

17.5.17.4 (a) Field Radiated EMI Test

The Contractor shall perform a Field Radiated EMI Test. The Field Test Procedure shall be compatible with UMTA-MA-06-0153-85-11, Radiated Interference in Rapid Transit Signaling Systems - Volume II Suggested Test Procedures. The Contractor shall submit a Field Radiated EMI Test plan to the Engineer for review and approval. **[CDRL 17-020]** The draft procedure shall be available at the Preliminary Design Review.

17.5.17.4 (b) Radiated Emission Limits

The following conditions must be satisfied:

Radiated emissions shall not exceed the emission limit of MIL-STD-461E, Curve RE02 for broadband emissions, which applies to Class B equipment, "Equipment and Subsystems in Non-Critical Areas".

Radiated emissions shall not exceed the following:

Emission limits are, on a plot of dB microvolts per meter per megahertz (dbuV/m/MHZ) versus log frequency, measured 50 feet from the center-line of the track:

- At 150 kHz, the lower limit, a level of 108 dbuV/m/MHZ.
- A straight line from 108 dbuV/m/MHZ at 150 kHz to 75 dbuV/m/MHZ at 200 MHZ.
- A straight line from 75 dbuV/m/MHZ at 200 MHZ to 90 dbuV/m/MHZ at 1000 MHZ.
- A straight line (flat line) from 90 dbu/m/MHZ from 1000 MHZ to 6000 MHZ.

The Contractor shall document the Radiated Test results in a report that shall be submitted to the Engineer for review and approval. The report shall identify the source of all narrow band emissions from 150 kHz to 6000 MHZ.

The Contractor shall cooperate with SCRRA in the satisfactory resolution of all complaints received by SCRRA and attributed to the cars. Complaints of radio, television, and telephone interference shall be included.

17.5.18 Destination Signs

The destination sign systems shall be tested to demonstrate Specification compliance. These tests shall include all possible combinations of variables of sign, live voltage, control and message configurations.

17.5.19 Toilet Room and Water System

The purpose of this test is to determine that the system operates and functions properly as integrated into the vehicle. Each aspect of the toilet area module and holding tank and water system module and toilet room furnishings shall be tested. The operations of the freeze protection devices shall be tested as part of the Climate Room testing.

17.5.20 Communication System

The public address, intercommunication, and radio equipment on each car shall be tested and adjusted as necessary for proper functioning as specified in Section 13. The vehicle and trainline network shall be tested on the cars for proper functioning and operation as specified in Section 5.7. Comprehensive tests shall be performed on the complete communications systems installed in the cars to ensure that all specified design parameters have been met.

17.6 COMPONENTS AND SYSTEMS PRODUCTION CONFORMANCE TESTS

17.6.1 General

All equipment on each car shall be given a functional test (production test) to assure proper operation at the manufacturer's facility prior to shipment. Test procedures shall be provided for approval to the Engineer and test reports shall be made available for approval at the Contractor's plant.

All equipment shall also be given a functional test (pre-delivery) on the completed car to test for proper operation by the Contractor prior to issuance of a Release for Shipment document by the Engineer. Test procedures and test reports shall be submitted to the Engineer for approval and shall become the property of SCRRA. Test Reports shall be included in each Car History Book as specified in Section 19.7.

The test to be performed by each manufacturer and the Contractor on each car component or subsystem shall be in accordance with the applicable industry standards listed in this Technical

Specification and the approved test plan. The following tests in this section list some, but not all, of the tests to be performed.

This shall be in addition to and shall not to replace the Contractor's and supplier's Quality Assurance Plans:

17.6.2 Electrical Apparatus

Each component that is separately assembled, housed and wired into a package unit prior to installation shall be tested at its point of manufacture and a certified test report, signed by the responsible Quality Assurance representative of the manufacturer, shall be furnished to the Contractor and made available to SCRRA. Tests shall be in accordance with IEEE Standard Number 11 for DC rotating machinery. AC rotating machinery shall be tested in accordance with IEEE Standard Number 112A for the electrical characteristics and IEEE Standard Number 11 for the mechanical characteristics. Control apparatus shall be tested in accordance with IEEE Standard Number 16 as appropriate.

17.6.3 Air Conditioning Unit

Each evaporator and condenser coil shall be proof pressure tested by the coil manufacturer, with a test certificate available for review.

Each complete unit shall be given a pressure test at 1.5 times the working pressure or 600 psig, whichever is greater (except that compressor test pressure should be according to the compressor manufacturer recommendations), and leak tested with a leak detector calibrated for a rate of 1.5 ounces per year. Following leak testing, the units shall be dehydrated and evacuated to 50 microns or less, with the pressure rise not to exceed 200 microns in 1 hour after isolation of the vacuum pump, and pressure charged to a minimum of 5 psig with refrigerant R407C. Each unit then shall be given a complete functional testing to verify its proper operation. At the conclusion of the functional testing, a filter-drier or its core and a strainer, as applicable, must be replaced with new. Fresh and return air filters (which are part of the unit) must be replaced with new air filters.

17.6.4 Motors

Each DC powered motor shall be given a "routine" test by the manufacturer in accordance with IEEE-11 to the applicable standards contained therein, as a minimum. Each AC powered motor shall be given a "routine" test by the manufacturer in accordance with IEEE-112 to the applicable standards contained therein, as a minimum.

The Contractor may propose, subject to approval, by the Engineer motor tests in compliance with IEC-349.

17.6.5 Battery

All Batteries shall be given a capacity test at the point of manufacture in accordance with the requirements included in APTA RP-E-007-98Rev 1.

17.6.6 Friction Brake Equipment

All pneumatic valves shall be test rack tested and/or certified according to its manufacturer's instructions.

All valves shall be test rack tested and certified to the latest COT&S per Federal Regulation 49 CFR 229, and 49 CFR 238.

All reservoirs shall be tested and certified to 49 CFR 229.

17.6.7 Communication System

As a minimum, the factory tests shall include all technical parameters delineated in Sections 13, and 15. A copy of test sheets, with serial numbers of all equipment tested shall be furnished to the Engineer certifying that the standards listed in Sections 13 and 15 have been met and that the method of measurement specified in the standards was followed in conducting the tests.

17.6.8 Truck

Critical areas of welds of each truck frame and truck bolster shall be inspected as required by Section 11.2. The completely assembled truck shall not exceed the clearance limits specified between the truck and the rail, as specified in Section 2.3.1.

17.6.9 Side Door Operators

Each side door operator and associated controls shall receive a routine test as defined by the manufacturer and approved by the Engineer.

17.6.10 Toilet Room and Water System

Each complete toilet room system and associated controls, piping, and tanks shall receive a routine test as defined by the manufacturer and approved by the Engineer.

17.7 VEHICLE LEVEL PRODUCTION CONFORMANCE TESTS

17.7.1 General

As a minimum, the tests listed in this section are to be performed on each car prior to the issuance of a Release for Shipment document by the Engineer. The Contractor's production test shall include all tests and adjustments, which can be made prior to delivery in order to keep car acceptance testing and adjustments to a minimum.

17.7.2 Watertightness

All areas of the sides, ends, and roof of each car shall be given a complete test for watertightness. The tests shall be performed before installation of sound deadening material, thermal insulation, and interior finish. Water shall be sprayed from nozzles which are spaced no more than three (3) feet from, and aimed directly at, the surface being tested. The nozzles shall be positioned no more than 17 inches apart in an equilateral triangle pattern and shall produce an overlapping spray pattern. Not less than 0.625 gallon per minute shall be delivered to each square foot of surface being tested, and the nozzle velocity of the water shall not be less than 150 feet per second. All spray applications shall run for 10 minutes before the inspection for leaks and shall run continuously during the inspection. Upon completion of the car, a spot test using localized nozzles shall be performed on the doors and windows. The Contractor shall submit, as part of the watertightness test procedure, an analysis of the water test fixture and apparatus demonstrating that all water nozzle pressures, amounts, and directions meet the requirements of this section. **[CDRL 17-021]**

Certain equipment boxes, because of the nature of the equipment they enclose, may be required to be watertight. These boxes shall receive a water test similar to the watertightness test of the carbody. The watertightness test shall be performed on the individual boxes prior to installation under floor in a manner simulating the conditions as would be expected with the boxes mounted on the car and again during the test of the complete carbody. During test of the boxes after installation, the required spray is to be directed at the exposed sides and ends of the boxes as would normally occur during car operations, including car washing, and as a simulation of water spray from the wheels. The water flow rate and velocity shall be as specified for carbody water test.

17.7.3 Weighing

The Contractor shall weigh each car and each truck at the time of shipment in accordance with Section 2.4. The weight of each end of the car shall be provided separately. A weighing device which provides a permanent printed record of the weight shall be used, and the weight tickets there from shall be submitted to the Engineer and copies thereof included in the Car History Book as detailed in Section 19.7. The weighing device shall be maintained within an accuracy of 0.2 percent. If the weighing device is electronic, it shall be calibrated at intervals of no more than sixty (60) days. If the weighing device is mechanical, it shall be calibrated immediately prior to weighing the first car and annually thereafter. Any total car weight deviation of greater than 300 pounds from the weight of the cars or other standard weight agreed to by the Contractor and the Engineer must be explained to the satisfaction of the Engineer prior to shipment.

It shall be demonstrated that the Load Weigh System recognizes weight changes in the car as well as determining that both empty and established parameters for the various loading conditions are met at all locations.

17.7.4 Car Wiring

When all wiring is completed on each car, the Contractor shall test each wire to verify continuity and proper polarity, connections, and wire identification. A direct current insulation test shall then be performed on each car as listed below. Finally, the Contractor shall perform a high-potential ground insulation test as listed below on all car wiring. All components and systems shall be in place when the high potential tests are performed, except that electronic or other low-voltage devices, which may be damaged by the test voltages, may be disconnected and their wire connections suitably disabled. The Contractor shall jumper the various wires in a system to insure that all parts of the system are tested. These tests shall be conducted at the

Contractor's plant to demonstrate compliance with the requirements of this section prior to car shipment.

17.7.4.1 Wiring Continuity Test

All circuits shall be tested on each car to ensure continuity and correct polarity of equipment and devices. All wiring connections and terminals shall be examined for tightness. Wiring shall also be checked for shorting between wires.

17.7.4.2 Insulation resistance Tests

Insulation resistance tests shall be conducted on all circuits within a device or system apparatus. Insulation resistance tests shall be conducted before high potential tests are conducted. Tests shall be conducted to verify the state of the insulation to the equipment case, between wiring of different voltage classes, and between the input and output circuit of high voltage by means of shorting jumpers if they are not inherently protected by the circuit in which they are used.

On items with double insulation, such as resistor grids mounted on insulators to a frame insulated from the carbody, each set of insulation shall be individually tested, *i.e*., resistors to frame and frame to carbody. The following insulation resistance limits shall apply under all environmental conditions including high humidity when all circuits on the vehicle of a given voltage class are connected in parallel:

Nominal Circuit Voltage DC or AC RMS	**Minimum Insulation Resistance**
Below 90 volts	2 megohms at 500 VDC
90 to 300 volts	4 megohms at 1,000 VDC
Above 300 volts	5 megohms at 1,000 VDC

The test limits for individual devices or apparatus shall be higher than the above listed limits as is appropriate for that hardware, so that the limits for the completed vehicle can be met.

17.7.4.3 High Potential Tests

A high potential test shall be conducted after the insulation resistance test is completed and passed. The high potential test shall be conducted on all circuits within a device or system. Tests shall be conducted to qualify the state of the insulation to the equipment case, between wiring of different voltage classes, and between the input and output circuit of high voltage line switches and circuit breakers. Semiconductor devices and lighting inverter ballasts may be protected against the test voltage by means of shorting jumpers if the devices are not inherently protected by the circuit in which they are used.

All components and systems shall be in place when the high potential tests are being performed. The Contractor shall jumper the various wires in a system to insure that all parts of a system are tested and to prevent capacitive currents or fault currents from passing through and damaging low voltage devices.

On items with double insulation, such as resistor grids mounted on insulators to a frame insulated from the carbody, each set of insulation shall be individually tested, i.e., resistors to frame and frame to carbody.

The test shall be conducted by applying the test voltage, as listed below, for a period of 1 minute, across the insulation being tested, the test shall be passed if there is no insulation breakdown or excessive leakage current. The test voltage shall be at a frequency of 60 Hz with a sinusoidal wave form. V, in the formula below, shall be the nominal system voltage for a circuit:

Nominal Circuit Voltage Volts DC or AC RMS	**Test Voltage, AC RMS**
Below 300 volts	2 V + 1,000 volts
Equal to or above 300 volts	2.25 V + 2,000 volts

Standard apparatus may be production tested for 1 second at a test voltage 20 percent higher than the above listed 1-minute test voltage. Alternative, high potential, test criteria, can be proposed as an approved equal, subject to the approval of the Engineer.

17.7.5 Doors, Operators and Controls

All doors and their operating systems shall be tested and adjusted on all cars to assure smooth functioning, proper fit, attainment of the specified speed of operation, and proper functioning of controls, cut-outs, and interlocks. This shall include all locker doors, access hatches, and equipment boxes. All power-operated doors shall be operated a minimum of 100 consecutive, successful cycles. Initiation of the cycling shall be via an Engineer approved means for each and trailer car to verify proper operation of the control circuits. Proper tension for opening and closing shall be checked on every door before and after the above test. Any door or door control failure occurring prior to completion of the test shall nullify the test, requiring that it be repeated from the beginning following correction and documentation of the failure.

17.7.6 Air Conditioning

The air conditioning system shall be functionally tested in all cars to demonstrate proper operation and temperature distribution. The thermostatic control system operation shall be demonstrated by test. All controls shall be tested. All components shall comply with Engineer approved adjustments and parameters determined and/or confirmed by the climate room tests.

17.7.7 Heating

The heating system, including cab, windshield, and protective heaters, shall be functionally tested in all cars. The operation of the thermostatic control system shall be demonstrated by test. Controls shall be checked and adjusted for even distribution and proper volume of heat. Heat shall be applied to the overhead heaters without airflow and a 1-hour test shall be performed with the high limit control switch cycling.

17.7.8 Exterior Lights

The cab car headlights, auxiliary, and marker lights on each car shall be aimed and adjusted to meet the requirements of 49 CFR 229.125 and 49 CFR 221, respectively.

17.7.9 Friction brake

The Contractor shall perform a complete functional test of the friction brake system prior to shipment of each car from his plant. This shall include, as a minimum, a test of command and load weigh signals, brake cylinder pressure settings, control and indicator tests, dead-in-tow operation, and leakage tests. Each car shall be subjected to a single car test and an air leakage test prior to commencing the functional test of the friction brake system.

17.7.10 Communication

Each radio shall be tested and adjusted to meet all technical parameters delineated in Section 13. Additionally, the antenna shall be adjusted, if necessary, for conformance with its specified radiation pattern. The entire communications system (public address, radio, passenger emergency, and cab intercom), including all car control logic/fault transmissions and train identification system, shall be tested for proper operation. Testing of the communication systems from cab to wayside shall be conducted cooperatively with the supplier of the radio equipment. If these tests cannot be performed at the Contractor’s plant, the facilities of SCRRA shall, upon delivery of the cars, be used at the Contractor’s expense. As part of the communications test, the complete AVI system shall be tested to demonstrate conformance to this Specification.

17.7.11 Trainline

The Contractor shall verify the accuracy of each car’s trainline connections by use of a test panel connected to each trainline and indicating that the proper trainline wires are energized when each of the various car controls (master controller, public address system, doors, etc.) is operated. This test shall be performed at both ends of each car. All spare trainline circuits shall also be tested. Where used, data communication train line signals shall be tested for proper signal characteristics over the line end to end. The test panel shall become the property of SCRRA and delivered after trainline testing is completed on the last car also check for cross connections and shorts.

With traction power disconnected, each controller and reverser shall be tested for correct sequence of operation in both power and braking by operating both the master controller and reverser and observing the function of the various pieces of apparatus involved and trainline signal response. Any component that fails to function in the proper sequence shall be repaired and the test repeated until successful before proceeding with other tests.

17.7.12 Clearance Checks

Each car shall be measured and tested to assure compliance with the clearances specified in Section 2.3 and Section 2.7. In addition, the centering of the carbody with respect to the trucks shall be measured and corrected if necessary.

17.7.13 Destination Signs

The destination sign systems shall be completely and thoroughly tested on each and every car to demonstrate compliance with this Specification. All possible destination sign and message configurations shall be demonstrated.

17.7.14 Leveling Tests

The height of each corner of the carbody shall be measured from the top of rail on a level section of track to check for proper carbody level with all air suspension components at proper design height. Side by side differences in height shall not exceed 0.25 inch. End to end differences in height shall not exceed 0.5 inches. The procedure used shall be approved by the Engineer.

17.7.15 Miscellaneous Tests and Adjustments

Functional tests shall be made on all cab functions and systems, which interface with the cab and operator for proper operation as specified. All fault and failure operations and indications for all car systems, such as door failures, overloads, system shutdowns, etc., shall be tested. Actual non-destructive failures shall be used. Simulated failures may be used with the approval of the Engineer. Included in this test shall be the cab information display system. This test shall include all levels of operations and maintenance displays and troubleshooting, information, warning, and indications. The specifics of this test shall be discussed during the design review stage.

17.8 POST DELIVERY AND ACCEPTANCE TESTS

SCRRA will provide the Contractor with acceptance test site space at its Central Maintenance Facility, which may be used to prepare cars for testing, rework, or modifications prior to acceptance. SCRRA will supply, at no charge to the Contractor, power and tracks for testing and movement of cars.

SCRRA will designate the hours (during off-peak and late evening periods, in general) that its tracks will be available for testing and assign crews as agreed upon by the parties. The Contractor shall give a minimum of seven (7) days written notice of crew and track requirements to the Engineer and a minimum of 48 hours written notice when canceling or postponing a previously scheduled test. In all cases, however, SCRRA's requirements will have priority. SCRRA gives no assurance to the Contractor that the requested number of hours per day, time of day, or number of days per week of track time will be available for testing. The Contractor shall be responsible for its costs and the costs of its subcontractors for all the tests required by the Specification. For dynamic tests that are to be conducted on SCRRA property, SCRRA will supply the test train operating crew and other individuals required by SCRRA policies for the conduct of such tests at no charge to the Contractor. Should the results of the dynamic tests indicate that the equipment did not comply with the requirements of the Technical Specification, the Contractor shall reimburse SCRRA for all SCRRA costs for retesting including but not limited to the cost of the test train operating crew and other individuals required by SCRRA policies.

17.8.1 General Requirements

The tests specified in this section are to be performed by the Contractor on SCRRA property. The tests shall be satisfactorily completed as a condition of acceptance. All tests shall be performed on all cars.

17.8.1.1 Inspection and Repair Requirements

After receipt of each car at the SCRRA site and before it is operated, it shall be carefully inspected jointly by the Engineer and the Contractor, and any part, device, or apparatus that requires adjustment, repair, or replacement shall be recorded by the Contractor who shall make such adjustment, repair, or replacement before acceptance testing is begun. All expenses and costs incurred in any necessary removal of cars from the designated delivery point and their return there for correction of defects shall be borne by the Contractor.

17.8.1.2 Functional Tests

A complete, orderly, and comprehensive check of each and every vehicle system shall be performed to assure its proper integrated and operation before commencement of test track operation. SCRRA-owned PTE shall not be used to perform any test. If any PTE is required, such PTE is to be furnished separately by the Contractor unless approved by the Engineer. Devices bypassed by the use of PTE (master controller, door-open, and door-close buttons for example) shall also be functionally checked. The Engineer reserves the right to test/check the cars as deemed necessary.

17.8.2 Insulation Resistance Tests

The insulation of all car circuits shall be subject to insulation resistance testing as specified in Section 17.7.4.2. The insulation of all high voltage circuits shall be subject to high potential testing as specified in Section 17.7.4.3.

17.8.3 Performance Tests

Performance tests shall be conducted by the Contractor on each car (except for the Pilot cars if approved by the Engineer) with the cars at AW0 load to demonstrate compliance with the requirements of this Specification, specifically Section 12.3, and shall be performed on SCRRA property. These tests shall be conducted with the cars instrumented to monitor all parameters measured during the cars testing. The performance of the cars shall be in accordance with the parameters and curves established with the cars.

The Contractor shall annotate all charts, reduce all data, prepare a written report, review them with the Engineer 24 hours prior to car acceptance, fold the charts for envelope storage, and provide them to the Engineer within seven (7) days after car acceptance as part of the individual car log book.

Each car shall be subjected to the same group of tests. The performance tests shall include, at a minimum:

- Full Service Braking,
- Emergency Braking,
- Wheel Slide,
- Fault/Status Data Transmission and Cab Message Display,
- No Motion, and
- Monitoring Systems.

In addition, each car shall be subjected to a series of approved system functional tests, including air system leakage tests to demonstrate proper operation of each car system. Trainline functional and performance tests (from both ends) to demonstrate proper operation of all appropriate trainline functions, dynamically on the test track by mating with accepted cars shall be performed.

All defects found during performance and acceptance testing are to be promptly corrected by the Contractor prior to acceptance by the Engineer. These shall be noted in the individual Car History Book car logbook. If any control logic of any system is modified, such modifications shall not be implemented until all documentation is submitted to and approved by the Engineer.

17.8.4 Operational Tests

After completion of the car performance testing and adjustment work specified, each car shall be given an operational (shakedown) test using SCRRA operating and test crews. The operational test shall include 50 miles of operation of each car. The Engineer, at his option, may require that the instrumentation used for functional testing be retained on the cars during this test. If, in the Engineer's opinion, the quality and reliability of the previously accepted cars is at a high (or low) level such as to justify a reduction (or increase) in the test mileage, the Engineer may require adjustment at his discretion.

The test shall include simulated revenue operation with stops at every station

At the end of the operational test, an abbreviated car performance test, AW0 only, one run from each category, shall be performed, and corrections made if necessary.

17.8.5 Miscellaneous Body Tests and Adjustments

Auxiliary circuits and equipment shall be tested for proper operation. All interior and exterior car lighting shall be tested for proper function including emergency operation. The proper functioning of the radio and the automatic vehicle identification with SCRRA's Central Control shall be tested. Any fault and failure operation and indication testing requiring road test and not completed under Section 17.8.3 shall be recorded.

Truck clearances, lengths, heights, and locations of electrical jumpers and any other end connections shall be validated.

Coupler installation shall be verified or adjusted to proper height and level.

Buffers shall be verified for proper alignment and level.

Air springs if equipped shall be leveled following the car leveling procedure in Section 11.11.4.

17.8.6 Reliability Demonstration

The purpose of this test is to establish a measure of system reliability and to demonstrate that the cars are free of design problems which could interrupt revenue service, or which present hazards to SCRRA property, personnel, and passengers. See Section 16.2 for additional reliability requirements.

Upon acceptance of the first five (5) cars by the Engineer, they shall be operated in revenue service for 1,800 car-miles each, without failure or service interruption. The Engineer may, at his option, couple and uncouple the cars and place them in differing relative orientations to exercise the couplers. The test shall be conducted through consecutive calendar days for a maximum of 20 hours per day, as much as practicable. Failure of the cars to meet the test criteria at any time during the test shall result in the test time clock being reset to zero (0) and a new test begun, but only after the redesign and the repair or replacement of the affected equipment has been completed.

SCRRA shall maintain and service the cars in accordance with maintenance schedules and procedures submitted by the Contractor and approved by the Engineer. Time for inspections and/or equipment maintenance and repair shall not be included in the test time. If any repairs or adjustments to the cars are required, beyond those required by the approved maintenance procedures, they will be considered failures. The Engineer reserves the right to make additional inspections to determine if failures have occurred.

Representatives of the Engineer, the Contractor, and major subcontractors shall be present during the conduct of the reliability tests. The Engineer and the Contractor shall maintain separate logs, which shall be used to document individual observations. All defects, failures, improper operations of an assembly, subassembly or component, and service interruption shall be recorded and the Contractor shall take immediate corrective action.

The Contractor shall install (at his expense) instrumentation on the cars to monitor the proper operation of various systems during the test period.

A separate report for each failure or malfunction of equipment shall be prepared by the Contractor indicating the reason for the failure, the repair required to correct the condition and, where applicable, corrective action required to prevent similar, subsequent abnormal operation and failures. These reports shall be reviewed and evaluated by the Engineer. Final acceptance of the repair or corrective actions and, in the case of dispute, the decision as to what constitutes failure or interruption in this test shall be made by the Engineer.

Depending on the season prevailing during the reliability test, the heating or air conditioning portion of the HVAC system shall be similarly tested. Upon change of season, the untested portion shall be given its 1,800 mile reliability test.

In the event that a failure occurs in one system under test causing an interruption in the Reliability Test, it shall not be considered an interruption for the other systems under test.

17.8.7 Fleet Reliability Test

The complete operational car fleet shall be monitored by the Contractor to demonstrate conformance with the reliability requirements of Section 16.2 for a period of twenty-four (24) months starting after the acceptance of the last car. On a monthly basis, the Contractor shall issue a report detailing the performance of each car and its equipment with regard to maintenance (which shall be detailed in an appendix by type) and the calculated period and cumulative mean distance between failures (MDBFs). Any component(s) found to cause the whole car and/or related subsystem MDBF to fall below the required performance level (see Section 16.2) shall be subject to redesign and modification. During the period such efforts are carried out, failures due to these component failures shall not be counted. However, upon completion, the modified car and/or subsystem shall be monitored for a period of no less than three (3) months or the remaining base period, whichever is greater, and the MDBF shall be acquired. If the use or failure of the component is weather or temperature related, the three (3) month period is to 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 730 consecutive calendar days in the event that modification is required.

Following a satisfactory completion of the test for all subsystems, the Contractor shall issue a final report summarizing the results and with all interim reports appended for completeness.

If a satisfactory completion cannot be obtained before the end of the specified warranty period, the Contractor and SCRRA shall resolve any outstanding issues in accordance with the Contract terms and conditions.

Any failure in the fleet reliability test shall be included in the fleet defect calculations; see Contract Documents.

End of Section

Contract Data Requirement List

CDRL No.	Title	Car Type	Reference Paragraph
17-001	Detailed Test Plan and Schedule	All	17.1
17-002	All Test Procedures	All	17.2.2
17-003	All Test Reports	All	17.2.3
17-004	Locations of Strain Gauges for the Truck Qualification Test	All	17.3.8.1
17-005	Location of Dial Indicators for Truck Qualification Test	All	17.3.8.2
17-006	List of Critical Locations for Truck Qualification Test	All	17.3.8.3
17-007	List of Critical Locations of Truck Frame for Radiographic Inspection	All	17.3.8.7
17-008	Door Life Cycle Test Parameters	All	17.4.4
17-009	Description of Laboratory for Air Conditioning System Design Qualification Test	All	17.4.5.1
17-010	Description of Test Facility for Carbody Structural Tests	All	17.5.1.1
17-011	CEM System Test Plan	All	17.5.1.14
17-012	Description of Facility and Instrumentation for Vehicle Climate Room Test	All	17.5.5.1
17-013	Clearance Measurements for Each Car Type	All	17.5.8
17-014	Clearance Test Templates	All	17.5.8
17-015	List and Methods of Fault Simulations for Compatibility Test	All	17.5.9
17-016	“Shake Down” Test Procedure	All	17.5.10
17-017	List of Tests for Friction Brake Thermal Capacity	All	17.5.10
17-018	Laboratory Inductive EMI Test Procedures	All	17.5.17.3

CDRL No.	Title	Car Type	Reference Paragraph
17-019	Field Inductive EMI Test Procedures	All	17.5.17.3
17-020	Field Radiated EMI Test Procedures	All	17.5.17.4
17-021	Vehicle Watertightness Test Facility and Procedure	All	17.7.2

SECTION 18

DOCUMENTATION AND TRAINING

SECTION 18

DOCUMENTATION AND TRAINING

TABLE OF CONTENTS

SECTION 18

DOCUMENTATION AND TRAINING

18.1 GENERAL REQUIREMENTS

This section defines the procedures and criteria by which the Contractor shall provide training, manuals, special tools, test and diagnostic equipment to SCRRA for the operation, troubleshooting and maintenance of the multi-level commuter rail passenger cars. The use of these procedures shall ensure appropriate and comprehensive documentation and equipment are developed, maintained and delivered.

18.2 TRAINING PROGRAM AND SUPPORT MATERIALS

18.2.1 General

The Contractor shall provide a training program which shall allow SCRRA trainers to conduct training for SCRRA's operating and maintenance personnel in all aspects of the operation, troubleshooting and maintenance of the cars. Instruction courses shall be conducted at a location suitable and convenient to SCRRA and approved by the Engineer. The Contractor shall coordinate with the Engineer to assure that the training commences within thirty (30) calendar days after delivery of the first car.

The program shall be of sufficient quality and depth of content to teach operation, servicing, maintenance, troubleshooting, and repair of the car and equipment. This program shall utilize both formal and informal instruction, mock-ups, models, manuals, diagrams, spare parts and parts catalogs. The Contractor may assume that the SCRRA rail operating and maintenance personnel have the basic skills pertinent to their respective crafts. All courses shall be presented in the English language. The Contractor shall submit, for review and approval, a detailed description of its training program and a schedule for its presentation, no later than one hundred-eighty (180) days after NTP. **[CDRL 18-001]** The Contractor shall provide the Engineer a list of all overhead transparencies, videos, and mock-ups that will be supplied to support the training program at least ninety (90) days prior to the scheduled shipment of the first car. **[CDRL 18-002]** The program shall be scheduled to be completely prepared, approved, and ready for presentation no less than sixty (60) days prior to the delivery of the first car. **[CDRL 18-003]** The program shall be designed, developed, and conducted for three (3) groups of personnel. The first group will consist of maintenance employees responsible for the electrical/electronic systems and subsystems of the vehicle. The second group will consist of maintenance employees responsible for all other systems than electrical/electronic systems and subsystems of the vehicle. The third group will consist of operators and other train service employees responsible for operation of the cars.

The program shall be conducted on the first car delivered as well as in SCRRA classrooms with furniture supplied by SCRRA (desks, tables, lecterns, etc.). The material covered shall be presented in a fashion that will enable SCRRA personnel to become knowledgeable with the operation and maintenance of the new equipment and shall comply with the course description format and lesson plan requirements. Written documentation shall be provided in Microsoft® Word format and presentations shall be provided in Microsoft® PowerPoint.

The program shall provide high quality, professionally prepared material printed on paper. The program shall also include means to determine the proficiency of the students. Final drafts of manuals, catalogs, and drawings for each student shall be delivered prior to the initiation of classroom instruction. Implementation of the training program shall be contingent upon review, approval, and final acceptance by the Engineer of all instructional material.

Throughout the training program and after completion of all modifications, the Contractor shall incorporate into the training program and training aids all design changes and modifications within five (5) days of approval of modification. The training program and training aids shall be current with the approved car design at all times.

18.2.2 Training Program Lesson Plans

The Contractor shall submit a complete set of the training program lesson plans, including a set of classroom lesson plans (one for each class), no later than thirty (30) calendar days prior to the start of the first class. This overall plan shall include:

1. Class topics and schedules organized by day for each session.
2. 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.
3. Lists of diagrams, displays, and teaching aids to be utilized for each day.
4. Special arrangements, tools, projectors and other equipment required for the class.
5. Instruction guides for each course to be taught within the program.
6. Lesson plan for the class with student workbooks which include a syllabus, objectives, schedule, outlines, figures, lesson summaries, and any other appropriate instructional information.

18.2.3 Classroom Sessions

Classes shall be scheduled 8 hours per day, five (5) work days per week. SCRRA holidays shall be observed. Class instruction periods shall normally be 50 minutes in duration with a 10 minute break between periods of instruction. Length of practical application periods shall be established by the Contractor. Classes shall be conducted for SCRRA training personnel.

General format of classes shall include:

- Introduction of material,
- Lecture,
- Hands on demonstration,
- Verbal test for comprehension, and
- Written test for comprehension.

18.2.4 Training Aids

The following materials shall be provided by the Contractor to be used as training aids for both operation and maintenance instruction programs:

- Instruction guides,
- Student Workbooks,
- HVAC equipment including controls,
- Auxiliary power supply equipment, including battery, inverter and controls,
- Braking equipment, including controls, tread brake unit(s), disc brake(s) and handbrake, disc rotor and wheel slide detection/correction system,
- Coupler and coupler apparatus,
- Door equipment and controls,
- ATS system equipment,
- Communication system equipment, and
- Complete trucks.

With the approval of the Engineer, spare equipment purchased by SCRRA for this Contract may be used for training.

The training aids shall comply with the following:

- All equipment utilized for training purposes shall be restored to new condition by the Contractor subsequent to its use for training purposes and the Contractor shall provide a full warranty for this equipment.
- Unaccepted vehicles on SCRRA property may be utilized for educational purposes, insofar as their use does not interfere with the acceptance program.
- Training aids may include actual samples of manually operable devices or working models of devises, the functions of which can be displayed without dismantling the device. The workings of other significant components shall be illustrated with diagrams or cut-away views, displayed with sufficient scale and clarity to be seen clearly.
- Operations and Maintenance Manuals shall be available for use in the training program.
- Wiring diagrams, when used as training aids and reference material, shall be marked and separated to facilitate comprehension. There shall be single-line functional diagrams of systems. Schematic diagrams shall include details of each component in the systems. Where parts are identified by initials or reference number, there shall be a key to permit precise identification.
- Transparencies, (8.5 inches by 11 inches) in size, shall be utilized with an overhead projector. Transparencies shall illustrate sub-assemblies showing component locations, component cutaways, schematics, and wiring diagrams. Transparencies depicting

hydraulic, pneumatic, and air conditioning systems shall include the direction of the flow for the particular medium. Electronic versions of presentations shall also be provided in Microsoft® PowerPoint.

- Notebook-size copies of all visual displays used by an instructor shall be included in the student handouts.
- All training materials, such as training aids and lesson plans, shall become the property of SCRRA after the completion of the training program. All documents shall be in Microsoft® PowerPoint or Microsoft® Word format. The Contractor shall be responsible for the condition of these materials for the duration of the training program, and shall replace all damaged materials unless the damage results from neglect by SCRRA. Lesson plans shall be updated as required during the course of instruction. The Contractor shall supply a master copy of all training program materials which shall include one (1) master camera ready copy and one (1) copy on electronic medium. **[CDRL 18-004]**

18.3 MANUALS AND CATALOGS

18.3.1 General Requirements

The following manuals are required and shall be delivered after approval in final form as specified herein:

- Operating Manual,
- Maintenance and Overhaul Manuals (Running Repair and Servicing Manuals and Heavy Repair and Overhaul Manuals),
- Illustrated Parts Catalog
- Electrical wiring, Pneumatic and Water Piping Schematic and Connection Diagram Manuals.

The goal of the manual design and development shall be completeness and accuracy of coverage in the most concise and well organized manner possible. The manuals shall be developed and validated by the Contractor as being accurate, suitable for the equipment provided under this Contract, and compatible with SCRRA maintenance facilities, and maintenance and operating personnel.

All manuals shall be written in clear, grammatically correct English. They shall be complete, thoroughly organized, and authentic with no extraneous material such as advertisements or irrelevant information. The quality required is embodied in the Air Transport Association of America's Specification No. 100, "Specification for Manufacturer's Technical Data," which shall be used as a general guide insofar as it pertains, although variations in type face and minor format details shall be permissible. The Contractor shall provide program authoring tools for all manuals to enable SCRRA to edit manuals as may be required after the Contract is fully executed. **[CDRL 18-005]** SCRRA preference is for Microsoft® Word or Microsoft® PowerPoint software.

Each figure used to illustrate the manuals shall be numbered and shall incorporate an integrated legend which shall identify, by letter or number, specific features of the subject of the figure. The appropriate figure numbers and legend identifying numbers shall be used as references within the descriptive text of the manuals.

SCRRA will supply approved sample manuals, for reference only, for the Contractor's use in developing the new manuals.

Manuals shall contain all operating, maintenance, servicing and storage procedures required by SCRRA to successfully operate, maintain and support the equipment provided. Instructions shall be included and safety equipment identified for the safe handling and disposal of hazardous materials.

It shall be the responsibility of the Contractor to ensure that all subcontractor materials used in the manuals meet all requirements of the Contract and Specification. The Contractor shall ensure that all information and details concerning the description, illustration, inspection, servicing, and replacement are included in the manuals for all equipment, including FRA and APTA recommendations and requirements, suppliers' recommendations and warranty provisions. The subcontractor materials shall be completely integrated into the Contractor-produced materials. They shall be designed, developed, and presented in a single style, conforming to the style and format detailed in this Specification. All materials produced under this Specification shall appear to have been produced "by a single hand." Inclusion of, or reference to, "out-of-format" material and/or material that does not meet the requirements of this Specification shall not be acceptable.

The car shall be treated as a whole and not as a grouping of disassociated parts. The material in the manuals shall be similarly organized and indexed.

The format of all data contained in each section of the manuals shall be consistent from section to section. All sections shall be subdivided, to the extent required by the subject matter, into the following topics:

- General subsystems description and operation,
- Functional block diagrams,
- Schematics,
- Wiring and piping diagrams,
- Lubrication and cleaning, including frequency, methods and trade identification of recommended materials, component location, and description,
- Inspection and maintenance standards including wear limits, settings, and tolerances,
- Basic overhaul periods for rotating apparatus,
- Installation and removal of components and apparatus, and
- Test and evaluation procedures.

Note: The detailed contents of sealed assemblies need not be displayed, but their function shall be explained, and the appropriate voltage and current values shown for each external connection and terminal. Procedures appropriate to their replacement, including methods and tests, shall be stated.

WARNINGS, CAUTIONS, and NOTES shall be included in the manuals as necessary in order to minimize the risk of personal injury to personnel or reduce the possibility that improper work methods and practices may result in damage to the equipment or render it unsafe. The definitions of WARNING, CAUTION, and NOTE shall be as follows:

- WARNING - A warning shall be used to emphasize an essential operation, procedure, or practice, which if not strictly observed, could result in death or injury to personnel. A warning shall precede the text to which it applies.

- CAUTION - A caution shall be used to emphasize an essential operation, procedure, or practice, which if not strictly observed, could result in damage to the equipment.
- A caution shall precede the text to which it applies.

- NOTE - A note shall be used to emphasize an important operation, procedure, or condition. A note may precede or follow the text to which it applies.

With respect to covers, reproduction, and binding, hardcopy (paper) manuals, shall comply with the following:

- All covers shall be approximately 0.0625 inches thick, resistant to oil, moisture, and wear, to a high degree commensurate with their intended use. Binders shall be white, locking, three (3) D-ring with clear acetate cover pockets.
- All printed material shall be clearly reproducible by dry copying machines. This precludes the use of halftone illustrations. Line drawings shall be required.
- Folding pages (maximum 11 inches by 17 inches) shall be permitted where the information conveyed cannot be presented clearly on single pages (8.5 inches by 11 inches). Diagrams and illustrations shall not be loose or in pockets.
- Punched holes shall be spaced the standard 4.5 inches apart. Metric binding shall not be used.

Following the issue of each hardcopy (paper) of the Manuals, the Contractor shall provide revised pages covering any changes (one (1) printed copy and two (2) on electronic medium), whether required by change of design or procedures or due to errors and omissions. Revisions shall be kept current during the warranty period and shall be supplied to SCRRA before or coincident with the arrival of the altered systems, parts, or components. During the warranty period, and for a period of five (5) years thereafter, the Contractor shall be responsible for providing up-dates to the manuals and catalogues for changes, modifications, retrofits, improvements initiated and/or performed by the Contractor that are applicable to the equipment provided under the terms of this Contract. These up-dates shall be submitted on a regular basis but no less frequently than every six (6) months during this period unless otherwise approved by the Engineer. All revised pages shall be noted as to revision date and applicable manual for easy and correct insertion in the manual(s). Each manual shall include a “Revision Page” on which each revision shall be listed chronologically. The “Revision Page” shall be revised and provided with each revision.

18.3.2 Operating Manuals

The Operating Manual shall contain all information needed for the optimum operation of the equipment. It shall include general vehicle familiarization material such as location, function, and operation of controls, gauges, indicators, and switches. It shall discuss the subsystems and other features of the car which the Operator may not be in a position to control or adjust but of which he should have some knowledge, including emergency procedures and troubleshooting information.

The manual shall be logically organized with systems and elements considered in descending order of importance. Care shall be taken that all statements are clear, positive, and accurate, with no possibility of incorrect implication or inference.

The manual shall be delivered in hard copy as pocket size, 4.5 inches wide, 7 inches high, and not more than 1.25 inches thick and in electronic medium as described in Section 18.3.6. It shall be bound along the 7 inch left side dimension. The pages therein shall be as large as can be accommodated without damage.

18.3.3 Maintenance and Overhaul Manuals

The Maintenance and Overhaul Manuals shall contain detailed analyses of each component of the car so that maintenance personnel can effectively service, inspect, maintain, adjust, troubleshoot, repair, replace, and overhaul it. The manuals shall also include all information needed for basic overhaul, periodic inspection, and servicing, including lubrication of each system, subsystem, and component. Periodic inspection, testing, and adjustment of all apparatus shall be organized in a separate section. A separate section shall contain all operation maintenance, troubleshooting, diagnosis, and repair data on each microprocessor component in the car.

Each manual shall include a separate section that provides a schedule, duration and list of tools for any maintenance tasks as described within other sections of the manual.

Procedures for adjustment and/or calibration shall describe manual settings of adjustable elements on the car and GO/NO GO limit tolerances.

Troubleshooting procedures and/or charts shall permit isolating faults to the point of a replaceable component.

Scheduled maintenance information shall include procedures for cleaning, lubricating, frequency, methods, and recommended materials.

Block diagrams, illustrations, and other visual aids shall be used to support text where applicable.

The instructions for the proper use and periodic inspections of test apparatus shall be included in the manuals.

The manuals shall be delivered in hardcopy and electronic medium as described in Section 18.3.6.

The hardcopy manuals shall be printed on 8.5 inch by 11 inch pages and the three (3) ring binder covers shall be 10 inches to 10.5 inches wide (depending on ring size), 11 inches to 12 inches high, and the overall thickness of each volume shall not exceed 3 inches. The manuals shall be divided into several volumes, if the materials cannot be contained within the maximum binder thickness. Adequate cross reference and a Table of Contents shall be provided in each volume.

18.3.4 Illustrated Parts Catalogs

The Illustrated Parts Catalogs shall enumerate and describe every component of the equipment provided under this Contract with its related parts and quantities, including the OEM part number, Contractor part number, SCRRA part number, and any commercial equivalents. Parts common to different components (such as bolts and nuts, electrical and mechanical fasteners, pipe fittings, etc.) shall bear the same Contractor number, size, type material, quantity per car, and location with a reference to the other components in which they are used.

Cutaway and exploded view illustrations shall be used to identify all parts. Each part or component shall be identified as part of the next higher assembly. Each illustration shall have all of its components identified with a figure index number with an accompanying Detailed Parts List utilizing the same index number designation. The Detailed Parts List shall enumerate each part by figure index number, description, quantity per car, quantity per assembly, vendor name, vendor part number, Contractor part number, SCRRA part number, and “useable on” code (when a part is used only on a specific model, version, etc., of the car).

The Illustrated Parts Catalogs shall be delivered in hardcopy and electronic medium as described in Section 18.3.6.

The hardcopy of the Illustrated Parts Catalogs shall be printed on 8.5 inch by 11 inch pages and the three (3) ring binder covers shall be 10 inches to 10.5 inches wide (depending on ring size), 11 inches to 12 inches high, and the overall thickness of each volume shall not exceed 3 inches. The Illustrated Parts Catalogs shall be divided into several volumes, if the materials cannot be contained within the maximum binder thickness. Adequate cross reference and a Table of Contents shall be provided in each volume.

18.3.5 Electrical Wiring, Pneumatic and Water Piping Schematic and Connection Diagram Manuals

The Contractor shall supply Electrical Schematic Wiring and Connection Diagram manuals. These manuals shall contain schematic wiring and connection diagrams and drawings illustrating all wiring and electrical apparatus and schematic piping and connection diagrams and drawings, as well as the layouts for piping and apparatus including all electrical devices, electro-pneumatic apparatus, and all microprocessor circuits and test points.

The manuals shall be fully indexed and cross referenced to enable locating any device or wire number or terminal point between each drawing schematic or part number.

The manuals shall be delivered in hardcopy and electronic medium as described in Section 18.3.6.

The hardcopy of the Electrical Schematic Wiring and Connection Diagram Manual shall be printed on folded 11 inch by 17 inch pages and the three (3) ring binder covers shall be 10 inches to 10.5 inches wide (depending on ring size), 11 inches to 12 inches high, and the overall thickness of each volume shall not exceed 3 inches. The Electrical Schematic Wiring and Connection Diagram Manual shall be divided into several volumes, if the materials cannot be contained within the maximum binder thickness. Adequate cross reference and a Table of Contents shall be provided in each volume.

18.3.6 Delivery Schedule and Quantities

Within one hundred twenty (120) days after Notice to Proceed, the Contractor shall submit to the Engineer for approval, Tables of Contents and sample formats and indices for all manuals. **[CDRL 18-006]** A progress payment will be keyed to the approval of sample formats and indices of these manuals.

The Contractor shall provide the Engineer with two (2) draft hardcopies of each of the manuals for approval sixty (60) days prior to acceptance of the first car. **[CDRL 18-007]** The Engineer will approve or supply comments on the draft manuals no later than forty-five (45) days after their receipt. A minimum of two (2) review cycles for all manuals shall be scheduled by the Contractor before submittal of the final approved drafts.

The Contractor shall provide the Engineer, no later than one hundred ten (110) days after acceptance of the final draft, forty (40) hardcopies of approved, complete Operating Manuals. **[CDRL 18-008]**

The Contractor shall provide to the Engineer, no later than one hundred ten (110) days after acceptance of the final draft, ten (10) sets of approved, complete Maintenance and Overhaul Manuals. **[CDRL 18-009]**

The Contractor shall provide to the Engineer, no later than one hundred ten (110) days after acceptance of the final draft, ten (10) sets of approved, complete Illustrated Parts Catalogs. **[CDRL 18-010]**

The Contractor shall provide to the Engineer, no later than one hundred ten (110) days after acceptance of the final draft, ten (10) sets of the Electrical Schematic Wiring and Connection Diagram Manuals. **[CDRL 18-011]**

All hardcopy manuals shall be submitted in final approved form. The Contractor shall submit a master copy of each manual which shall include one (1) master camera ready copy printed on durable sheets and one (1) copy on electronic medium utilizing MS Word® (version to be approved by the Engineer) no later than one hundred-ten (110) days after review and acceptance of the final draft of the manuals. **[CDRL 18-012]** The submittal shall include all Program Authoring Tools.

18.4 SPECIAL TOOLS, TEST AND DIAGNOSTIC EQUIPMENT

18.4.1 General

The Contractor shall provide all equipment specified in this Section for comprehensive maintenance and in-service testing of vehicles and bench testing of components and subsystems. All of the special tools and test equipment identified shall be delivered thirty (30) days prior to the delivery of the first Car or for use as required by the Training Program, whichever comes first. **[CDRL 18-013]**

The diagnostic test equipment shall be supplied in two (2) levels. The Maintenance Facility Bench Test Equipment (MFBTE) shall allow identification of failures in individual assemblies to the Lowest Level Replaceable Unit (LLRU). The Portable Test Equipment (PTE) shall identify failures on the vehicle to the lowest replaceable assembly, such as a printed circuit card in a logic rack or an individual valve in a pneumatic or hydraulic system.

No later than one hundred twenty (120) days after NTP, the Contractor shall submit to the Engineer for review and approval a comprehensive list of all proposed special tools and test equipment. **[CDRL 18-014]** For each different tool and item of test equipment, the Contractor shall submit a description of the use and operation and drawings that define the equipment envelope, the required work space envelope, and utility requirements. This information shall be incorporated into the list of special tools and test equipment submitted. The Contractor shall be responsible for revising the list for any design changes to the cars and test equipment that affects the special tools and test equipment. Each special tool and item of test apparatus shall be accompanied by:

1. Complete diagrams, schematics, and maintenance and calibration instructions for the device itself,
2. Procedures for the use of the test equipment for maintenance, calibration, and trouble-shooting of the associated carborne system, assembly, or sub-assembly.

Acceptance of all special tools and test equipment shall take place subsequent to a Contractor demonstration that the tools and test equipment perform their intended function. The Contractor shall make all modifications to tools and test equipment specified herein that are required because of changes and modifications made to the vehicle or any of its subsystems.

The Contractor shall supply manuals and training for all custom software applications supplied with test equipment. **[CDRL 18-015]** MS Access® format shall be used to sort and store applicable data and shall be arranged to be compatible with MS Excel® software.

18.4.2 Maintenance Facility Bench Test Equipment (MFBTE)

One (1) set of bench test equipment shall be supplied by the Contractor to support off-vehicle repair and maintenance activities. The MFBTE shall be designed for testing, troubleshooting, and calibrating all electrical, electronic, pneumatic, mechanical, and electro-mechanical components of each vehicle subsystem necessary and critical to the proper operation of that subsystem. Design of each tester shall be such that input signals or supplies can be varied over the full working range of the device.

The MFBTE shall be for use at maintenance and repair facilities. The Contractor shall coordinate with SCRRA to ensure compliance with safety requirements and compatibility with SCRRA maintenance facilities. The MFBTE shall be suitably buffered to protect against its failure when testing and troubleshooting defective units.

The MFBTE shall be designed to enable a technician to perform rapid testing, troubleshooting to the discrete component level, and calibration of all equipment, except where specifically waived below. This equipment shall include, but shall not be limited to: each type of electronic circuit board, including motherboards and back plane wiring; relays; sensors; contactors; breakers; filters; transducers; friction brake system components and valves; pressure switches, including those from the HVAC system; antennae; and modules used in any car system. The MFBTE shall be automated to the greatest extent possible so that a technician need only plug in or hook up a unit under test (UUT) and identify the UUT; automatic functional testing shall then begin. Automatic testing shall determine and indicate the health of the UUT such that it is obvious, without further intervention by the operator, whether or not the UUT is acceptable for service including an automatic evaluation of the unit’s functional status and calibration. If the UUT is declared defective or out of calibration, the MFBTE shall guide the operator through additional steps to enable the operator to identify the defective component. For example, if a PCB is under test and it is identified as being defective, the MFBTE shall have all equipment necessary, with instructions, schematics, and drawings, to guide the operator through the troubleshooting steps, which may include probing the PCB to make various measurements to determine which component(s), such as a resistor, capacitor, transistor or IC chip, is defective. It is not expected that the MFBTE will automatically identify the faulty component. There shall be a menu of tests to choose from so that a complete test can be initiated, or portions of the complete test can be initiated, to check repairs made.

PCB units shall be considered to belong to one of three categories identified below. These categorizations shall be used to define the capability of the MFBTE with respect to each PCB. Category 1 boards are those which have a density of components, component types, and component mounting, which allow manual probing of the board when troubleshooting to identify the defective component, i.e., resistor, capacitor, IC, etc. Category 2 boards are high density boards which utilize multi-layer construction, surface mount components, large ICs with close-spacing of pins, or special ICs such as processor chips, PLAs, ASIC devices, and other custom components which may preclude effective manual troubleshooting. Category 3 boards are commercial off-the-shelf PCB units purchased from industrial OEMs, which are non-repairable, or for which design information is not available from the OEM to support troubleshooting and repair. The Contractor shall submit a list of Category 2 and 3 boards to the Engineer for approval at the system Design Reviews.

If the UUT is a defective PCB of Category 1 or Category 2, the MFBTE functional test shall assist the technician to identify functional groups of components that are defective. For Category 1 PCB units, the MFBTE and its documentation shall enable troubleshooting to the component level. For Category 2 PCB units, the MFBTE shall not be required to enable troubleshooting to the component level, but the documentation shall enable troubleshooting to the component level using more sophisticated test equipment. At the time that the categorization of boards is submitted to the Engineer for approval, there may be boards that are an aggregate of Category 1 and Category 2. The MFBTE and documentation requirements for such aggregate boards shall be as above for the corresponding regions of the board. If the unit under test is a defective PCB of Category 3, the MFBTE shall not be required to enable testing beyond the PCB functional level. The documentation provided shall enable form, fit, and functional replacements of all PCB units.

Shop electric power will be available for bench tester use. Bench testers shall be designed to operate on 120 or 230 VAC, 60 Hz. The bench test devices, when used in accordance with instructions supplied by the Contractor, shall test and calibrate the vehicle equipment to a level equal in quality to that performed by the original supplier. Shop air will be available at 140 psi for bench test use.

18.4.3 Portable Test Equipment (PTE)

Portable Test Equipment (PTE) shall be supplied for all on-board systems to aid in maintaining, troubleshooting, and calibrating the vehicle equipment.
Each PTE shall be supplied with an instruction manual that describes its use, the expected results, troubleshooting and repair of the tester. Complete parts lists and schematic diagrams of the PTE shall be included.

The Contractor shall provide two (2) of each PTE. The Contractor shall also provide part numbers and prices for all portable test equipment to enable SCRRA to purchase additional quantities. **[CDRL 18-016]**

If Microsoft® Windows® compatible “laptop” computers are used with the PTE for several vehicle systems, their functions may be combined. Six (6) such laptop units with all necessary software installed shall be supplied. These units shall be a “top-of-the-line” configuration at the time of supply as approved by the Engineer.

The carborne equipment design shall use multi-pin connectors to establish all the connections required for utilization of the PTEs. Power required for operation of the PTEs shall be from the carborne low voltage power supply and the carborne auxiliary power supply, as appropriate for the function. There shall be no high-voltage connections between the vehicle and any PTE. It shall not be necessary to remove, dislodge, dismount, or disconnect any component, card, wire, chassis, terminal, or cable in order to perform periodic calibration or trouble diagnosis while using the PTEs.

The PTEs shall include all cables, connectors, and associated equipment to interface with the test points.

18.4.3.1 Functional Requirements

The function of the PTEs shall be to produce all operating commands and other input signals necessary to fully exercise all functions and components of the particular system or subsystem under test, and to measure or indicate all of the output signals and responses produced by a system by means of indicators such as lamps, meters, oscilloscopes, gauges, or computer controlled displays. It shall be acceptable to require a visual check for system response, such as closure of a contactor, provided the responding item of equipment does not require removal of other equipment, or use of hand tools to permit observation of its response, and does not require the technician to move more than 15 feet to perform the required observation. When used according to the instructions supplied by the Contractor, each PTE shall enable the technician to fully check and calibrate the system or subsystem under test and to locate and replace any removable component which has fully or partially failed. The PTE shall also operate in a passive monitoring mode to permit observation of the functions of its related systems while the vehicle is operated at all normally. Response indicators and input-signal generators shall be built into the PTEs to the maximum extent possible and shall have accuracy commensurate with the alignment tolerances specified. The Contractor shall submit details of any proposed deviations from the requirements of this section to the Engineer for review and approval**. [Part of CDRL 18-014]**

18.4.3.2 Physical Requirements

The PTE shall perform under the environmental conditions imposed by the activities of the vehicle inspection, test and repair shop within the environmental conditions specified in Section 2.7.3. The test equipment shall be completely portable and suitable for rough handling during use on the shop floor, pit locations, in the yard and on cars during dynamic testing. The test equipment shall be self-protected in the event of overload, ground, or short-circuit condition.

Response and output indicators and input signal generators shall be industrial grade. Each PTE shall be housed in an aluminum or fiberglass suitcase-type enclosure with a removable cover suitable for use during dynamic testing and in a shop environment. All meters supplied, as part of the PTEs shall be of a variety capable of withstanding industrial service. The weight of any PTE shall not exceed 30 pounds without the prior approval of the Engineer.

18.4.3.3 Interface Connections

Connection of the PTE to the car equipment shall be through a test plug conveniently located on the vehicle so that the technician is able to observe the functioning of the system while it is under test.

Interface connectors between the PTE and the system under test shall have recessed pins to prevent bending and breakage. All connections shall be manually operated and robust with weather-tight, quick disconnect, multi-pin connectors.

18.4.3.4 Cables and Hoses

External hook-up, multi-conductor cables shall be provided to connect the vehicle systems to the PTE. A minimum number of cable connections shall be used to connect the test equipment to the systems under test. Cables shall be flexible, abrasion resistant and oil resistant. The connecting cables and hoses shall be stored within the PTE case.

The Contractor shall not require connection of external apparatus to the PTEs without the prior written approval of the Engineer. In such cases, terminals shall be provided to allow connection of the required apparatus. However, such apparatus shall be considered part of the PTEs and shall be supplied with it on a one-to-one basis.

If a laptop computer is used as a PTE for two (2) or more systems, and if the connection to these systems is by means of a serial data link, the Contractor shall define a standard cable and connector for use in connecting the laptop computer to the systems. One such cable shall be supplied with each laptop computer which functions as a PTE.

18.4.3.5 Devices to be Provided

PTEs shall be provided for at least the following vehicle equipment:

- Friction Brake including wheel slide detection/correction system,
- Auxiliary Power Supply (APS)/Low Voltage Power Supply (LVPS),
- Battery Charger,
- HVAC,
- Door Control,
- ATS,
- IC/PA,
- Destination Sign,
- Event Recorder,
- Alerter,
- Locomotive MU Control Trainline
- Door Control and Communication Trainline,

18.4.4 Vehicle Monitoring Units (VMU)

A separate workstation shall be provided for the storage and analysis of data collected from the Monitoring and Diagnostics System. The workstation shall include a customized program to perform the following tasks:

- Retrieve data from various PTE computers used to download car data,
- Retrieve data directly from a vehicle,
- Provide data storage for both statistical and fault data,
- Sort and store all data using Microsoft® Windows® - compatible data storage formats,
- Provide custom reports including multiple variable sorting on time, car, number, specific fault, failed system, and other relevant parameters;
- Provide procedures for archiving and retrieving older data,
- Initiate car system self test routines, where applicable.

The Contractor shall provide the workstation and appropriate software with all instruction manuals. **[CDRL 18-017]** The hardware and software design review package shall be submitted to the Engineer for approval. **[CDRL 18-018]**

End of Section

Contract Deliverables Requirement List

CDRL No.	Title	Car Type	Reference Paragraph
18-001	Detailed Description of Training Program and Schedule for Presentation	All	18.2.1
18-002	List of All Overhead Transparencies/Videos and Mockups Supplied to Support Training Program	All	18.2.1
18-003	Training Program Prepared, Approved and Ready for Presentation	All	18.2.1
18-004	Master Copy of All Training Program Materials	All	18.2.4
18-005	Program Authoring Tools for All Manuals	All	18.3.1
18-006	Tables of Contents and Sample Formats and Indexes for All Manuals	All	18.3.6
18-007	Two (2) Draft Hardcopies of Each Manual	All	18.3.6
18-008	Forty (40) Copies of Approved, Complete Operating Manuals	All	18.3.6
18-009	Ten (10) Sets of Approved, Complete Maintenance and Overhaul Manuals	All	18.3.6
18-010	Ten (10) Sets of Approved, Complete Illustrated Parts Manuals	All	18.3.6
18-011	Ten (10) Sets of Approved, Complete Electrical Schematic Wiring And Connection Diagram Manuals	All	18.3.6
18-012	Master Copy of the Approved Manuals	All	18.3.6
18-013	Special Tools and Test Equipment Delivery	All	18.4.1
18-014	Comprehensive List of All Proposed Special Tools and Test Equipment	All	18.4.1
18-015	Manuals and Training for All Custom Software Applications Supplied with Test Equipment	All	18.4.1
18-016	Part Numbers and Prices for All Portable Test Equipment	All	18.4.3

CDRL No.	Title	Car Type	Reference Paragraph
18-017	VMU Workstation and Appropriate Software with All Instruction Manuals	All	18.4.4
18-018	VMU Hardware and Software Design Review Submittal	All	18.4.4

SECTION 19

CONTRACT MANAGEMENT

SECTION 19

CONTRACT MANAGEMENT

TABLE OF CONTENTS

SECTION 19

CONTRACT MANAGEMENT

19.1 PROJECT MANAGEMENT

19.1.1 General

The Contractor's project management program and team shall professionally and efficiently manage and execute the requirements of this Specification. The program shall be sufficiently comprehensive to enable SCRRA to ascertain, with a high degree of confidence, that the Contractor will meet the requirements of this Specification, and to allow SCRRA to affectively monitor the contractual effort.

The Contractor agrees that its core team, at a minimum, shall include the key personnel listed and that each shall be assigned to the project in the capacities listed. The key personnel shall remain in the listed position unless, due to circumstances beyond the Contractor's control, they must be replaced. Any replacement of key personnel shall be subject to the approval of SCRRA. Any key personnel, removed from the project, shall be replaced by an equally qualified person. SCRRA reserves the right to require Contractor to replace any of the Contractor's key personnel that it finds unacceptable.

Key personnel for this Contract shall include the following:

- Project Manager. See Section 19.1.2 for the definition of responsibilities.
- Project Engineer. The Contractor's Project Engineer shall be the technical leader responsible for coordinating and overseeing all engineering and testing activities.
- Systems Integrator. The Contractor's Systems Integrator shall be the technical leader responsible for coordinating and overseeing all system interfaces and system integration between and among vehicle systems.
- Lead Electrical Engineer. The Contractor's Lead Electrical Engineer shall be the technical leader responsible for coordinating and overseeing all electrical engineering and testing activities.
- Lead Mechanical Engineer. The Contractor's Lead Mechanical Engineer shall be the technical leader responsible for coordinating and overseeing all mechanical engineering and testing activities.
- Lead Structural Engineer. The Contactor's Lead Structural Engineer shall be the technical leader responsible for coordinating ad overseeing all structural engineering and testing activities for the carbody and truck.
- QA/QC Manager. The Contractor's QA/QC Manager shall be the technical leader responsible for coordinating and overseeing all quality assurance and quality control activities.

The Contractor's key personnel shall attend all Progress Review Meetings and participate as required to support the agenda in Section 19.1.7.

19.1.2 Contractor's Project Manager

The Contractor shall assign an individual on a full-time basis, fluent in written and spoken English, and approved by SCRRA, to serve as Contractor's Project Manager for this Contract. **[CDRL 19-001]** This individual shall have at least 10 years of prior experience in management of rail passenger vehicle procurements and be familiar with design, subcontractor equipment procurement, manufacture, test, communications, and inspection of rolling stock. This individual shall be granted full authority to render decisions on behalf of the Contractor pertaining to technical and commercial decisions regarding the Contract. The Contractor shall provide documentation acceptable to SCRRA that certifies that the Contractor's Project Manager has said authority. The Contractor's Project Manager shall serve as the Contractor's representative in all meetings with SCRRA and/or its duly appointed representatives. No substitution of the Contractor's Project Manager will be permitted without SCRRA's prior written approval.

19.1.3 Project Management Responsibilities

The Contractor's Project Manager shall represent the Contractor during meetings, discussions, communications, progress meetings, design review meetings, warranty, contract change negotiations, and open item meetings with SCRRA. The Contractor's Project Manager and supporting staff shall be capable of addressing all issues on the agenda for each scheduled meeting. The Contractor's Project Manager shall arrange to have Contractor and subcontractor supporting staff, and other applicable resources (including, for example, suppliers, available as required to participate in applicable meetings, discussions, and other communications between Contractor and SCRRA.

19.1.4 Management Program

19.1.4.1 General

The Contractor shall establish an organization to properly manage this procurement program for the Contract. The organization shall be highly responsive to the needs of SCRRA as required in this Contract.

19.1.4.2 Management Plan

The Contractor shall develop and submit to SCRRA for approval a Management Plan. The Management Plan shall be submitted no later than forty-five (45) days after Notice To Proceed (NTP) to the Contractor. **[CDRL 19-002]**

The Management Plan shall show all design reviews, testing, inspections, and audits required by the Contract and shall include, but shall not be limited to:

1. An organization chart including names and a definition of the responsibilities and qualifications of all personnel therein for the Contractor and major suppliers. As appropriate, staff of the Contractor and major suppliers at the local office, design, manufacturing, assembly, and SCRRA project site locations shall be identified.
2. The internal methods, communications, correspondence coding system, and correspondence control to be used to monitor, oversee, and manage the Schedule, technical performance, changes, subcontracts, purchase orders, material procurement, in-service support, warranty, systems assurance analysis, tests, and demonstrations.
3. A Master Contract Schedule in Critical Path Method (CPM) format showing key milestones, events and activities.
4. A list of drawings and documents to be submitted during the design review phase of the Contract and a schedule for the submittal of these drawings and documents.
5. An updated and expanded Contract Deliverable Requirements List (CDRL) based on the Contract and on the information in each Section of this Technical Specification within sixty (60) days after Contractor NTP. The CDRL shall contain the consolidated listing of all required deliverables including specific format, quantity, frequency, and paragraph reference of submittal as required by the Technical Requirements. Submittals include, but are not limited to, schedules, plans, procedures, reports, certificates, samples, certifications, test results, and as-built drawings. The CDRL shall be in accordance with the following column headings:

   - Item No: Numeric identifier
   - Title: CDRL item
   - Reference Section: Location of requirement within the Contract Documents
   - Description: Brief description of required due dates and frequency
   - Quantity: Number of documents, units, or copies required
   - Planned submittal date
   - Person responsible for preparing the CDRL

19.1.4.3 Submittal Review Plan

To expedite the design review and approval process, the Contractor shall develop a comprehensive plan for prioritizing the review of submittals in cooperation with SCRRA. For this reason, the Contractor shall schedule a series of meetings with SCRRA within two weeks of submittal of the Management Plan to develop the Submittal Review Plan. This plan will be based on the Drawing and Document Schedule and CDRL submitted in the Management Plan, and will include drawings at levels of indenture below that of those in the Drawing Schedule. The Submittal Review Plan, once agreed to, shall become part of the Management Plan. Subsequent updates to the Submittal Review Plan shall be performed as required to meet the needs of the Contract. **[CDRL 19-003]**

The Submittal Review Plan shall group submittals into categories based on their criticality to various phases of the program. Suggested submittal groupings are as follows:

- Concept submittals must be reviewed and approved early in the program to allow further design work to proceed. These should be key conceptual design submittals that define basic car and system configurations and demonstrate Specification compliance at the car and system level.
- Submittals that must be reviewed and approved prior to the start of procurement activities.
- Submittals that must be reviewed and approved prior to the start of manufacturing.
- Submittals that must be reviewed and approved prior to first article inspection.
- Submittals that must be reviewed and approved prior to the start of car testing.
- Submittals that must be reviewed and approved prior to delivery of the first car.
- Submittals that may be deferred for review and approval to some point after delivery of the first car.
- As-built submittals.
- Submittals for information only (i.e., formal review and approval is not required).

Note that, in some cases, it may be mutually agreed that drawings scheduled for completion at an early stage in the program do not require review until a later stage, depending on the agreed-upon criticality of those drawings to the overall design. Note also that SCRRA approval of the Submittal Review Plan and the agreed-upon deferral of review and approval for a given submittal does not in any way relieve the Contractor from compliance with the Technical Specification or from the responsibility to produce an acceptable design. Items subject to review must comply with the requirements of the Contract. Any items which are proposed as alternatives to the Contract requirements must be submitted to SCRRA for review and approval, whether identified as such in the original Submittal Review Plan or not.

The Submittal Review Plan shall also include a description of review program logistics, particularly those aspects of the program that supplement the traditional submittal and review process in order to accelerate design review and approval. These may include provisions for non-binding up-front reviews that are contingent on the ultimate receipt of supporting drawings, in-process design reviews convened as needed, and any other methods for expediting review that are deemed appropriate by the Contractor and found acceptable to SCRRA. A report that updates the status of the Submittal Review Plan shall be submitted to the Engineer for review and approval as part of the monthly progress review report.

19.1.4.4 Weight Control and Weight Balance Plan

The vehicles shall be designed and manufactured having a weight not in excess to the values stated in Section 2. The Contractor shall develop and submit, for review and approval, a weight control and weight balance plan. The plan shall include the proposed design weight for each car type and the means and methods employed to insure that the manufactured weight of each car complies with the Contract requirements. A report detailing weight control and weight balance programs for each car type shall be submitted within sixty (60) days after NTP to the Engineer for review and approval. Each report shall be updated at least monthly during the design and manufacturing phases and submitted to the Engineer for review and approval as part of the monthly progress report. **[CDRL 19-004]** This shall continue until the first car of each type is weighed. The weight control and weight balance reports shall be validated on the first completed car of each type prior to shipment from the Contractor's plant.

The Contractor shall implement a comprehensive program to control car weight and weight distribution. Prior to the first design review, the Contractor shall submit:

- A proposed weight data record format,
- Initial weight and balance estimates, and
- A proposed procedure for ensuring control of car and truck weight and balance, and car component-weight location.

The records for the first car of each type and for the first production car of each type shall contain as a minimum:

- Sum of estimated carbody and car-mounted equipment weights;
- Location of equipped carbody center of gravity (cg) with indicated location of carshell cg, and the cg's of individual major equipment relative to longitudinal/vertical and transverse geometric centerlines of the finished carbody;
- Magnitude and location of the center of the carbody load applied to each truck centerplate relative to longitudinal and transverse geometric centerlines of the finished carbody;
- Weight and cg of each truck as equipped for service;
- Weight supported by the rail under each wheel for the truck alone and for the combined car and truck;
- Sum of all wheel loads; and,
- Contract empty car weight.

This data shall be updated and revised at frequent intervals throughout the car design and manufacturing phases as more precise estimates and actual weight data become available, and shall be submitted to the Engineer.

The submission shall include the most recent weights for the car without trucks, each truck and the complete car. It shall also include a list of weights for every system on the vehicle, and indication of percentage of the estimated weight that the system contributes to the total estimated weight. As equipment scale weights become available, they shall replace the estimated weights in these reports. The Contractor shall require the full cooperation of its subcontractors in this effort, and shall require weighing of sample components at the earliest possible dates.

The final weight balance and placement of equipment shall be as approved by the Engineer. **[CDRL 19-005]** If the weight imbalance on the first car of each type is greater than allowed by Section 2.4.3, the Contractor shall prepare a plan for correction of the imbalance to the specified level for the approval of the Engineer, and the car shall be modified to the approved plan. If after completion of modifications the car is compliant, the weight control and weight balance reports shall be revised to reflect the modifications made and submitted for approval. All cars from second car of each type shall be manufactured to the revised and approved report.

19.1.5 Monthly Progress Reports

After initial approval of the Master Contract Schedule the Contractor shall submit to SCRRA a copy of the updated Master Contract Schedule containing data as of the end of each month for each month. **[CDRL 19-006]** This data shall be collected into a Monthly Progress Report. The Monthly Progress Reports will serve as a joint review and agreement on project progress.

Monthly Progress Reports shall specifically include:

- All items listed in the Management Plan,
- Actual completion dates for activities completed during the report period,
- Actual start dates for activities started during the report period,
- Estimated remaining durations for activities in progress,
- Estimated start dates for activities scheduled to start during the six weeks following the report period,
- Changes in the durations of activities and minor logic changes,
- Workaround plans needed to make up for schedule slippage, as necessary,
- A narrative in bullet format highlighting problem areas and corrective actions being taken to resolve the actual/potential problem,
- Record of the Contractor’s drawing/document status per Section 19.2.1,
- Engineering Change requests Status Report per Section 19.3,
- Change Order Log indicating pending or open Change Orders,
- Financial summary,
- Activities not previously included in the Master Contract Schedule necessary to complete the work,
- Status of correspondence including open items, and
- A summary list of actual car weights by car number, the cumulative average car weight along with a graphic comparison of cumulative average car weight with individual car weight by car number.

The Contractor shall include with the Monthly Progress Report an updated Master Contract Schedule containing data as of the end of each prior month. The Monthly Progress Report is due the fifth day of each month for the life of the project.

The Contractor shall also provide a narrative, which shall state the Work actually completed and reflect the progress in terms of days ahead of or behind the specified dates for each of the work items, as well as percent completed. During the manufacturing, assembly, and testing phases, Contractor shall supplement the narrative with color photographs (film or digital) to show the status and/or problem areas of the work-in-progress. SCRRA may request supplemental detailed reports and/or photographs if those, provided in the Monthly Progress Report, are determined to be inadequate.

19.1.6 Master Contract Schedule and Updating

Schedule is of paramount importance in this procurement. Contractor shall submit a time-scaled CPM schedule indicating achievement of key milestones, both design and construction, using the date of Notice to Proceed for the purposes of preparing the initial Master Contract Schedule. Accompanying this schedule shall be a narrative describing the Contractor’s approach to implementing and maintaining this schedule. With regard to the schedule submittal, Contractor shall:

- Indicate all activities by ID and description
- Indicate Early Start, Start, Early Finish, and Finish dates for all activities
- Indicate all activity durations
- Indicate logical connections between all activities
- Indicate float for all activities
- Indicate a specific date for each milestone activity

As a minimum, Contractor shall include the following activities:

- Preparation and submittal of general arrangement drawings
- Design of each major subsystem and component
- Manufacture of each major subsystem and component
- Delivery of each major subsystem and component to manufacturer
- Design Conformance Test of each major subsystem and component
- First Article Inspection of each major subsystem and component
- Manufacture of car shell no. 1 subassemblies
- Car shell no. 1 assembly
- Cab car shell with CEM features assembly
- Car shell no. 1 load testing

- Cab car shell with CEM features load testing
- Parts manufacture for first set of trucks
- Assembly of first set of trucks
- Testing of the first set of trucks
- Assembly of first cab car
- Water test of first cab car
- Factory testing of first cab car
- Assembly of first trailer car
- Water test of first trailer car
- Testing of first trailer car
- Shipping of each cab car to SCRRA
- Shipping of each trailer car to SCRRA
- Delivery and acceptance of each cab car
- Delivery and acceptance of each trailer car
- Completion of each major payment milestone

The Contractor shall update the Master Contract Schedule in the following manner:

- Initial schedule shall remain the same for each update.
- Actual progress shall be shown using different colored lines or lines of a different pattern from those used when preparing the initial schedule. Actual progress shall be shown directly under the activity with the percentage complete indicated as of the date the report was prepared.
- Date of the updates shall be provided.
- Actual start/finish dates shall be shown for activities in progress.

19.1.7 Progress Review Meetings

Progress Review Meetings (PRMs) shall be held every month. Depending on the subject matter to be covered in the Progress Review Meetings, SCRRA may opt to conduct certain meetings at its own facilities, the car construction facilities or facilities of the Contractor's subcontractors. SCRRA will endeavor to make these locations known to the Contractor at least fourteen (14) days prior to the meetings. SCRRA is amendable to conducting approximately one third of the progress review meetings via video conferencing or via web-based conferences.

The Contractor and SCRRA shall collaborate to prepare an approved agenda for the meetings five (5) working days prior to the scheduled meeting date.
The appropriate Contractor personnel, based upon the approved agenda, shall attend.

As a minimum, the following topics shall be discussed:

- Introduce new attendees and areas of responsibility.
- Review minutes of previous, related meetings.
- Review the updated Master Contract Schedule.
- Discuss work accomplished since previous meetings, including: design status, fabrication difficulties, product delivery status, schedule slippages, impacts arising from proposed changes, and other circumstances which might affect progress of the work.
- Discuss sequence of critical work and schedule of manufacturing using the Contract Schedule and Monthly Progress Reports.
- Discuss status of engineering, manufacturing, and quality assurance/control activities.
- Discuss changing conditions and possible time extensions.
- Discuss corrective measures to maintain Contract Schedule when necessary.
- Discuss status of Training Program and manuals.
- Discuss work to be done in the next six weeks.

Each of the inquiries, reports, and requests for solution of problems presented during such meetings shall be answered, if possible, during the meeting. Those not answered during the meeting shall be answered, solved subsequent to the meeting and the resolution documented and delivered in person or mailed to SCRRA's designee for comment and approval, within five (5) working days of the close of the meeting, or longer time frame, if acceptable to SCRRA. Such answers shall be communicated to SCRRA in writing, or in a mutually agreed upon manner. Contract Review meeting minutes shall be prepared by SCRRA and submitted to the Contractor for review and concurrence.

19.1.8 Contractor Representatives

The Contractor, and its subcontractors, shall provide qualified technical and administrative support on SCRRA's property commencing with the arrival of the first car and concluding with the completion of the warranty program. The Contractor Representatives shall be fluent in written and spoken English and fully qualified for the on-site tasks. Included among the personnel shall be a full range of engineering skills, until such time as all cars are accepted. All necessary specialized Contractor and subcontractor support shall be available on-site, within 48 hours of notification, to assist the on-site personnel in the investigation and resolution of car and equipment malfunctions.

Contractor Representatives shall be identified as such by the Contractor and display appropriate identification while on SCRRA property. Contractor's on-site personnel must undergo SCRRA's safety training prior to access to SCRRA facilities and adhere to all SCRRA policies and procedures with respect to third parties at SCRRA facilities and any applicable government regulations.

19.2 CONTRACTOR'S DRAWINGS, DOCUMENTATION, AND DATA REQUIREMENTS

19.2.1 Review Procedures for Drawings, Documents, and Data

The Contractor shall submit three (3) hardcopies and one (1) electronic copy of all documents, data, assembly and installation drawings required to convey concept, design, dimensions, maintenance, operation, and overall assembly aspects and interfaces for review. The required electronic copy shall be created and submitted using a software package and release/revision approved by the Engineer. All documents submitted by the Contractor shall be in the English language.

The Contractor shall submit drawings in accordance with the Submittal Review Plan (refer to Section 19.1.4.3) within the Contractor's Management Plan. As described in Section 19.1.4.3, this Plan is based on the Contractor's Submittal Review Plan. Subassembly drawings shall also be submitted to facilitate the review of assembly and installation drawings. Drawings shall be accompanied by material specifications, process specifications, flammability and smoke emissions data, and test data required to permit review of the drawings. SCRRA reserves the right to request additional drawings, documents, or data, or any combination thereof to support the review process, and Contractor shall furnish such. When submitting drawings of structural parts or assemblies for the carbody structure, equipment supports, and trucks; the Contractor shall also submit, for review and approval, stress analyses for these parts or assemblies in summary form. Other Contract deliverables including material samples, test plans, test procedures, and analyses as required by this Specification shall be submitted in the quantities specified. Contractor submittals shall be reviewed and approved before manufacturing any parts, as indicated in the Submittal Review Plan.

Except as provided below, or as defined in the Submittal Review Plan; the Engineer will review and disposition Contractor submittals, within thirty (30) days after receipt by the Engineer. The Engineer will make good faith efforts to review and disposition, and return if requested, Contractor submittals (other than manuals and catalogues identified in Section 18, Documentation and Training) within twenty-one (21) days or less, except when Contractor submittals exceed the submittal maximum of 100 drawings in a thirty (30) day period. The Engineer will disposition all manuals and catalogs identified in Section 18, Documentation and Training within ninety (90) days after receipt by the Engineer. The Engineer will respond to the Contractor at an address within the United States designated by the Contractor. To prevent grouping of drawings into excessively large packages submitted to the Engineer, the Engineer will not be obligated to review more than 100 drawings and/or technical documents, within any given thirty (30) day period. In the event that more than 100 drawings and/or technical documents are submitted for review in any given thirty (30) day period, the Engineer will make every effort to review them within the thirty (30) days, except, if specifically identified elsewhere in the Specification. If this is not possible, the Engineer will review them in accordance with priority order as mutually agreed to between the Contractor and the Engineer.

As submitted by the Contractor, the drawings, documents and data shall be accompanied by a letter of transmittal listing drawing and document titles, numbers and revisions. If more than one (1) drawing or document is submitted at a time, the drawings and documents shall be listed in the transmittal letter in numerical sequence.

No extension of Contract time will be allowed for revision of Contractor's drawings or documents, which have been determined to be either in a status of, "Not Approved" or "Approval Pending." Such drawings and documents shall be resubmitted by Contractor and will be reviewed and returned to the Contractor within the same time constraints as would be applied to the drawings and documents when initially submitted. Drawings shall be submitted in an orderly and logical sequence (e.g. main assembly followed by subassemblies in order of drawing number) to enable the Engineer to readily determine and review the interface relationships between all major structural elements and their subassemblies and also between the structural elements and the attached apparatus, equipment, wiring, piping and hardware.

The Contractor shall maintain a record of Contractor and Subcontractor drawing and document status. This shall include drawing and document numbers, revision letter, drawing title, date submitted, transmittal document, disposition by type and date, and the document number identifying the disposition. This status shall be updated not less than monthly and submitted to SCRRA as part of the Monthly Progress Report (reference Section 19.1.5).

19.2.2 Requirements for Drawings, Documents, and Data

All drawings shall be produced electronically utilizing computer-aided design software. All other documents and data shall be produced electronically utilizing Microsoft® Software, such as Word or Excel. Manual revisions to drawings, documents and data shall not be permitted. All dimensions shall be expressed in the English system using decimal numbers; all wording shall be in the English language. All terminology used shall be conventional to the U.S. transit and railroad industries. Drawings shall be made to the third-angle projection system.

Each drawing shall be provided as a Bentley System's Micro Station V8 drawing with *DGN file extensions or AutoCAD® with *.DXF or *.DWG file extensions. Such drawings shall include outline and arrangement drawings of the major items of apparatus, as well as detail drawings of all assemblies, sub-assemblies, components, integrated wiring schematics, and wiring lists for equipment and apparatus. SCRRA review and approval of the Contractor's submittals shall be attained before beginning any manufacture associated with such submittal. Sufficient drawings and supporting information shall be submitted to convey concept, design, dimensions, maintenance, operation, overall assembly, and interfaces. Detailed part drawings shall be submitted for each assembly as well as arrangements and details of all apparatus including apparatus within equipment boxes. Outline or otherwise incomplete drawings will not be acceptable. These conditions shall also apply to subcontractor-furnished material and components. The Contractor shall submit a list of drawing, document and date software that will be used on the Contract to the Engineer for approval. **[CDRL 19-007]**

A revision block shall be provided for all documents, drawings, and data. The revision block shall identify the revision level, date of revision, the initials of the engineer authorizing the revision, a description of the change and a summary of the change, the location of the change and the reason for making the change. The full description of the change and the reason for making the change shall be provided on an Engineering Change Request (ECR) or similar document accompanying the submittal and appropriately referenced in the revision block. Once a submittal is approved by SCRRA, Contractor shall submit an ECR to the Engineer for approval before incorporation of any subsequent document, drawing, and data revisions to such previously approved submittal. Upon receipt of ECR approval, the document, drawing, and data shall be revised and the document, drawing, and data, with the accompanying approved ECR, shall be submitted as a package for final approval. No additional revisions to an approved documents, drawings, and data shall be made without an approved ECR.

All structural drawings shall be sufficient scale and size to clearly delineate the shape and size of all assemblies, members and components. The drawings shall be completely dimensioned. Tolerances shall be indicated on each drawing. Build up of materials shall be shown and identified (thicknesses dimensioned). Full and complete information regarding location, type, size, and extent of all welds shall be clearly shown on the drawings. All joints and connections shall be detailed, with all dimensions, showing the size of the fasteners, and complete AWS, or equivalent, weld symbols (including size and process). The list of materials shall include the material's specifications with grade, temper, thickness, and nominal size.

All drawings shall be divided into zones to make it easier to locate details. The zones shall be approximately 3 inches by 3 inches in size. The vertical divisions must be designated by the use of letters letter and the horizontal divisions designated by numbers. Whenever a cut, section or detail is referenced on a drawing, its location, by sheet and zone, shall be noted. Wherever the cut, section, or detail is shown, the location by sheet number and zone from whence it came shall be noted.

All drawings supplied by the Contractor shall be delineated in a manner that permits the wiring, piping, and mechanical interface relationships between components furnished by the Contractor and its Subcontractors to be clearly identifiable.

Whenever a reference is made on a drawing to a material or process by the Contractor's own specification number; the drawing shall also give the commercially, equivalent designation. If there is no commercial equivalent, the Contractor shall provide copies of its specification.

Totally integrated vehicle schematics relating to all electrical and pneumatic systems shall to be provided. The schematics shall, at a minimum, include component identification, component values, waveforms, voltages, currents, resistance values, wire identification, connector identification, and connector pin numbers. All components on PC boards shall be individually shown in the schematics. Schematics shall be comprehensive in nature and thoroughly detailed to permit use by SCRRA shop electricians and air brake technicians to troubleshoot and repair vehicle systems. Schematic location (page number, for example) of the energizing portion of each device (such as the coil in a relay) shall be noted adjacent to the operating portions (such as relay interlocks) of the device.

A set of device tables shall be located in a single section at the rear of the schematic book. This table shall be arranged in logical fashion by system device type. This table shall include data for all system and subsystem components including but not limited to:

- Electrical control and power components (groups, panels, PC cards, contactors, relays, circuit breakers, capacitors, inductors, resistors, specialized modules, rectifiers, thyristors, diodes, fuses, and other components, as appropriate).
- Electrical machinery (rotating equipment, reactors, transformers, pumps, fans, compressors, switchgear, and other machinery).
- Pneumatic control and power devices (valves, chokes, strainers, reducers, and other components).
- Pneumatic machinery (compressors, air cylinders, air motors, air latches, and other machinery).

As a minimum, device listings shall include the following:

- Location in schematic and schematic designation,
- Type, model, and part number,
- Location on vehicle,
- Function,
- Schematic symbol,
- Appropriate ratings data, and
- Interface information, as appropriate.

The integrated schematic drawings shall be formatted by subsystem, using identical device symbols and wire and pipe designators for each subsystem. All interfaces, from page to page, and subsystem to subsystem, shall be clearly delineated. The integrated schematic and narrative shall be designed, drafted, assembled, and published by the Contractor, or by a single subcontractor placed under contract for that purpose. It will not be acceptable to assemble a collection of subcontractor drawings, independently produced, into a single, vehicle integrated schematic. To ensure clarity, the Contractor shall select lettering and detail size to be legible for a schematic page reduced to a size of 8.5 inch by 11 inch; however, the schematic shall be submitted in an 11 inch by 17 inch page format.

Wiring diagrams shall include integrated, connection diagrams and a wire list in book form based on the integrated schematic. The diagrams shall show all wiring, raceways, conduits, and connections.

The wire list shall include each individual wire segment in the vehicle, listed separately, whether the wire is used for the transfer of power or information.

As a minimum, the following information shall be provided for each wire segment:

- Wire code (schematic designation),
- Origin (FROM device/terminal),
- Destination (TO device/terminal),
- Wire size,
- Voltage rating,
- Length,
- Appropriate specifications,
- Jacket color, and
- Harness designation.

Instructional drawings for manuals shall be prepared in accordance with the requirements of Air Transport Association of America (ATA) Specification No. 100 "Specification for Manufacturer's Technical Data" and shall be prepared so that reduction can be made to 8.5 inches by 11 inches dimensions.

The following ASME standards for the preparation of drawings shall apply: Y1.1, Abbreviations for Use on Drawings; Y14.5M Dimensioning and Tolerancing; Y14.2M Line Conventions and Lettering; Y14.3M Multiview and Sectional View Drawings; V32.2, Graphics Symbols for Electrical and Electronic Diagrams; and V32.14, Graphic Symbols for Logic Diagrams. The requirements for ATA and ANSI/ASME standard graphic symbols and abbreviations may be waived by the Engineer provided a system of standard abbreviations and symbols for all drawings submitted is used, and the Contractor provides SCRRA with five hardcopies of a bound booklet and one electronic copy in a format which contains a legend cross-referencing all abbreviations and graphic symbols used on drawings to those required by the ATA and ANSI/ASME standards.

19.2.3 Drawing, Document, and Data Review

The Contractor, in compliance with the approved Master Contract Schedule, shall submit in electronic form to the Engineer for review and approval drawings, documents, and data required by the Specification, or necessary to demonstrate compliance with the Specification requirements.

The Contractor shall provide an indexed drawing database listing all drawings in an electronic format, approved by the Engineer, containing information on all drawings. The database shall include the builder's and manufacturers' drawing numbers and shall be arranged in drawing number ascending order and embody the following information:

- Drawing Size,
- Drawing Number,

- Revision Number,
- Issue Date,
- Electronic File Location,
- System,
- Number of Sheets,
- Company Name,
- Blank (SCRRA use),
- System Identity,
- Drawing Title, and
- Revision Date.

This database file shall be uploaded to the Project Extranet as defined in Section 19.2.4. This database shall be maintained and kept current by the Contractor on a real-time basis. The data base file shall be uploaded no less frequently than every two (2) weeks. **[CDRL 19-008]** The database shall be compatible with the capabilities of the Extranet in that by accessing the database on the Project Extranet, the user shall be able to search the database in a variety of linear and non-linear ways, depending on the user's starting point. The user shall be able to browse the database and search for files by system, manufacturer, drawing title (both by keyword and text string), and drawing number. When the desired drawing file is located, the user shall be able to locate and view the electronic file within the Project Extranet.

Within sixty (60) days after Notice To Proceed, the Contractor shall submit to the Engineer, a full functioning database with all capabilities described above for review and approval. The database shall represent all types of technical submittals and shall be approved by the Engineer. **[CDRL 19-009]**

Drawings, documents, and data submitted by subcontractors or suppliers shall be thoroughly reviewed and approved by the Contractor to ensure that they meet Contract Documents (as to form, fit and purpose) and the Technical Specification requirements before submittal to the Engineer for review and approval.

19.2.4 Submittal Form

All submissions shall be properly referenced to clearly indicate the location, service, and function of each particular subject, and shall include the proper references to the appropriate Specification Section including drawing numbers and details. Where the manufacturer's publications in the form of catalogs, pamphlets, or other data sheets are submitted in lieu of prepared technical submittals, such submissions shall specifically indicate the item for which approval is requested. Submissions showing only general information shall not be considered acceptable.
Where temperatures are expressed in both Fahrenheit and Celsius, the value in parentheses is for reference only; compliance with the Specification shall be measured in terms of the value first

stated, whether Fahrenheit or Celsius. Drawings shall be made to the third-angle projection system.

Every drawing shall include a complete bill of material and parts list in the field of the drawing or on a separate sheet of the same drawing. All parts or sub-assemblies, including subcontractor-furnished items, which form a part of the assembly, sub-assembly, or piece depicted, shall be described. Each assembly drawing shall include the weight and center of gravity of the assembly. All drawings shall reference the number of the drawing of the next higher sub-assembly or assembly on which it is used. This requirement does not apply to standard hardware or electrical and electronic components.

Revisions to technical submittals, affecting previously submitted technical information (drawings, reports, documents, etc.), shall be re-submitted for approval as they are issued. No more than three (3) alterations/changes shall remain unincorporated on any submittal at any time.

Approval does not relieve the Contractor of its obligation to meet all requirements of the Contract. Approval of a submittal which contains a deviation from, or breech of, the Specification does not constitute approval for that deviation or breech unless such deviation has been specifically requested in writing and approval granted in writing according to Contract requirements separate from the approval process. All requests for deviations from approved documents shall be submitted, reviewed, and approved by the Engineer prior to release of the drawing for installation.

Each Engineering Change, Deviation, Material Review Board (MRB) repair, or similar variance affecting form, fit, or function shall be incorporated on the affected drawings when it applies to five (5) or more cars. Such drawings shall be clearly labeled with the SCRRA car numbers that apply to each configuration. Those variances applying to fewer than five (5) cars may also be incorporated on the affected drawings or the variances may be furnished separately. If furnished separately, they shall also be described in the Car History Book for each car involved with a cross reference to the affected drawings.

If the Contractor's drawing system is such that drawings of details are not included in the assembly, sub-assembly, and arrangement drawings as described above, the Contractor shall submit copies of all detail drawings to the Engineer. The Contractor shall maintain all drawings for a period of thirty (30) years. He shall make available, without charge, for a minimum of ten (10) years from the date of acceptance of the last car, drawings of any details required for extraordinary repairs arising from accidents or mandated or unanticipated changes. During the remaining twenty (20) years, SCRRA shall be provided with all requested drawings at an agreed to cost.

The submittal of electronic files of all drawings, letters, attachments, CDRLs, and other documents shall be via the Project Extranet. The Project Extranet shall be a designated URL address on the World Wide Web (www) to which all submittals to SCRRA will be uploaded. All transmittals from SCRRA to the Contractor will be via the Project Extranet.

19.3 DRAWING, DOCUMENT AND DATA CHANGES

Changes to the documents, drawings, or data shall be controlled by the processing of Engineering Change Requests (ECRs). All ECRs must address Section 1.6.5 requirements and the following:

- Delivered manuals,
- Car effective, and retrofit requirements,
- Delivered product (retrofit),
- Electromagnetic interference characteristics,
- Reliability and maintainability,
- Safety,
- Schedules of deliveries,
- Spare parts provisioning,
- Source or repairable items (source control drawing), or
- Weight or balance.

All ECRs, together with documentation and cost information, shall be submitted to the Engineer for review and approval prior to implementation. The Contractor shall maintain an Engineering Change Status Report which shall list all approved changes, their status, and completion dates. The status shall be included with the Monthly Progress Report. **[CDRL 19-010]** Implementation of an ECR shall require incorporation in all vehicles of that type unless approved by the Engineer as an effective point change. Any changes to the schedule resulting from an ECR implementation shall be subject to the approval of the Engineer.

19.3.1 As-Built Drawings

The Contractor shall submit to the Engineer for review and approval, within sixty (60) days after completion of first of each type of car, within sixty (60) days after completion of the last car, and then again after completion of all modifications, a list of all “as-built” drawings to be supplied in accordance with this section. The as-built drawings shall include one (1) set of hard-copy prints and two (2) sets of electronic media files, supplied on CD-ROM in Micro Station V8 (*.DGN) or AutoCAD® (*.DXF, *.DWG) format of the following drawings: **[CRDL 19-011]**

- Drawings of all assemblies, subassemblies, and arrangements of the cars, as finally manufactured and modified.

- All detail drawings of those assemblies, subassemblies, and arrangements.
- A complete bill of material for all assemblies, subassemblies, or arrangements.
- A final integrated electrical schematic, wiring diagram, and wire list defining all wiring and electrical apparatus on the car.
- Final schematic piping and connection diagrams illustrating the piping layout and apparatus.
- All interface control drawings down to LRUs.
- All approved detailed Manufacturer's drawings.
- All materials furnished by the Contractor and by its suppliers, down to and including the module and circuit board level. In every case, outline drawings shall not be considered acceptable.

All information required above shall also be supplied in a single electronic format usable by SCRRA. The preferred format is Micro Station V8.

The as-built drawings shall incorporate all engineering and manufacturing changes. Deviations shall also be incorporated, with copies provided in a separately indexed section.

19.3.2 Drawings Requiring Approval

Drawings to be furnished by the Contractor for approval by the Engineer shall include, but not be limited to, those listed below. The Engineer reserves the right to request additional drawings as required to clarify and amplify the intent of drawings furnished. **[CDRL 19-012]**

19.3.2.1 General

- Exterior elevations of both sides of vehicle
- Exterior elevations of both ends of vehicle
- Floor plan
- Reflected ceiling plan
- Roof plan
- Interior, longitudinal sections of both sides of vehicle
- Interior elevations of both ends of vehicle
- Plan layout, cab equipment locker
- Layout of cab console and operator's compartment
- Interior elevations of cab layout
- Equipment layout and locations
- Reflected plan, conduit and cable layouts

- Reflected plan, piping layout
- Side elevation, equipment layout
- Relation of ends of vehicles on curves, and showing vertical and horizontal coupler swings both static and dynamic
- Carbody and wayside clearance drawings (static and dynamic)

19.3.2.2 Sections

- Transverse sections to show all variations in cross section such as through doors and windows, roof, etc.
- Transverse section to show extreme movements of vehicle (including yaw) permitted by vehicle suspension and running gear
- Transverse and longitudinal sections to show physical relationship of major components
- Transverse sections to show vertical and lateral undercar equipment clearances to rail and roadbed

19.3.2.3 Framing and Miscellaneous Drawings

- Underframe and bolster - plan elevations and sections
- Anti-climbers - plan, elevations and sections
- Side frame(s) - plan, elevations and sections
- Roof frame - plan, elevation and sections
- End frame - plan, elevations and sections
- Coupler attachment to underframe - plan, elevations and sections
- Equipment compartments

19.3.2.4 Trucks

- Truck assembly – plan, elevations and equipment application
- Truck frame - details
- Bolster - details
- Suspension (primary and secondary) - details
- Wheels - details
- Axle - details
- Journal bearings - details
- Axle assembly – complete

- Brake equipment - details
- Speed sensors - details
- Ground brushes - details

19.3.2.5 Air Conditioning Unit

- Plan, and elevations
- Installation details and interfaces
- Electrical and piping schematics
- Assembly details
- Controls

19.3.2.6 Door

- Plan, elevations and sections
- Hardware and attaching details
- Assembly details
- Central

19.3.2.7 Coupler, Yoke, and Draft Gear

- Plan and elevations

19.3.2.8 Ducting (HVAC and ECU)

- Plans, elevations and sections
- Joining details
- Installation details

19.3.2.9 Equipment Boxes, Compartments and Lockers

- Plan, elevation and sections
- Hardware details

19.3.2.10 Lighting Fixtures

- Location
- Assembly and installation details
- Equipment accessibility

19.3.2.11 Seating

- Plan, elevations, and sections
- Attaching details and stanchions
- Wheelchair area plan, elevation and sections
- Assembly and installation details

19.3.2.12 Auxiliary Electric Equipment

- Auxiliary power supply - Assembly and installation details
- Low voltage power supply - Assembly and installation details
- Battery - Assembly and installation details
- Circuit breaker panels - details

19.3.2.13 Toilet Room, Water, and Waste System

- Plan, elevations and sections
- Installation, service and interface details
- Integrated schematic (hydraulic, pneumatic, electric)
- Piping - Assembly and installation details

19.3.2.14 Brake System

- Pneumatic control units - Assembly and installation details
- Other brake hardware - details
- Monitoring system - details
- Wheel slide detection/correction system - Assembly and installation details
- Truck mounted brake system components - details

19.3.2.15 Stanchions and Handrails

- Plan, elevations and details
- Assembly and installation details

19.3.2.16 Interior Lining Panels, Bulkheads and Windscreens

- Plan, elevations and sections
- Attachment and installation details

19.3.2.17 Sub-Floor and Finished Floor

- Plan, elevations and sections
- Attachment and installation details

19.3.2.18 Electrical Drawings

- Schematic wiring diagram - nominal 480 VAC equipment
- Schematic wiring diagram - nominal 36 VDC equipment
- Schematic wiring diagrams - nominal 72 VDC equipment
- Schematic wiring diagrams - nominal 120 VAC equipment

19.3.2.19 Pneumatic Diagram

- Schematic piping diagram - air brake equipment, air suspension, etc.

19.3.2.20 Test Equipment

- Hardware drawings
- Equipment Layout Diagrams
- Electrical and Pneumatic Schematics (for non-PC based test equipment)
- Mounting Schematics

19.3.3 Post-Delivery and Warranty Drawing Support

The Contractor shall provide to the Engineer and SCRRA, at no additional cost, at any time requested prior to delivery of the reproducible drawings, working drawing prints in electronic files to enable SCRRA to maintain, service, and repair the cars. The Contractor shall also provide the Engineer, within sixty (60) days after acceptance of the first car and prior to delivery of any remaining cars, a list of all drawings to be supplied to SCRRA, which may be needed to perform extraordinary repairs. **[CDRL 19-013]**

The electronic version of the Contract drawings shall be provided in an AutoCAD® format that allows SCRRA to up-date the drawings to incorporate enhancements and product improvements developed after completion of the Work and warranty period.

19.3.4 Subcontractor Certification

The Contractor shall obtain from each of its subcontractors and suppliers of any tier, a written certification that the method being used for installation and connection of its equipment by the Contractor is satisfactory to such subcontractor/supplier. The certification shall be submitted to the Engineer.

19.4 DESIGN REVIEW REQUIREMENTS

19.4.1 Specification Review

Within fifteen (15) days after NTP, the Contractor's Project Manager, the Contractor's technical specialists, major subcontractors and suppliers, and the Engineer shall perform a detailed review of the Specification. During this meeting the Contractor will be asked to provide an explanation of the approach planned in response to each Specification requirement. The Engineer will answer any questions which the Contractor may have regarding Technical Specification requirements.

19.4.2 System and Vehicle Concept

Within 120 days after Notice to Proceed, the Contractor shall submit a detailed Design Requirements and Traceability Report. This report shall identify the supplier/subcontractor for each vehicle system; interfaces among the vehicle systems and the vehicle itself; specification requirements for each vehicle system and interface; and the entity responsible for satisfying the requirements identified. The report shall be in a data base format approved by the Engineer and shall contain sufficiently detailed information to define the concept being developed for each vehicle system and its integration into the vehicle. This report is to be approved by the Engineer prior to the Contractor's submission of any preliminary design review packages. **[CDRL 19-014]**

The report shall be updated on a monthly basis through to completion of vehicle delivery.

Coinciding with the Design Requirements and Traceability Report, the Contractor shall submit drawings of the outline and sections of the cars showing proposed configuration of each car type, locations of equipment, and block diagrams showing interfaces between the vehicle and all vehicle systems. The drawings shall include sufficient details and dimensions to allow the Engineer to evaluate the arrangement of equipment, passenger seating and standing capacity, passenger comfort, systems integration, and passenger flow onto, off of and through the car, toilet room layout, door locations, and passenger information equipment. The drawings shall be dimensioned to locate all elements from the longitudinal centerline, the pulling face of couplers and top of rail. These drawings shall present the concepts that will be developed through the design review process. **[CDRL 19-015]**

19.4.3 Design Concept Review

Within one hundred twenty (120) days after approval of the Design Requirements and Traceability Report, the Contractor shall prepare conceptual design drawings for each vehicle system, including car structure, for review by the Engineer. Drawings shall be submitted for review and comment. No sooner than fifteen (15) days after receipt of conceptual design drawings, a Design Concept Review Meeting, as scheduled in the approved Management Plan, shall be held at SCRRA or its representatives' office in the United States. **[Part of CDRL 19-015]**

No less than ten (10) days prior to the meeting, the Contractor shall submit a System Functional Description for each system in the Vehicle Design Concept Report that:

- Clearly defines the subsystems that constitute the overall system.
- Describes and graphically depicts each interface between the subsystems.
- Shows how the requirements of the Technical Specification are allocated to the subsystems. This will include descriptions of how single requirements, including control and timing requirements, will be decomposed into several requirements allocated to separate subsystems.
- Defines names for subsystems and the interfaces between them to assure consistent terminology used by all suppliers.
- Defines each system's LRUs and LLRUs.

The descriptions of the subsystems, as presented in the design review documentation and presentations will need to match this overall system description in function, interfaces, and terminology. This document shall be updated as the design progresses and be resubmitted as necessary, but no less frequently than every other month to the Engineer for review and approval. **[CDRL 19-016]**

19.4.4 Design Review Meetings General

The design development and review involves an iterative process that requires the exchange of information amongst the Engineer, the Contractor and its suppliers and subcontractors. The Contractor shall conduct formal design review meetings with the Engineer for the carbody, interior furnishings and arrangements, major equipment, apparatus, each system, and the integration of each system into the vehicles. To support this process, a series of design review meetings as scheduled in the approved Management Plan will be held in which the Contractor conducts a presentation in accordance with a previously approved agenda. In its presentation, the Contractor shall address design approaches, concepts, and design details for the vehicle(s), each system and subsystem and all associated test equipment. During these design review meetings, action items will be identified, with each action item assigned to an individual for disposition by a pre-determined response date. A design review action item log will be maintained by the Engineer.

Design review meetings will typically be one to three days in duration and should not address more than one system or subsystem except for system interface issues. At least twenty (20) days prior to a design review meeting, the Contractor shall submit the agenda and a data package covering information to be addressed in the meeting for review and approval by the Engineer. **[CDRL 19-017]** Design Review meetings shall be held at locations as mutually agreed and shall include sites of SCRRA, the Contractor, and any of its subcontractors or suppliers. The minutes, of the design review meetings, are to be prepared by the Engineer.

The first design review meeting in each phase shall cover the overall system design as described in the System Functional Description.

Attendance at design review meetings shall include the Contractor's Project Manager, representatives of the Contractor, appropriate subcontractors and suppliers, and the Engineer.

19.4.5 Preliminary Design Review

The Contractor shall submit preliminary design review packages for the carbody (each car type), coupler and draft gear, door and door control system, cab and locomotive controls, HVAC system and controls, lighting and lighting controls (interior and exterior), low voltage power supply and battery charger, trucks, friction brakes and pneumatic systems, communications system, operational system, trainline system, car interior (arrangement and materials for each car type), passenger seats, toilet room, and all major equipment and apparatus. The preliminary design review package must include sufficient detail to define the proposed design and to allow the Engineer to determine that the design complies with the requirements of the Contract. Each preliminary design review package shall include, as applicable, the following information:

1. System design implementation
   - system functional description
   - top level diagrams (block diagrams)
   - system schematics (interconnection diagram)
   - system assembly outline drawings
   - component data sheets related to the system
   - list of system and vehicle interfaces
2. Weight schedule
   - estimated weight list broken down to system component level
3. Software Documentation
   - software requirements specification
   - software requirements traceability matrix
   - software release strategy
4. Reliability, Accessibility, Maintainability and System Safety
   - reliability prediction analysis with support information
   - maintainability analysis with supporting information
   - reliability summary
   - preliminary hazard analysis
   - lowest removal unit list (keyed to item 2, Weight schedule)

5. Testing
   - testing strategy table - component level, system level and system integration level

6. Design Requirements and Traceability Report
   - up-dates and revisions
   - validation method
   - outstanding items list

7. Action items, CDRL and Correspondence status
   - listing of all open issues, requests

8. Other Supporting Information and Reports
   - EMC control plan
   - fire safety analysis and test plan
   - traceability and serialization plan
   - configuration management plan
   - proposals for changes, alternatives and value engineering improvements
   - other items as appropriate

All open issues, action items and clarifications resulting from previous correspondence, working sessions and PDR meeting must be satisfactorily addressed and approved by the Engineer prior to commencing the final design review activities.

19.4.6 Final Design Review

The Final Design Review (FDR) will take place when the definition of design and interfaces are complete and approved by the Engineer. The FDR is to provide the opportunity to review, revise, and agree on the details of the final design prior to release of the designs for manufacture. The FDR concerns design, application and installation details and should not modify the basic design defined through the PDR phase. Any open engineering items and related program management issues must be discussed and resolved during the FDR. The FDR package shall emphasize design details and shall include details of the equipment, its installation, performance, manufacturing process(es), operating logic and interfaces. Each FDR package shall have all the information required to permit the Engineer to determine whether the system, equipment and/or apparatus complies with the Contract requirements. The Contractor shall submit final design review packages for the carbody (each car type), coupler and draft gear, door and door control system, cab and locomotive controls, HVAC system and controls, lighting and lighting controls (interior and exterior), low voltage power supply and battery charger, trucks, friction brakes and pneumatic systems, communications system, operational system, trainline system, car interior (arrangement and materials for each car type), passenger seats, toilet room, and all major equipment and apparatus. Each final design review package shall include, as applicable, the following information:

1. System design implementation

- system functional description (system, vehicle and train levels)
- block diagrams (system, vehicle and train levels)
- system schematics (interconnection diagram)
- system assembly drawings
- component data sheets
- definition and list of characteristics for system, vehicle and train interfaces
- system installation, maintenance access and special tool drawings
- Manufacturing scheme (who, what, where, when and how)

2. Weight schedule
    - calculated/actual weights broken down to system component level

3. Software Documentation
    - software requirements specification
    - software requirements traceability matrix
    - software design description
    - software verification and validation report

4. Reliability, Accessibility, Maintainability and System Safety
    - reliability prediction analysis with support information
    - maintainability analysis (preventative and corrective)
    - reliability summary
    - safety analysis and traceability matrix
    - lowest removal unit list (keyed to item 2, Weight schedule)

5. Testing
    - test procedure list - component, system, vehicle and train levels
    - test locations
    - test schedule

6. Design Requirements and Traceability Report
    - up-dates and revisions
    - validation method
    - define responsible entity
    - outstanding items list
    -

7. Action items, CDRL and Correspondence status
    - listing of all open issues, requests

8. Other Supporting Information and Reports
   - EMC control plan
   - fire safety analysis and test plan
   - traceability and serialization plan
   - configuration management plan
   - proposals for changes, alternatives and value engineering improvements
   - other items as appropriate

19.4.7 Critical Design Review

As part of the design review process, the Contractor shall present for the Engineer's review and comment, the pre-production unit for those items identified within Section 1.9.7. This presentation shall include a maintainability demonstration that shall be video taped or digitally recorded and submitted as part of the meeting minutes. Satisfactory resolution of SCRRA's comments is necessary for completion of the CDR.

As part of the design review process, the Contractor shall furnish FAI units of the car's systems. These FAI units shall be presented as part of the Critical Design Review (CDR) and in advance of production units for the Contract. All action items, issues and concerns identified during the FDR phase shall be satisfactorily resolved and approved by the Engineer prior to commencing the Critical Design Review phase. The principal purpose of these FAI units is to enable the Engineer to evaluate the units design prior to commencement of production. The Engineer will evaluate the FAI units for maintainability, repair and replacement of LRUs, accessibility and other general design aspects. The maintainability portion shall be demonstrated, video recorded with the recording submitted for inclusion in the meeting minutes. If approved by the Engineer, the FAI unit may also be utilized by the Contractor for functional testing purposes. FAI units shall be furnished for the trucks, coupler, event recorder, LVPS, friction brake equipment, door operator control panel, door operator, HVAC unit and controls, public address amplifier, destination/information signs and controls, and the radio. FAI reports shall be submitted for review and approved by the Engineer for all FAI items as specified in Section 1.9.7
All action items, issues and concerns identified during the CDR phase shall be satisfactorily resolved and approved by the Engineer to complete the Critical Design Review phase.

19.5 ADDITIONAL DRAWINGS, DOCUMENTS, AND DATA TO BE FURNISHED BY CONTRACTOR

19.5.1 Contract Deliverables Requirement List (CDRL)

The CDRL submitted by the Contractor shall also include the following items:

- Single line control schematic and functional block diagrams for each subsystem, showing all values, operations, and control components.

- General control circuit interface data such as type of signal, range, circuit loading and impedance, type of transducer or pickup, and mechanical requirements.
- Graphs and curves showing response and functional characteristics of major subsystems and components.
- Documentation of analyses conducted by the Contractor, as specifically called for in these Specifications.

19.5.2 Samples and Materials Portfolio

Three (3) sets of physical samples of the materials approved for this vehicle, including, but not limited to, plastics, upholstery material, paint coupons, floor coverings, signage, and other decorative materials, shall be submitted for review and approval no less than three hundred sixty-five (365) days after NTP or as required by the Master Contract Schedule. Each sample shall be identified with the manufacturer's name, ordering reference, material specification, all locations of use on each car type, quantities per car type, and drawing reference. The samples and required data shall be submitted in a loose-leaf book format. **[CDRL 19-018]** The materials will be cut to a standard size (whenever possible) and contained in sturdy, clear plastic 8.5 inch by 11 inch holders. The holders will be collected in large 3-ring binders.

As a minimum, the samples of interior materials and paint shall include, but are not limited to:

a) Interior panels (all types, finishes and colors),

b) Carpet,

c) Rubber flooring and molding,

d) Ceiling panels,

e) Side window and wall panels,

f) Seat foam,

g) Seat upholstery,

h) Seat trim,

i) Other visible seat materials,

j) Armrest (finish),

k) Cab Console (finish),

l) Step treads, risers and nose,

m) Interior trim,

n) Stainless steel sheet,

o) Stanchions, handrails, and handholds,

p) Windows with sealing gaskets (all types),

q) Interior panel trim pieces (all types),

r) Door seals (all types),

s) Interior decals, graphics and signage (all types),

t) Lighting assemblies with diffusers,

u) Windscreens,

v) Gasket and seal materials (all types),

w) Insulation materials (thermal and acoustic), and

x) Door Hardware (latches, locks and hinges).

As a minimum, the samples of exterior materials and paint shall include, but are not limited to:

a) Window rubber extrusion and lace,

b) Exterior paint (all colors),

c) Truck paint,

d) Exterior Sheeting (unpainted surfaces),

e) Reflective tape,

f) Vehicle wrap material,

g) Exterior trim including end caps,

h) Safety appliances and steps,

i) Gasket and seal materials (all types), and

j) Exterior decals, graphics and signage (all).

The SCRRA standard set of Decals, Graphics and Signage for a trailer car is provided in Section 20. The Contractor shall provide samples of all Decals, Graphics and Signage for each vehicle type that are to be provided by the Contractor in the Samples and Materials Portfolio.

19.5.3 Production Photographs

No more than six hundred (600) days after NTP, the Contractor shall furnish two (2) sets of 8 inch by 10 inch un-mounted photographic prints, one (1) set of negatives, and electronic digital JPEG format files for each view of the car. **[CDRL 19-019]** Each photograph will bear an adhesive label, which will identify the photo by number and title. Pictures are to be taken of the cars during each step of construction and as finished assemblies. The pictures shall record the build to completion of one car of each type (Cab and Trailer). No more than three hundred sixty-five (365) days after NTP, a listing of all proposed views shall be submitted for review and approval by the Engineer. **[CDRL 19-020]**

Construction pictures shall consist of at least 200 color views showing all phases of construction, illustrating construction progress and design features, which will be hidden from view upon completion of the car. The views shall include, but are not limited to:

a) Carshell splice,

b) Floor assembly,

c) Sidewall assembly,

d) Endwall assembly,

e) Roof assembly,

f) Ceiling assembly,

g) Cab assembly,

h) Truck assembly,

i) Electrical enclosures, lockers and cabinets,

j) Equipment lockers,

k) Wiring termination,

l) Duct installation,

m) Door installation,

n) LVPS installation,

o) Toilet room installation,

p) Tank and reservoir installations waste, water, and air,

q) Lighting installations, all interior and exterior assemblies,

r) Pneumatic piping, and

s) HVAC unit installation.

At least 80 color views of both a finished trailer car and cab car showing the interior, design features, both sides and both ends of each car, exterior taken, perpendicular to the car surface, and a three-quarter view of each car type.

19.5.4 Spare Parts

The Contractor shall be responsible for developing two (2) lists of spare parts. Both spare parts lists shall include the manufacturer's name, address, e-mail/website (as applicable) part number, and description and as appropriate, the Contractor's part number. The Contractor shall notify the Engineer of any changes that affect the spare parts requirements. The Contractor shall be responsible for up-grading spare parts that were subject to modification during the Contract period.

There shall be no restriction preventing SCRRA from direct procurement of spare and replacement parts from original equipment manufacturers.

The first list developed and submitted by the Contractor shall be a list of capital spare parts adequate to support the operation of the cars. The Contractor shall assist SCRRA in the selection of capital spare parts based on maintenance requirements and design life cycle criteria. **[CDRL 19-021]**

The second list developed and submitted by the Contractor shall be a complete list of consumable spare parts that will be necessary for SCRRA to operate the cars for a period of two (2) years from date of acceptance of the first car. **[CDRL 19-022]**

19.6 EQUIPMENT SERIALIZATION PROGRAM

The Contractor shall furnish a comprehensive Asset Identification System in compliance with SCRRA Bar Code practice. Duplicate serial numbers shall not be utilized within a type or model series. At a minimum the list of serialized components shall include all items listed in the FAI list of Section 1.9.7. Reference Section 20.5 for bar coding requirements.

19.7 CAR HISTORY BOOKS

The Contractor shall provide SCRRA with a Car History Book for each car, as a hardcopy and in an SCRRA approved electronic media, at the time of acceptance. **[CDRL 19-023]** Prior to delivery of the Pilot cars, the Contractor shall provide SCRRA with a draft copy of the proposed Car History Book format and contents for review and approval. **[CDRL 19-024]** The Car History Book shall provide a record of tests, measurements, analysis and procedures performed on that specific car as well as the origin and identity of major components. As such, forms and records included in the book should contain signatures and certifications where appropriate.

Each Car's History Book shall accompany the car through manufacture and acceptance. The contents of the book shall be originals. After acceptance of the car, the book and an up-to-date electronic version shall be submitted to SCRRA within fourteen (14) days.

The books cover/binder and all external labels shall be waterproof. The cover/binding shall accommodate and protect 8.5 inch by 11 inch pages and match the thickness of its contents. Pages must be arranged so that photo-copying can be accomplished without compromising the integrity of the documents and/or bindings.

19.7.1 Car History Book Contents

Each Car History Book shall contain the following general information:

- SCRRA Contract number and description.
- A title page with the name of the project managers of the Contractor and SCRRA; in addition to key managerial personnel of both the Contractor and SCRRA.
- A signature key page with designated blocks for printed name, signature, company affiliation, and identification number (if any) for each person given authority to sign any certifications (test, measurements, releases, etc.) in the books.
- A table of contents (Pre-shipments and post-shipments sections shall be separate from any other sections).

Each Car History Book shall contain, but is not limited to, the following car-specific information:

- Car Number (Contractor Number and SCRRA Road Number), type, and class.
- Certified weight, including scale tickets with car number and date. Weights shall include independent weight of each equipped truck as well as the entire car.
- Acceptance Certificates. The acceptance (conditional) certification shall include a clause stipulating that SCRRA signatories accepting the car have verified that all documentation in the Car History Book is complete with affixed signatures and certifications, as required.
- Description of modifications and completion dates of incorporation.
- A record of any abnormalities that occurred during the manufacture of the car or its subsystems (including assemblies such as the truck or HVAC system, etc), including their authorized repair procedures and quality control approval of work performed.
- Serial numbers of all trucks, wheels, axles, cab equipment, and all other serial numbered apparatus.
- List of software configuration of the car at the time of acceptance. The list shall include the name of the software, a brief description of the programs purpose (e.g. wheel slide monitoring), the system(s) the software operates on/controls, the software author or provider, software version and last revision date.
- Shipping documents. The release to ship certification shall include a clause stipulating the car has been verified as Contract compliance and that all documentation in the Car History Book is complete, with affixed signatures and certificates, as required. The release to ship certification shall be signed by the approved Contractor's representative and SCRRA designee releasing the car.
- Summary detail of each test and formal inspection performed on the complete vehicle or any part thereof with signatures where appropriate. This documentation shall include tests, measurements and inspections performed during manufacture, acceptance and warranty.

- Written report of each test performed on the car and its apparatus per Section 17.
- Wheels, axles, journal bearings, and gear mounting records (including pressing charts).
- Heat Numbers and Mill Reports for Wheels and Axles.
- Mill Reports for Other Material.
- Main Reservoir Certificates.
- Duplicate FRA F 6180-49A Forms for Cab Cars.
- All approved Contract changes, Engineering changes, and deviations incorporated into the car which are not incorporated on all cars.
- All modifications to the car not incorporated on all cars.
- List of all MRB repairs applying to the car.
- Car dimension record sheets.
- While the Technical Specification does not allow the use of hazardous material, if it is determined that potentially hazardous material has been incorporated into the car, a record of such material and its location shall be maintained in the Car History Book, including a record of any subsequent removal.
- Provisions for recording inspection, servicing and major overhaul events.
- Any other information required by the Specification to be in the Car History Book.

The Car History Books shall be kept up-to-date by the Contractor and shall record all changes, retrofits, and additions made to each car until each car has been accepted by SCRRA. Documentation on changes made to cars by the Contractor during the warranty period shall be furnished to SCRRA (in print) for inclusion in the Car History Book.

19.7.2 Serial Numbers

The Contractor shall furnish the Engineer with a record of the serial numbers for all major components as approved by the Engineer on all cars as delivered. **[CDRL 19-025]** Serial numbers shall be included in the Car History Book. The Contractor shall also submit:

- A list of the serial numbers by system and components for each system and component as listed in Section 1.9 and Section 16. **[CDRL 19-026]**
- A list, by car number, of the serial numbers of systems and components on each car. **[CDRL 19-027]**

End of Section

Contract Data Requirement List

CDRL No.	Title	Car Type	Reference Paragraph
19-001	Contractor Project Manager	All	19.1.2
19-002	Management Plan	All	19.1.4.2
19-003	Submittal Review Plan	All	19.1.4.3
19-004	Weight Control and Weight Balance Plan	All	19.1.4.4
19-005	Final Weight Balance and Placement of Equipment	All	19.1.4.4
19-006	Monthly Progress Reports	All	19.1.5
19-007	List of Drawing, Document and Data Software	All	19.2.2
19-008	Indexed Drawing Database Uploaded to Project Extranet Continuously	All	19.2.3
19-009	Indexed Drawing Database with Full Functionality	All	19.2.3
19-010	Engineering Change Status Report, as part of Monthly Progress Report	All	19.3
19-011	As-built Drawings	All	19.3.1
19-012	Drawings Requiring Approval	All	19.3.2
19-013	Post-delivery and Warranty Drawing Support	All	19.3.3
19-014	Design Requirements and Traceability Report	All	19.4.2
19-015	Design Concept Drawings	All	19.4.3
19-016	System Functional Descriptions and Vehicle Design Concept Report	All	19.4.3
19-017	Agenda and Data Package for Design Review Meetings	All	19.4.4
19-018	Samples and Materials Portfolio	All	19.5.7
19-019	Photographic Prints, Negative, and Digital JPEG Format File for Each Car View	All	19.5.8.1
19-020	List of All Proposed Car Views	All	19.5.8.1

CDRL No.	Title	Car Type	Reference Paragraph
19-021	List of Capital Spare Parts	All	19.5.4
19-022	List of Consumable Spare Parts	All	19.5.4
19-023	Car History Books	All	19.7
19-024	Draft Car History Book format and contents	All	19.7
19-025	Record of Serial Numbers for All Major Components	All	19.7.2
19-026	List of Serial Numbers by System and Components for Each System and Component	All	19.7.2
19-027	List by Car Number of Serial Numbers of Systems and Components	All	19.7.2