Governments
SANBAG
Working Together

San Bernardino Associated Governments
1170 W. 3rd Street, 2nd Floor San Bernardino, CA 92410-1715
Phone: (909) 884-8276 Fax: (909) 885-4407 Web: www.sanbag.ca.gov

TRANSPORTATION MEASURE I

■ San Bernardino County Transportation Commission ■ San Bernardino County Transportation Authority
■ San Bernardino County Congestion Management Agency ■ Service Authority for Freeway Emergencies

Support Material Agenda Item No. 34

Board of Directors Meeting

July 6, 2016

10:30 a.m.

Location
San Bernardino Associated Governments
Santa Fe Depot - First Floor Lobby
1170 W. 3rd Street, San Bernardino, California 92410

Discussion Calendar

Transit

34. Redlands Passenger Rail Project - Procurement of Diesel Multiple Unit Rail Vehicles

That the Board, acting as the San Bernardino County Transportation Commission:

A. Make a finding by at least a two-thirds vote that the procurement of the Diesel Multiple Unit rail vehicles for the Redlands Passenger Rail Project qualifies to be conducted through competitive negotiation under Section 130238 of the California Public Utilities Code.

B. Approve the release of Request for Proposals No. 16-1001531 for the procurement of Redlands Passenger Rail Project Diesel Multiple Unit rail vehicles.

C. If only a single response to the request for proposals is received, delegate authority to the Executive Director or his designee to determine and make a finding, if appropriate, that the Commission made every effort to generate the maximum feasible number of proposals from qualified sources, before proceeding to negotiate with the sole proposer.

Full draft Technical Specification for procurement of Diesel Multiple Unit Passenger Vehicles for future rail service between San Bernardino and Redlands is attached.

SANBAG

DMU Passenger Vehicles

Technical Specification
Draft

April 28, 2016

Table of Contents

1.0 INTRODUCTION

1.1 GENERAL

These technical provisions define the design parameters and functional requirements for the DMUs solicited in this RFP.

All system and component designs submitted shall be service-proven and shall have successful documented operating histories and life-cycle cost information.

Technical information provided by SANBAG shall be for the Contractor's guidance and shall not be understood to be necessarily accurate and factual. The Contractor shall verify, inspect, test, or otherwise check the accuracy of information provided by SANBAG as necessary to ensure compliance.

This document's use of the words "must," "shall," "directed," "required," "ordered," and "designated," or similar words, shall be understood to mean that these are requirements of SANBAG, unless otherwise expressly stated. Any alternative to such items must be submitted for SANBAG's formal approval prior to its use.

When referring to SANBAG, this document's use of the words "approved by," "accepted by," or "satisfactory to," or similar words, shall be understood to mean that the item in question was considered acceptable at the time of submittal. Any approval or acceptance SANBAG gives under the Contract shall not relieve the Contractor of its full responsibility for compliance with all Contract Documents and requirements.

The reference standards listed at the beginning of each section are provided for convenience. It is the responsibility of the Contractor to implement all applicable standards.

1.2 ACRONYMS AND DEFINITIONS

The following acronyms and abbreviations appear in this document, defined as indicated:

AA	Aluminum Association
AAR	Association of American Railroads
AATCC	American Association of Textile Chemists and Colorists
ABS	automatic block signals
AC	alternating current
ADA	Americans with Disabilities Act
ADU	aspect display unit
ABMA	American Bearing Manufacturers Association
AFI	Air Filter Institute
AFO	audio frequency overlay
AISI	American Iron and Steel Institute
AMCA	Air Movement and Control Association
AN	Aeronautical and Navy
ANSI	American National Standards Institute
AOQL	average outgoing quality levels
APA	APA-Engineered Wood Association

APC	automatic passenger counting
APS	auxiliary power supply
APTA	American Public Transportation Association
AQL	acceptable quality level
AREA	American Railway Engineering Association
AREMA	American Railway Engineering and Maintenance Association
ASCII	American Standard Code for Information Interchange
ASHRAE	American Society of Heating, Refrigeration, and Air Conditioning Engineers
ASIC	application-specific integrated circuit
ASME	American Society of Mechanical Engineers
ASNT	American Society of Nondestructive Testing
ASTD	American Society for Training and Development
ASTM	American Society for Testing and Materials
ATA	Air Transport Association of America
ATO	automatic train operation
ATP	automatic train protection
ATS	automatic train supervision
AVAS	automatic voice announcement system
AVT	Alternate Vehicle Technology, see also ETF
AWG	American wire gauge
AWS	American Welding Society
BAFO	Best and Final Offer
BHP	brake horsepower
BLS	Bureau of Labor Statistics
BOM	bill of materials
CBTC	communications-based train control
CCH	communications control head
CCTV	closed-circuit television
CCU	communications control unit
CDA	Copper Development Association
CDRL	Contract Data Requirements List
CDU	central diagnostic unit
CEM	crash energy management
CFFA	Chemical Fabrics and Film Association
cfm	cubic feet per minute
CFR	Code of Federal Regulations

CM	corrective maintenance
C of C	certification of compliance
CPLD	complex programmable logic device
CRC	cyclic redundancy check
CWI	certified welding inspector
CWR	continuously welded rail
DB	dry bulb
dBA	decibel
DBE	disadvantaged business enterprise
DC	direct current
DIN	Deutsche Industrie Norm (German industrial standard)
DMU	Diesel Multiple Unit
DOT	[United States] Department of Transportation
DR	design review
DTE	diagnostic and test equipment
DTEM	diagnostic test equipment manual
DVCS	digital vehicle communication system
DVR	digital video recorder
EB	emergency brake
ECP	engineering change proposal
ECU	electronic control unit
EEPROM	electrically erasable programmable read-only memory
EER	energy efficiency ratio
EHU	electro-hydraulic unit
EIA	Electronic Industries Association
EMC	electromagnetic compatibility
EMI	electromagnetic interference
EN	European Standards
EPA	Environmental Protection Agency
EPDM	ethylene propylene diene monomer
EPROM	electrically programmable read-only memory
ETF	Engineering Task Force
FAA	Federal Aviation Administration
FAI	First Article Inspection
FAR	Federal Aviation Regulation
FCC	Federal Communications Commission

FDR	final design review
FEA	finite element analysis
FED	federal
FMECA	failure mode effect and criticality analysis
FMVSS	Federal Motor Vehicle Safety Standards
FPGA	field programmable gate array
FRA	Federal Railroad Administration
FRP	fiberglass-reinforced plastic
FSB	full service brake
FTA	Federal Transit Administration
GEBR	guaranteed emergency brake rate
GFCI	ground fault circuit interrupter
GFI	ground fault interrupter
GPS	global positioning system
HAZ	heat-affected zone
HPCU	hydraulic pressure control unit
HRC	Rockwell C hardness
HRM	Heavy Repair and Overhaul Manual
HSCB	high-speed circuit breaker
HV	hardness Vickers
HVAC	heating, ventilation, and air conditioning
HVDC	high-voltage direct current
Hz	hertz
ICD	interface control document
ICEA	Insulated Cable Engineers Association
ID	identification
IDR	intermediate design review
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IFI	Industrial Fasteners Institute
IGBT	insulated gate bipolar transistor
I/O	input/output
IP	internet protocol
IPC	illustrated parts catalog
IPCEA	Insulated Power Cable Engineers Association
IS	integrated schematic

ISD	Instructional Systems Design
ISO	International Organization for Standards
JEDEC	Joint Electron Device Engineering Council
JIC	Joint Industrial Council
KHz	kilohertz
ksi	kilopounds per square inch
kW	kilowatt
LAHT	low-alloy, high tensile strength (steel)
LED	light-emitting diode
LLRU	lowest level replacement unit
LRU	line replaceable unit
L/V	lateral to vertical force
LVDC	low-voltage direct current
LVDN	low-voltage distribution network
LVPS	low-voltage power supply
MCWB	mean coincident wet bulb
MDBF	mean distance between failures
MDBCF	mean distance between component failures
MDBSF	mean distance between service failures
MDBTD	mean distance between train delays
MDS	monitoring and diagnostic system
MHz	megahertz
MIL	Military Specification
mm	millimeter
MMIS	Maintenance Management Information System
Mohm	megaohm
mph	miles per hour
MRB	Material Review Board
MRSS	maximum revenue service speed
ms	milliseconds
MSB	maximum service brake
MSDS	material safety data sheet
MSS	Manufacturers Standardization Society of the Valve and Fittings Industry
mT	millitesla
MTBCF	mean time between component failures
MTBF	mean time between failures

MTTR	mean time to repair
mV	millivolts
NAL	net axle lateral
NDT	non-destructive testing
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NESC	National Electrical Safety Code
NFL	no field lubrication
NFPA	National Fire Protection Association
NIST	National Institute of Standards and Technology
NTP	notice to proceed
OCC	operations control center
OEM	original equipment manufacturer
OHDS	overhead heat duct sensor
OSHA	Occupational Safety and Health Administration [U.S. Department of Labor]
OSI	Open System Interconnection
P&ID	piping and instrumentation diagram
PA	public address
PC	personal computer
PCB	printed circuit board
PDR	preliminary design review
PEI	passenger emergency intercom
PF	power frequency
PIS	passenger information system
PIV	peak inverse voltage
PM	preventive maintenance
psi	pounds per square inch
psig	pounds per square inch gage
PT	pressure transducer
PTC	positive train control
PTE	portable test equipment
PTFE	polytetrafluoroethylene
PTU	portable test unit
PQR	Procedure Qualifications Record
PVB	polyvinyl butyral
PVC	polyvinyl chloride

PWM	pulse width modulated
QA	quality assurance
RC	resistor-capacitor
RDP	Reliability Demonstration Plan
RF	radio frequency
RFP	Request for Proposal
RMM	Running Maintenance Manual
RMS	root mean square
rpm	revolutions per minute
RTM	requirements traceability matrix
SAE	Society of Automotive Engineers
SANBAG	San Bernardino Associated Governments
SCQ	sub-critical quench
SIC	Standard Industrial Classification [U.S. Department of Labor]
SMD	surface-mounted devices
SPL	sound pressure level
SPMP	Software Project Management Plan
SQAP	Software Quality Assurance Plan
SQC	statistical quality control
SRTM	software requirements traceability matrix
SSP	system safety program
SSPP	system safety program plan
SUM	software user manual
SVD	software version description
t	time
TC	train control
TEFC	totally enclosed fan cooled
TFE	tetraflourethylene
TIG	tungsten inert gas
TIR	total indicator reading
TNC	train network controller
TP	technical provision
TOD	train Operator’s display
TOR	top of rail
TS	Technical Specification
TTW	train to wayside

TWC	train-to-wayside communications
TXV	thermal expansion valve
UDP	User Datagram Protocol
UL	Underwriters Laboratories, Inc.
UMTA	Urban Mass Transportation Administration (now FTA)
UN	Unified National (thread standard)
UNR	Unified National Radius
UV	ultraviolet
v	velocity
V	volt
V&V	verification and validation
VAC	volts of alternating current
VDC	volts of direct current
VMM	Virtual Machine Manager
VNC	vehicle network controller
VOD	vehicle Operator display
VPI	vacuum pressure impregnation
VSWR	voltage standing wave ratio
VVVF	variable voltage, variable frequency
WB	wet bulb
WBE	women's business enterprise
WLAN	wireless local area network
WPS	welding procedure specifications

1.3 DEFINITIONS

The terms defined below may appear in this document.

active cab: The controlling vehicle cab in a train.

ADA: Americans with Disabilities Act; specifically, 49 CFR, Part 38, Accessibility Specifications for Transportation Vehicles.

adhesion, coefficient of: During rolling contact, the ratio between the tangential force at the wheel-rail interface and normal force.

Alteration: A change or substitution in the form, character, or detail of the Work done or to be done within the original scope of the Contract.

Approval: Acceptance in writing by SANBAG.

Approved or Approved Type: Design, type material, procedure, or method given approval by SANBAG.

assembly: A collection of subassemblies and components typically performing a variety of functions within the context of a larger system, for example trucks, electronic control units, and air compressors.

Authority: The purchaser and end user of the DMU vehicle.

auxiliary equipment: Any mechanism or structure other than the vehicle body, traction motor, or propulsion equipment gearing that performs a function at any time during the operation of the DMU, such as the heating and cooling subsystem, pumps, auxiliary inverter, vehicle door mechanism, air compressor, or vehicle lighting.

auxiliary power: Vehicle-sourced electrical power, other than traction power.

average brake rate (v/t): The velocity (v) at which brake force (as measured by motor current or brake cylinder pressure) has ramped up to its full service level, divided by the elapsed time (t) required to go from that speed to a lower speed.

average deceleration rate: The ratio between the vehicle speed at which braking effort achieves the commanded value and the elapsed time from that occurrence to zero vehicle speed. The elapsed time does not include braking effort buildup time during jerk limiting and does not include Operator reaction time or allowable dead time.

AW0: Weight of empty ready-to-run vehicle.

AW1: AW0 plus full seated load, including crew.

AW2: AW1 plus standees at four passengers/m^2.

AW3: AW1 plus standees at six passengers/m^2.

AW4: AW1 plus standees at eight passengers/m^2.

blending: In braking, the simultaneous control of dynamic (rheostatic and regenerative) and friction braking, with the effort of each continuously proportioned to achieve the required total braking effort.

braking effort: Retarding force developed by the propulsion subsystem, braking subsystem, or a combination of both subsystems.

bridge plate (or platform bridging device): A device that bridges the gap between the passenger platform and vehicle floor to provide ADA level-boarding compliance.

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

car: A section of a vehicle or unit that consists of a separate car shell and associated systems.

coast: The mode of operation in which no propulsion (positive traction) or braking effort is in effect, except for normal drive train losses.

compatibility: The condition in which vehicle performance and control are operationally identical between two or more vehicles. Compatibility will allow multiple vehicles to couple together, with control of systems on all vehicles being affected by any lead vehicle of the consist.

consist: Two or more vehicles or units coupled together.

console: The control panel located in the cab of a vehicle directly in front of the Operator's seat.

Contract Drawings: Drawings provided by SANBAG as part of this procurement.

Contractor's Drawings: Items such as general drawings, detail drawings, graphs, diagrams, sketches, calculations, and catalog cuts prepared by the Contractor for use in its manufacturing facility, assembly facility, or shop to fabricate, assemble, and install parts of the vehicle, whether manufactured by it from raw materials or purchased from others in a ready-to-use condition.

coupler: A device for mechanically coupling vehicles together. This term is also applied to connectors, as in "electric coupler" and "pneumatic coupler."

Critical Material: All material that might pose a hazard to passengers or maintenance personnel.

critical path: In a production schedule, a sequence of stages toward the achievement of a final task that accounts for all other tasks that must be completed to accomplish the final task.

Days, Working: Those calendar days during which regular business is conducted, excluding Saturdays and Sundays and all federal, state, and municipal holidays that are observed by SANBAG during the duration of the Contract.

deadman feature: A device designed to detect a lack of attention or disability of an Operator and to automatically apply braking when it detects such lack of attention or disability.

design life: The period of time for which the vehicle is intended to be safely and reliably usable for its original purpose.

draft gear: The resilient portion of the coupler device that cushions buff and draft forces transmitted between coupled vehicles.

dwell: The period of time from the instant a train stops at a station until the instant the train resumes moving.

dynamic braking: Braking that is not part of the friction braking system and is instead produced by the propulsion system.

electric braking: A type of dynamic braking in which the power generated by the traction motors, when driven as generators, is either regenerative or dissipated in resistor banks.

emergency stop: The bringing of a vehicle or train to a halt by applying the emergency brake (EB). Once initiated, the emergency brake application cannot be released until the vehicle or train has stopped.

equal: Providing the same function, performance, and reliability.

fail-safe: A design principle of a system or hardware configuration that ensures that a failure shall not result in an unsafe condition.

Failure: A condition in which equipment does not function as specified, designed, or expected.

Failure, Service: Any failure that prevents a vehicle from being placed into service or from completing a trip as scheduled.

failure rate: The frequency of failure, expressed as failures per hour or failures per mile; the mathematical reciprocal of mean time between failures (MTBF) or mean distance between failures (MDBF).

First Article: The first item produced that conforms and defines all subsequent production items. First Articles are intended for review by SANBAG.

form, fit, and function: The physical attributes of a device that allow the device to be used in place of another device due to similarities of general shape (outline, clearances), mounting arrangement (footprint), and operation (inputs/outputs) of the device.

full service braking: The maximum braking effort employed to stop a vehicle in the absence of an emergency stop signal.

gauge, track: The distance between the inside face of rails, usually measured 5/8 inch below the top of the centerline of heads of running rails and at a right angle thereto.

Guard: An individual on board who may assist the Operator with some vehicle and train operations.

headway: The time separation between two trains, both traveling in the same direction on the same track; measured from the time the front end of the leading train passes a given reference point to the time the front end of the train immediately following passes the same reference point.

indicated: As presented in this document.

inspector: The person or firm designated by SANBAG as its quality control representative.

interface: The points where two or more systems, subsystems, or structures meet, transfer energy, or transfer information.

interlock: A condition whereby one function depends on the operation of another function.

irretrievable: Describes an application of the brakes that cannot be released until the train is at zero speed.

jerk: Time rate of change of acceleration and deceleration, equal to the second derivative of velocity.

lead vehicle: In the direction of travel, the forward-most vehicle of the train.

light: The transparent portion of a window.

line replaceable unit (LRU): A component of a system that, when failed or in need of repair, is intended to be exchanged and repaired off of the vehicle. The exchange, including removal of one component and installation of its replacement, is designed to be accomplished within one working shift.

liner (as in interior liner): The visible covering material for the walls, ceiling, and other interior surfaces of the vehicle.

load weighing: The measurement of total passenger weight for the purpose of adjusting tractive effort to produce a constant acceleration or braking rate.

maintainability: The degree to which any system or equipment can be rapidly, easily, effectively, and properly maintained.

manufacturer: The builder or producer supplying materials, equipment, or apparatuses for installation on the vehicle.

mask, window: Interior liner that surrounds the windows, often molded to include the sill and other portions of the sash.

mean distance between failures (MDBF): The mean operating mileage between independent failures.

mean distance between component failures (MDBCF): The mean operating mileage between independent failures of a component.

mean distance between service failures (MDBSF): The mean operating mileage between independent service failures.

mean distance between train delays (MDBTD): The mean operating mileage between train delays caused by equipment or system failures.

mean time between failures (MTBF): The mean operating time between independent failures.

no motion: The vehicle speed at or below the lowest speed detectable by the vehicle control systems.

Operator: The individual on board who is responsible for the vehicle and train operation.

part: See *component*.

performance: The measure of output or results obtained by a component, system, person, team, or the like, as specified in the Contract Documents.

primary power: The unconditioned electric power that enters the propulsion system from an onboard power source.

procurement: The furnishing of all the items, materials, equipment, data, design, services, management, labor, and incidentals specified or otherwise necessary for, in a proper and timely

fashion, designing, manufacturing, delivering, and testing the DMUs or otherwise completing the Work.

proof (used as a suffix): As in splash proof, dustproof. The device and contents are impervious to, or unharmed by, application of the indicated material.

railroad: Owner and/or operator of the right-of-way used for commuter rail service.

recovery time: The time required for a system or condition to return to its original state (or some stated percentage of its original value) after being disrupted or destabilized.

redundancy: The existence in a system of more than one means of accomplishing a given function.

regenerative braking: Electric braking in which the power generated by the traction motors, when driven as generators or alternators, is conditioned and returned to the contact line or onboard energy storage.

reliability: The probability of performing a specified function without failure and within design parameters for the period of time indicated.

revenue service: The provision of transportation services to SANBAG's customers.

service: As in service use, service braking. The operation of the vehicles under normal conditions.

service-proven design: Any component, system, or subsystem that has a proven history of successful operation in revenue service similar to that of SANBAG's commuter rail system. Proof of successful operation shall be substantiated by submission of reliability/failure data, service time and location, modification information, and maintenance records as required by the Contract Documents.

slide, wheel: During braking, the condition during which the rotational speed of the wheel is less than that for pure rolling contact between tread and rail.

slip, wheel: While tractive effort is applied, the condition during which the rotational speed of the wheel is greater than that of pure rolling contact between tread and rail.

spare parts: Components supplied by the Contractor to SANBAG intended for use in maintenance or repair of vehicles.

speed, balancing: The speed attained by the vehicle or train when resisting forces exactly equal to applied tractive forces.

speed, base: The speed at which the maximum constant acceleration can be maintained at the rated propulsion system output.

speed, schedule: The average speed of a vehicle or train, from terminal to terminal, obtained by dividing the distance between these points by the time taken to make the trip including time for intermediate station stops.

spin, wheel: See *slip, wheel*.

start-up spare parts: Spare parts provided by the Contractor to support the DMUs first delivered to SANBAG.

stop, emergency: The bringing of a vehicle or train to a halt by applying the emergency brake (EB).

stop, service: The bringing of a vehicle or train to a halt by applying the service brake.

subassembly: A collection of components used to perform a distinct function, usually in conjunction with other subassemblies and components, as part of a larger system. Subassemblies are usually replaceable as units and include items such as circuit boards, bearings, and valves.

superelevation: On a curve, the vertical distance, measured in millimeters (or inches) between the (higher) outer rail and the inner rail.

Technical Provision (Technical Specification): Specific requirements setting forth the descriptions of elements of the Work to be performed or supplied; the quality of required labor, material, and equipment; and the method of measurement and payment for the identified elements of the Work.

Technical Specification: See *Technical Provision*.

tight (used as a suffix): As in watertight, airtight. Enclosed or protected as to completely exclude the indicated material from passage.

time constant: Slope of curve in units of controlled variable per unit of time, measured during the buildup time interval.

time, buildup: In response to a step-forcing function, the time interval from ten percent (10%) of the total change in value to the attainment of ninety percent (90%) of the total change in value of the controlled variable. Build-up time is equal to response time minus dead time.

time, dead (also time, reaction): Time from the occurrence of a step change of the control signal to the attainment of ten percent (10%) of the total change in value of the controlled variable.

time, down: The time during which equipment is not capable of doing useful work because of maladjustment, malfunction, or maintenance in progress.

time, response: Time from the occurrence of a step change of control signal to the attainment of ninety percent (90%) of the total change in value of the controlled variable.

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

traction system: The system of wheels, motors, gears, brakes, direct controls and appurtenances that propels or retards a vehicle in response to control signals.

tractive effort: The horizontal force that is measured at the wheel-rail interface.

train: Any number of units coupled together and moving as one.

trainline: The means of sending a signal to all vehicles in a consist through a continuous electrical or pneumatic circuit connected through appropriate coupling devices.

tram: Short form referring to trammel point inspection of truck frames for squareness. “in tram” is the condition of ideal truck geometry in which the axles are perfectly parallel and the wheels longitudinally in perfect alignment. The centers of the journal bearings represent the corners of a perfect rectangle. Verification that a truck is in tram is determined by measuring the diagonal and longitudinal distance between reference points on the axle bearing housings.

unit: The single operating unit, which may consist of one or more sections or cars.

vehicle: see *unit*.

vehicle, low floor: A vehicle with a partial or full low floor area, as described by this Specification.

wainscot: The lower portion of a wall, especially if finished differently than the upper portion.

warm-up time: The elapsed time from application of power to an operable device until it is capable of performing its intended function.

warp, track: The vertical distance between the plane of any three of four rail head contact points (two on each rail) forming a rectangle and the remaining point.

1.4 DESCRIPTION OF WORK

The Work shall include the designing, manufacturing, testing, furnishing, delivery, and performance testing of DMUs. The Work shall also include delivery of data, manuals, drawings, training and support services, spare parts, special tools, and test equipment, which shall be delivered as specified in the Contract

Documents. Deviations from these requirements are permitted only with specific approval of SANBAG. The Contractor is responsible for the design and integration of all vehicle systems such that all specified requirements are achieved without conflict or error within or between systems. It shall be the Contractor's responsibility to see that all managers, engineers, designers, Suppliers, and Subcontractors are informed of all specified requirements and that appropriate engineering management tools are used so that coordination and communication occurs between the designers of interrelated systems.

The Contractor is responsible for the selection, application, and integration of equipment and materials as necessary to conform to specified requirements. All equipment provided under the Contract shall be new. Rebuilt or refurbished equipment is prohibited. New equipment damaged during execution of the Contract may be restored to new condition only where approved by SANBAG on a case-by-case basis, and all restorations shall be performed by the original equipment manufacturer. The Contractor shall review the Contract Documents in their entirety. The Contractor is advised that all drawings and exhibits furnished as part of the Contract Documents are provided as illustrations for reference only.

1.5 INFRASTRUCTURE DESCRIPTION

The vehicle shall operate safely on the infrastructure used by SANBAG. The characteristics of this infrastructure are provided in Section TP 2.0, Design and Performance Criteria. In addition, the Contractor shall be responsible for becoming familiar with the SANBAG system. SANBAG will make available for review existing information upon request at a mutually convenient time and place.

1.5.1 Performance

The vehicle shall meet the performance requirements of SANBAG, which are contained in TP 2.0, Design and Performance Criteria. The Contractor's test plan shall include elements that demonstrate the ability of the vehicle to meet the performance requirements of SANBAG.

1.6 INDUSTRIAL DESIGNER/HUMAN ENGINEERING

1.6.1 The Contractor shall use industrial design services to guide the vehicle design during the design and manufacturing phases of the Contract so that the design of the individual elements of the vehicle combine to form a uniform image.

1.6.2 The Contractor, with the aid of the industrial designer, shall emphasize safety, human factors (ergonomics), aesthetics, manufacturability, maintainability, and cost considerations when developing the design of the vehicle.

1.6.3 Industrial design services shall include, but not be limited to:

a. Vehicle interior and exterior aesthetics

b. Cab equipment arrangement and Operator's console

c. Selection, presentation, and integration of materials, colors, and finishes

d. Human factors (ergonomics)

e. Evaluation of ADA compliance

f. Interior and exterior markings and signage

g. Maintenance accessibility

h. Concept sketches and full color renderings

1.6.4 The vehicle design shall consider the human-factors engineering relevant to anthropometric data on the U.S. adult population and be based on human factors engineering, with the range of people being from the 5th percentile female to the 95th percentile male as defined by "The Measure of Man and Woman," revised edition.

1.7 DELIVERABLES

None

END OF SECTION

2.0 DESIGN AND PERFORMANCE CRITERIA

2.1 CITED REFERENCES

40 CFR Part 1039	Control of Emissions from New and In-Use Nonroad Compression-Ignition Engines
49 CFR Part 38	Americans with Disabilities Act: Accessibility Specifications for Transport Vehicles
49 CFR Part 213	Track Safety Standards
49 CFR Part 229	Railroad Locomotive Safety Standards
49 CFR Part 231	Railroad Safety Appliance Standards
49 CFR Part 238	Passenger Equipment Safety Standards
49 CFR Section 239.101	Emergency Preparedness Plan
ANSI S1.4	American National Standard Specification for Sound Level Meters
ANSI S1.6	American National Standard Preferred Frequencies, Frequency Levels, and Band Numbers for Acoustical Measurements
ANSI S1.11	American National Standard Specification for Octave-Band and Fractional-Octave-Band Analog and Digital Filters
ANSI S1.13	American National Standard Measurement of Sound Pressure Levels in Air
APTA	Manual of Standards and Recommended Practices for Passenger Rail Equipment
EN 50155	Electronic Equipment Used on Rolling Stock
FRA	*Technical Criteria and Procedures for Evaluating the Crashworthiness and Occupant Protection Performance of Alternatively Designed Passenger Rail Equipment in Tier 1 Service* (ETF1)
FRA MP & E 98-14	Safety Appliance Securement
FTA-VA-90-1003-06	Transit Noise and Vibration Impact Assessment
IEC 61373	Railway applications – Rolling stock equipment – Shock and vibration tests
ISO 2631-1	Evaluation of Human Exposure to Whole Body Vibration – Part 1: General Requirements
ISO 3095	Acoustics: Measurement of Noise Emitted by Rail-bound Vehicles
ISO 3381	Acoustics: Measurement of Noise inside Rail-bound Vehicles
MIL-STD-461A	Electromagnetic Interference Characteristics
UMTA-MA-06-0153-85-6	Conductive Interference in Rapid Transit Signaling Systems, Volume II: Suggested Test Procedures, 85-6, Method RT/CE02A, Conductive Emission Test, Vehicle
UMTA-MA-06-0153-85-8	Inductive Interference in Rapid Transit Signaling Systems, Volume II: Suggested Test Procedures

UMTA-MA-06-0153-85-11 Radiated Interference in Rapid Transit Systems, Volume II: Suggested Test Procedures

2.2 GENERAL

2.2.1 SANBAG is developing a rail transit system; the route will be a 8.9-mile commuter rail system with sidings and station platforms that originates at the Downtown San Bernardino Transit Center and terminates at University of Redlands campus. This line consists of 4 new stations. The stations are envisioned as being able to accommodate two DMU vehicles and be compliant with the requirements of the Americans with Disabilities Act (ADA). One or more of the stations may also accommodate Metrolink services. The passenger equipment to be procured will be DMU vehicles with a capacity to carry at least 150 passengers in each unit. The passenger load includes both seated and standing riders.

2.2.2 The DMU vehicles shall be of a modular design, permitting the addition of non-cab middle cars to the base DMU to increase the passenger-carrying capacity of the vehicles. The expanded DMU vehicle shall be capable of meeting the performance requirements outlined in Section TP 2.14, Performance Requirements.

2.2.3 The passenger equipment shall be designed to comply with the requirements of the most recent (at the time of Final Proposal submission) version of the applicable requirements of 49 CFR Part 229 and of 49 CFR Part 238 Subparts B – Safety Planning and General Requirements, and C – Specific Requirements for Tier I Passenger Equipment, as well as APTA's *Manual of Standards and Recommended Practices for Passenger Rail Equipment*. In addition, the Contractor is responsible for identifying and complying with all relevant federal, state, and local requirements even if not specifically listed in this document. Waivers may be obtained as required for selected equipment.

2.2.4 The vehicle shall be equipped with all applicable safety appliances required by 49 CFR Part 231. Safety appliance attachment to the vehicle shall be in compliance with FRA MP & E 98-14. This vehicle, as constructed, manufactured, assembled, and delivered shall fully conform to all provisions of those requirements unless otherwise specified in these Technical Provisions and shall be furnished with components, materials, equipment, and systems that comply fully with those requirements.

2.2.5 SANBAG has a strong preference for a vehicle structure that features a crash energy management (CEM) design. If this design does not meet the FRA Tier I crashworthiness and occupant protection standards, including the compressive (buff) strength requirements set forth in 49 CFR Section 238.203, the Contractor shall work with SANBAG to submit a waiver request to the FRA regarding these requirements. The waiver request will follow the format and requirements outlined in FRA's *Technical Criteria and Procedures for Evaluating the Crashworthiness and Occupant Protection Performance of Alternatively Designed Passenger Rail Equipment for Use in Tier I Service* report (ETF1). The Contractor shall demonstrate that it has the capability to perform the necessary analysis, testing, and other tasks required to successfully complete the waiver process.

2.2.6 The Contractor shall provide for each car the onboard emergency equipment listed in 49 CFR Section 239.101(6)(i), (ii), and (iii). The Contractor shall propose a suitable enclosure and mounting location for such equipment for SANBAG's approval **[CDRL 2-1].**

2.2.7 The Contractor shall supply and install passenger emergency instructions in each car that, at a minimum, meet the requirements of 49 CFR Section 239.101 (7) (ii). The Contractor shall submit a proposal detailing the appearance and location of each passenger emergency information sign or decal for SANBAG's approval **[CDRL 2-2]**.

2.2.8 The passenger vehicle and its systems shall be designed and manufactured to comply with the requirements of 49 CFR Part 38 Subpart E.

2.2.9 The Contractor may propose alternative standards besides the ones listed in this specification. Requests to apply any alternative standard shall be accompanied by a narrative comparing both standards, and citing justification indicating the substitution's equivalency.

2.2.10 The vehicles and trains shall be capable of unrestricted bi-directional operation within the performance limits provided in these Technical Provisions.

2.2.11 Automatic mechanical, pneumatic, and electrical couplers shall be provided at each end.

2.2.12 Vehicles shall be equipped so that if they become inoperable, they can be towed or pushed out by a fully functional vehicle. Under these towing or push out conditions, the specified performance requirements shall be relaxed. The Contractor shall submit to SANBAG a complete list of limitations required for towing/push out operations **[CDRL 2-3]**.

2.2.13 The Contractor shall provide a mechanical coupler adaptor that will permit towing and push out of the vehicle by a railroad locomotive and will accommodate the different coupler design and coupler heights.

2.2.14 SANBAG has a strong preference for a vehicle that features a Diesel- Electric propulsion systems and that will allow for a possible future conversion to a hybrid propulsion design, where regenerative braking current can be recovered by an internal energy storage device, or that may be converted to a fully electric propulsion system that permits autonomous operation without catenary or other external power supply between stations.

2.2.15 The vehicle shall be designed and manufactured to operate successfully within the environment of the SANBAG system in the greater San Bernardino, California, area.

2.2.16 The car body structure, truck structure, seat frames, and equipment boxes shall be designed for a service life of 30 years minimum based on an average annual operating distance of 125,000 miles (200,000 km) per vehicle without requiring structural repair or replacement for any reason other than collision damage, vandalism, natural disasters, or misuse.

2.2.17 With the exception of wearables and consumables, all other equipment shall be designed for a minimum service life of 15 years subject to routine maintenance, overhaul, or replacement. Major subassemblies requiring overhaul or replacement to meet the requirements of this section shall be identified at design review (DR).

2.2.18 Unless agreed to otherwise by SANBAG, the vehicle shall use subassemblies that minimize the life-cycle costs of the vehicle.

2.3 SERVICE-PROVEN DESIGN

2.3.1 Vehicle systems and subsystems and equipment designs shall be service-proven to the greatest extent possible. SANBAG will evaluate the applicability of "service-proven" according to the risk associated with each particular design. In general, a service-proven design will meet all the following criteria:

a. Successful revenue rail operation for at least five (5) years

b. Adequate performance of its function in previous applications

2.3.2 To establish a design's service-proven history, the Contractor shall submit as part of the proposal specific details of the application history. The Contractor may offer, for approval, a design that is basically unchanged from a service-proven design, but which must be varied slightly in design or manufacture to meet SANBAG's requirements. The Contractor shall show, in detail, what has been changed in the equipment and why such changes will not adversely affect operation and performance.

2.3.3 Evidence documenting service-proven design shall be furnished as part of the proposal for the following systems and components:

a. Coupler and draft gear
b. Traction control
c. Diesel engines
d. Transmission units
e. Final drive gear units
f. Friction brake system and control
g. Door operators and controls
h. Air comfort system
i. Truck frames
j. Wheels and axles
k. Auxiliary power supply, including generator, power conditioning equipment, low-voltage power supply and battery charger
l. Event recorder
m. Batteries
n. Passenger Information System (PIS)
o. Cameras and digital video recorder DVR equipment

2.3.4 SANBAG may waive some requirements for detailed design review and design conformance testing when service-proven equipment is provided. In general, the decision to waive design and test requirements will be based on SANBAG's understanding of the historical success of the equipment applications.

2.4 DESIGN FOR REFURBISHMENT

2.4.1 The passenger vehicle shall be designed to simplify future overhaul and refurbishment, including repair and replacement of all systems and their constituent parts. Removal and replacement of system equipment shall be possible without causing damage to other systems or to the carbody.

2.4.2 Interior panels and equipment shall be of a modular design suitable for future refurbishment.

2.5 AESTHETIC APPEARANCE

2.5.1 To the greatest extent possible, consistent with regulatory requirements, safety, satisfactory performance, and maintainability, vehicle equipment shall be hidden from sight.

2.5.2 Cover panels shall be readily removable and/or hinged for maintenance access. Hinged panels shall be provided with a means for locking in the open position.

2.5.3 The interior design and layout of the vehicle shall provide an attractive appearance. The interior design shall enable the vehicle to be easily maintained in a clean state.

2.6 VEHICLE GENERAL CHARACTERISTICS

2.6.1 The Contractor shall submit a seating conceptual layout with the proposal that offers the best trade-off between passenger seating capacity and standing and circulation space **[CDRL 2-4]**.

2.6.2 Luggage racks shall be provided as specified in Section TP 15.6, Luggage Racks.

2.6.3 Bicycle racks shall be provided.

2.6.4 There shall be a minimum of two ADA-compliant wheelchair locations in each vehicle. Seats located in the wheelchair area may be flip-down types.

2.7 CLEARANCE REQUIREMENTS

2.7.1 The vehicles and attached equipment shall be built within the outline of the Equipment Diagram, Plat C as defined by Association of American Railroads (AAR), except where necessary at the door thresholds for compliance to ADA-Requirements under 49. CFR 38. The respective interfering elements shall be designed as "sacrificial"

2.7.2 The vehicles, when coupled as trains as specified, shall be able to negotiate:

a. A 12.5° curve

b. A no. 8 crossover having 12-foot-2-inch track centers

c. All yard or shop tracks negotiated by current SCRRA commuter trains.

2.7.3 The Contractor shall submit for SANBAG's approval design configuration drawings showing the static and dynamic clearance envelope for the vehicles, indicating compliance with Section TP 2.7, Clearance Requirements **[CDRL 2-5]**.

2.7.4 The Contractor shall perform tests as specified in Section TP 21.0, Vehicle and Systems Testing, to demonstrate compliance with the static and dynamic clearance requirements.

2.8 WAYSIDE CHARACTERISTICS

2.8.1 The following Technical Provisions provide the basic track and wayside limitations under which the vehicle or train shall operate in revenue passenger service. The Contractor shall be responsible for obtaining any additional data required, either by requesting the data from SANBAG or by performing site surveys.

2.8.2 **Track maintenance.** Main track will be maintained to the tolerances defined in 49 CFR Part 213 for Class 4 track, yard track will be maintained to Class 2 conditions.

Track data is provided in Table 2-1.

Table 2-1: Track Data

Dimension	Maximum	Minimum
Track gauge	56.5 in (1,435 mm)	
Tangent track length (between reverse curves): Mainline Yard	 – –	 200 ft (61.0 m) 60 ft (18.3 m)
Horizontal curve radius: Mainline Yard	 – –	 12 degrees 30 seconds (459 ft) 12 degrees 30 seconds (459 ft)
Superelevation	5.5 in (140 mm)	–
Grade:	3.50% (unlimited)	–
Minimum vertical curve length	–	100 ft (30.48 m)
Rate of grade change	3% each 100 ft (30.48 m)	–
Station tangent track length (in advance of and trailing station boarding platform)	–	60 ft (18.3 m)
Rail type: CWR	136 RE canted at 1 in 40	
Platform curve	No curved platforms	
Platform length	600.0 ft	300 ft (97.1 m)
Platform height	23 in (584.2 mm)	
Distance platform – center track	5ft 3 in (1600.2 mm)	

2.9 INTERFACE INFORMATION

2.9.1 The Contractor shall attend meetings with SANBAG and SANBAG's other contractors to establish the proper equipment interfaces.

2.9.2 The Contractor shall develop and maintain comprehensive equipment interface information **[CDRL 2-6]** to allow timely completion of the design of all other project elements that relate to the vehicles and their equipment. Examples of required interface elements are:

a. Carbody static and dynamic outlines
b. Jacking pad locations
c. Wheel diameter, gauge, and profile information
d. Wheel hub configuration
e. Distance between centers of trucks
f. Truck wheelbase
g. Identification of all axle-mounted equipment
h. Maximum mounting and release pressures for axle-mounted equipment
i. Attachment of trucks to carbody
j. Fuel filling locations
k. Fuel filling requirements
l. Sandbox inlet port configuration
m. Truck dynamic outline
n. Axle loading diagram
o. Cab and Operator's console layout

2.10 ENVIRONMENTAL CRITERIA

2.10.1 The vehicle shall be capable of being operated, stored, and maintained at specified performance levels within the environmental conditions present on SANBAG's railroad system in the greater San Bernardino, California, area listed in Table 2-2.

Table 2-2: Environmental Conditions in the San Bernardino, California, Area

Condition	Maximum	Minimum
Ambient temperature	120 °F (49 °C)	20 °F (–15 °C)
Relative humidity	100%	5%
Wind: Operating – 1-min wind Operating – 3-sec gust Storage – 3-sec gust	 40 mph (64 km/h) 70 mph (113 km/h) 100 mph (161 km/h)	 – – –
Rainfall rate	6.5 in (165 mm) in 24 hr	–

2.10.2 The vehicle shall operate over grade crossings on surface streets in the presence of dust, trash, leaf accumulation, and other pollutants characteristic of urban and rural environments.

2.10.3 The vehicle shall operate in the presence of airborne pollutants, such as dust, acids, and oxides, characteristic of the San Bernardino, California, area.

2.10.4 With maximum allowable wheel and rail wear, the vehicle must be able to operate successfully under the above conditions with no entry of moisture or other contaminants into any compartment, component, or device that could cause equipment on the vehicle to malfunction or be damaged; that could increase maintenance requirements; or that could cause premature wear or failure.

2.11 WEIGHT CRITERIA

2.11.1 Passenger weight shall be assumed to be 154 lbs. (70 kg).

2.11.2 For design and performance purposes, the weight of the vehicles shall be defined as follows:

a. AW0: Empty vehicle operating weight, ready to run with fuel tank and sand boxes full

b. AW1: Fully seated vehicle load and one Operator, plus AW0

c. AW2: Normal load vehicle weight at 2.7 ft^2 per standing passenger (4 passengers per m^2) exclusive of seating area and operator cabs, plus AW1

d. AW3: Crush load vehicle weight at 1.8 ft^2 per standing passenger (6 passengers per m^2), exclusive of seating area and Operator cabs, plus AW1

e. AW4: Structural design weight at 1.35 ft^2 per standing passenger (8 passengers per m^2), exclusive of seating area and Operator cabs, plus AW1

2.11.3 The design of each vehicle and the arrangement of attached equipment shall be such that the following limits of weight variation and balance are maintained with the vehicle standing on level, tangent track:

a. Deleted

b. The load on wheels on one side of any truck shall not differ by more than four percent (4%) from the load on opposite side wheels for a vehicle weight of AW0 when referenced to the weight on that truck.

2.11.4 SANBAG prefers a vehicle design that minimizes weight while maintaining the required structural strength.

2.11.5 The Contractor shall submit a vehicle weight distribution report for the vehicle **[CDRL 2-7]** that will detail the weights of all major subassemblies. The report shall include the weight distribution on each truck and on each axle. Weight targets and actual measurements shall be clearly identified.

2.12 SHOCK AND VIBRATION

2.12.1 Component Design Criteria

2.12.1.1 All vehicle equipment shall be designed to operate without damage or degradation of performance when subjected to vibration and shocks encountered during normal service.

2.12.1.2 Equipment design and mounting arrangements shall be based on the specific location of the equipment on the vehicle and shall take into account the influence of adjacent components as well as the effect of normal vehicle operation. It shall be the Contractor's responsibility to assure that the operating environments specified below are not exceeded.

2.12.1.3 The Contractor shall ensure that equipment will withstand all normally occurring random shock and vibration magnitudes transmitted through the vehicle axles and suspension and present at the support points for each piece of equipment. At a minimum, equipment shall withstand the following shock and vibration levels:

a. Car body-mounted components above the secondary suspension shall be designed and installed to withstand continuous sinusoidal vibrations of 0.4 g peak at any frequency from 1 Hz to 100 Hz in the three major axes, and randomly oriented shock impulses of 3 g peak

in each major axis. Alternatively, components may be designed and installed to withstand shock and vibration as specified in EN 12663-1.

b. Truck-mounted components above the truck primary suspension shall be designed to withstand, at a minimum and without fatigue or deterioration for the design life of the vehicle, continuous random vibrations of 1.5 g peak within the frequency range of 1 Hz to 100 Hz in all directions and shock pulses of 20 g in the vertical axis and 6 g in the lateral and longitudinal axes, occurring approximately 100 times per operating day. Alternatively, components may be designed and installed to withstand shock and vibration as specified in EN 13749.

c. Truck-mounted components in an unsprung environment shall be designed to withstand, at a minimum, continuous random vibrations of 15 g peak within the frequency range of 5 Hz to 2,000 Hz in all directions and shock pulses of 100 g in each major axis, occurring approximately 100 times per operating day. Alternatively, components may be designed and installed to withstand shock and vibration as specified in EN 13749.

2.12.1.4 In cases where components are mounted in a partially sprung environment, the Contractor shall be responsible for defining the environment to avoid failure of the components **[CDRL 2-8]**.

2.12.2 Vibration Generation

2.12.2.1 Deleted

2.12.2.2 With the vehicle stationary and with all auxiliary units including the propulsion engines operating simultaneously at rated capacity, the vertical or horizontal vibrations of the floors, walls, seat frames, or any surfaces with which the passengers or the Operator can come in contact shall not vibrate to the extent that noise is produced under all conditions defined by ISO 2631-1.

2.12.3 Ride Quality and Passenger Comfort

2.12.3.1 The vehicle shall provide a smooth, comfortable ride, free from excessive vibration and shock throughout the operational environment in acceleration, coast, and braking modes.

2.12.3.2 Vehicle elements mounted in the passenger areas shall be free from resonance and shall be properly isolated to avoid annoying audible and visible distraction. The frequencies of the sources of excitation such as wheels, motors, gears, and brakes shall be within the parameters established in these Technical Provisions at speeds from 0 to 79 mph (127 km/h).

2.12.3.3 Ride quality shall be evaluated against the requirements of ISO 2631-1 or EN 12299.

2.12.3.4 The processed root mean square (RMS) acceleration values shall not exceed the 4-hour vertical (a_z) and 2.5-hour transverse (a_x and a_y) boundaries defined in ISO 2631-1 or EN 12299.

2.12.3.5 The range of frequencies for which ride quality is evaluated shall be 1 to 80 Hz for all load and operational conditions. Should any suspension frequency lie above or below this range, vehicle dynamic modeling as defined in Section TP 2.13.3 shall define and quantify this mode and shall be subject to modified ISO 2631-1 or EN 12299 criteria.

2.12.3.6 The Contractor shall conduct ride quality and stability tests in accordance with Section TP 21.0.

2.13 VEHICLE DYNAMIC PERFORMANCE

2.13.1 A vehicle as a whole and each of its subsystems shall operate without unsafe oscillations or hunting at all speeds up to the safe design speed under all conditions of wheel and rail wear that is within specified limits. The safe design speed shall be no less than the vehicle maximum speed plus ten percent (10%). Hunting oscillations shall be as defined in 49 CFR Section 238.227.

2.13.2 The Contractor shall be responsible for assessing the existing and planned track and for identifying any track geometry features to which the vehicles will be sensitive in terms of stability, curve negotiation, and derailment potential. The report on this survey shall be submitted to SANBAG for information **[CDRL 2-9]**. The vehicle dynamic analysis shall explicitly consider referenced track standards. If any track features are fundamentally incompatible with the vehicle design, these must be communicated to SANBAG at the earliest opportunity.

2.13.3 The Contractor shall perform detailed dynamic modeling of the vehicle, using a proven rail vehicle dynamic analysis package, such as NUCARS or VAMPIRE. The analysis package shall be subject to SANBAG's approval prior to use. This model shall include all appropriate degrees of freedom, masses, stiffness, and damping elements for maximum length units. The model shall be validated by appropriate stability and curve negotiation testing on the first vehicle.

2.13.4 The model(s) shall accurately predict the ride quality, ground-borne vibration, curving performance, lateral stability, and derailment safety of the vehicle on SANBAG's track. In all of the following cases, the vehicle condition shall be assessed:

a. With new and any worn wheel profile not condemnable by SANBAG's planned practice;

b. At all vehicle load conditions and operating speeds; and

c. With a range of suspension characteristics consistent with those possible due to the prescribed maintenance recommendations.

2.13.5 Modeling of ride quality and ground vibration input shall demonstrate that the vehicle meets the requirements of Section TP 2.14, Performance Requirements, with verified suspension and track characteristics.

2.13.6 Modeling of curving performance shall demonstrate that when the vehicle is traversing curves or tangent track with irregularities, on the mainline and in the yard, the requirements of Section TP 2.14 are met.

2.13.7 Modeling of vehicle stability shall confirm that the vehicle does not exhibit any unstable limit cycle oscillations at any speed up to ten percent (10%) above the maximum operating speed, and that it satisfies the requirements of Section TP 2.14.

2.13.8 The Contractor shall provide to SANBAG a report demonstrating that the final vehicle design complies with all requirements of this section **[CDRL 2-10]**. Any changes made to the vehicle after this submittal must be reconfirmed and distributed to SANBAG.

2.14 PERFORMANCE REQUIREMENTS

2.14.1 The following establishes the performance required of the DMU, whether operating as a single vehicle or in a multiple unit train of up to and including two vehicles of similar or dissimilar weights, as specified below.

2.14.2 All combustion engines shall be in compliance with the Environmental Protection Agency (EPA) Tier 4 final emission requirements, or the highest requirement in effect on the delivery date, in accordance with the applicable rated power of the engines selected as they are in effect on the delivery due date as defined by 40 CFR Part 1039.

2.14.3 All performance requirements shall be met according to the following conditions:

a. Operation shall be considered to be on level, tangent, and dry track, unless otherwise indicated.

b. The achievable adhesion shall be assumed to be no greater than a coefficient of 0.20 for acceleration and 0.15 for braking.

c. Average rates are defined as change in vehicle speed divided by elapsed time, after initial buildup.

d. Designs shall include rotating inertia of the equipment.

e. Braking rates shall include train resistance and may include gear losses.

f. Deleted

g. Low voltage direct current (LVDC) power may vary throughout the full specified range.

h. Unless otherwise specified, all acceleration requirements shall be based on AW0 through AW2 vehicle weights, and all specified braking requirements shall be based on AW0 through AW3 vehicle weights.

i. Ambient conditions may vary throughout the range specified in Section TP 2.10, Environment Criteria.

2.14.4 Duty Cycle Requirements

2.14.4.1 The thermal capacity of the propulsion system shall be based on the duty cycle of a train operating in continuous revenue service over the entire line from The Downtown San Bernardino Transit Center to the University of Redlands station, making all stops, at maximum allowable operational speeds and the specified full acceleration and braking rates, with all vehicles at AW2 loading over the entire line.

2.14.4.2 The thermal capacity of the propulsion system shall be sufficient to enable a train, immediately after the completion of a roundtrip over the entire line from Downtown San Bernardino Transit Center to University of Redlands Station at AW2 loading, to complete one terminal-to-terminal journey in either direction at maximum allowable operational speeds and the specified full acceleration and braking rates at any weight up to AW3.

2.14.4.3 The thermal capacity of the friction braking system shall be based on the duty cycle specified in TP 2.14.4.1 and TP 2.14.4.2, using friction brakes only and with all vehicles at AW3 loading.

2.14.4.4 Route profiles to be used for duty cycle and run time design purposes are included in Appendix A-C. Station dwell times shall be thirty (30) seconds and terminal layover time shall be ten (10) minutes. The ambient temperatures shall be assumed to be worst case.

2.14.4.5 The Contractor shall submit to SANBAG for approval calculations demonstrating compliance with TP 2.14.4.1, TP 2.14.4.2 and TP 2.14.4.3 **[CDRL 2-11]**.

2.14.5 Degraded Performance Operation

2.14.5.1 One AW3 loaded train shall be able to push or pull an AW3 loaded train with inoperative propulsion and braking systems locked out, between any two adjacent stations at reduced speed and performance. The same consist of two trains, empty of passengers, shall then be able to return to the maintenance facility, making all safety stops along the way at reduced speed and performance. The maximum reduced speed shall be no less than 25 mph (40 km/h).

2.14.5.2 With the friction brakes on one truck of a train inoperative, the friction braking system shall be capable of operating between any two adjacent stations at AW3 load, with no permanent damage to the brake system, with a reduced maximum speed. The reduced speed shall be as recommended by the friction brake manufacturer but not less than 25 mph (40 km/h).

2.14.5.3 A train shall be capable of making a complete stop on the maximum downgrade at AW3 load with the friction brakes on one truck inoperative, without causing damage to or exceeding the thermal limits of the system.

2.14.5.4 With one propulsion set of a train inoperative, the propulsion system shall be capable of operating between any two adjacent stations at AW3 load, with a reduced maximum speed as defined by the Contractor and approved by SANBAG. The reduced maximum speed shall be no less than 25 mph (40 km/h).

2.14.5.5 A train shall be capable of movement, without rollback, from a standing start on the maximum up-grade, with one propulsion set inoperative at AW3 load.

2.14.5.6 The Contractor shall submit to SANBAG for approval calculations demonstrating compliance with TP 2.14.5.1, TP 1.14.5.2, TP 2.14.5.3, TP 2.14.5.4, and TP 2.14.5.5 **[CDRL 2-12]** and shall identify the most onerous duty cycle for the propulsion and friction braking systems **[CDRL 2-13]**.

2.14.6 Acceleration and Braking Requirements

2.14.6.1 A train shall be capable of completing a service run over the entire length of the SANBAG system at AW2, between the Downtown San Bernardino Transit Center and the University of Redlands Station in 18 minutes travelling in the eastbound direction and in 17 minutes travelling in the westbound direction. The end-to-end travel times will include full station stops and minimum station dwell times as defined in Appendices A to C to this document.

2.14.6.2 The Contractor shall submit to SANBAG for approval calculations demonstrating compliance with the requirements in Section TP 2.14.6.1 **[CDRL 2-14]**. The Contractor shall carry out performance qualification tests for the complete vehicle to prove compliance with the calculated acceleration requirements and braking requirements as specified in Section TP 2.14.6, Acceleration and Braking Requirements.

2.14.7 Speed Requirements

A train shall be capable of operating continuously at AW3 weight, on level tangent track, at a balancing speed of at least 79 mph (127 km/h). The vehicles' maximum operating speed shall be no less than 79 mph (127 km/h) with fully worn wheels. All equipment shall be designed to operate continuously at the maximum operating speed without damage to any components and without heating or wear of any components in excess of values used to calculate design life.

A train shall be capable of operating continuously at AW3 weight, on level tangent yard track, at a maximum speed of 10 mph (16.1 km/h).

2.14.8 Emergency Braking Requirements

2.14.8.1 Emergency braking shall be provided by a combination of load-weight compensated emergency friction brakes and sanding. Track brakes may also be used. Emergency brake applications shall not be jerk limited and shall result in an irretrievable stop to zero speed.

2.14.8.2 The emergency brakes shall provide the following performance on level dry tangent track, over the entire speed range for trains weighing up to and including AW3:

a. A nominal net emergency brake rate of 2.5 mph/sec (1.12 m/sec^2) but no greater than 3.2 mph/sec at any brake entry speed between 65 mph and zero. Instantaneous variations in the emergency brake rate shall be within twenty percent (20%) of the nominal values.

b. Under worst-case mechanical and friction material conditions, and the worst case of a single-point failure, a minimum guaranteed emergency brake rate (GEBR) of 1.05 mph/sec (0.47 m/sec^2) shall be achieved.

c. A maximum GEBR stopping distance from 65 mph of 2,931 ft (893 m), not including the distance covered during reconfiguration to braking time, plus an allowance of up to 114 ft (34.4 m) for the distance traveled during brake buildup time.

2.14.8.3 Emergency brake control shall be fail-safe to the extent that no detectable single point failure in the friction brake system, or series of common-mode or common-cause failures added to any combination of undetected failures, can result in the availability of less than seventy-five percent (75%) of emergency braking effort at any instant over the entire speed range, exclusive of magnetic track brake contribution. Worst-case failure conditions shall also include brake performance degradations and undetected failures that occur between scheduled maintenance intervals, and the effects of such degradation shall be added to the single failure or series of common-mode or common-cause failures in assuring the specified GEBR and GEBR stopping distance as required in Section TP2.14.8.2.

2.14.8.4 The Contractor shall submit to SANBAG for approval calculations demonstrating compliance with Section TP 2.14.8, Emergency Braking Requirements **[CDRL 2-15]**. The Contractor shall also submit a quantified risk assessment to demonstrate that the mean time between hazards of not achieving the GEBR is greater than 1.0×10^7 hours **[CDRL 2-16]**. Revised calculations shall be submitted whenever there is a change in the brake equipment configuration, or whenever tests demonstrate any assumptions are in error. The Contractor shall perform qualification tests to prove compliance with the deceleration requirements as specified in Section TP 21.0, Vehicle and Systems Testing.

2.14.9 Rollback Protection

2.14.9.1 The traction control system shall coordinate the release of the brakes and the application of tractive effort to preclude rollback of a vehicle or train with a weight of up to AW3 on a 3.5% gradient.

2.14.10 Jerk Limit

2.14.10.1 The rate of change of vehicle or train acceleration or deceleration after the dead time shall not be greater than 3.0 mph/sec^2 (1.34 m/sec^3) under all normal operating conditions. Failure of the jerk limiting system shall not limit braking effort.

2.14.10.2 The jerk rate limits specified shall apply to all normal power and service braking applications and to re-applications of power and braking when controlled by the spin/slide protection equipment.

2.14.10.3 Emergency brake applications and any associated ramp-out of propulsion shall not be jerk limited.

2.14.10.4 When the cab signal system detects an over-speed condition, release of power shall be jerk limited.

2.14.10.5 Application of full service penalty braking initiated by the cab signal system shall not be jerk limited.

2.14.10.6 Release of the friction brake at zero speed in response to master controller commands need not be jerk limited.

2.14.11 Load-Weighing

2.14.11.1 A load-weighing system for vehicle weights up to and including AW3 shall be used to meet the requirements of these Technical Provisions. Accuracy of the load weighing system shall ensure compliance with vehicle acceleration and service braking requirements.

2.14.11.2 If the load weighing system fails to operate normally, then the truck with the failed system shall respond to acceleration and braking commands, as if it were loaded to AW1 conditions.

2.14.12 Zero Speed Detection

An apparatus shall be provided to detect all vehicle motion down to and including zero speed (defined as a velocity of less than 2 mph (3 km/h for more than 1 second). The speed detection system shall generate a fail-safe signal.

2.15 CONTROL AND INTERLOCK SIGNALS

2.15.1 Control and interlock signals, where required, shall be capable of providing signal strength sufficient for a train to tow a disabled train.

2.15.2 If propulsion and braking trainlines ever appear in an abnormal combination, the most restrictive signal shall govern. The implementation of these signals shall be fail-safe so that all failures tend toward a more restrictive mode. Discrete trainlines shall define the coast position (NOT power), full service brake and emergency braking positions or as otherwise approved.

2.15.3 Selection of propulsion or braking modes shall be a direct result of the master controller position. The signal shall follow fail-safe principles of using higher-level signals for the propulsion mode and lower-level signals or zero (loss of signal) to request braking. Alternative proven designs may be considered but will be subject to SANBAG's approval.

2.15.4 Direction Control

2.15.4.1 Direction signals shall be a pair of trainlines, energized individually to determine the direction of operation. Energizing or not energizing both trainlines at the same time shall inhibit propulsion.

2.15.4.2 Direction signals shall originate at the forward Operator's console. Selection shall be "forward" or "reverse," with interlocks as specified in Section TP 6.0, Doors.

2.15.4.3 During reverse operation, vehicle speed shall be limited to 5 mph (8 km/h).

2.15.5 Emergency Brake Control

2.15.5.1 Activation of the console emergency stop pushbutton, movement of the master controller to the emergency brake position, or activation of the passenger emergency brake devices shall command emergency braking.

2.15.5.2 Emergency brake trainline command signals, activated from the console-mounted emergency stop pushbutton, shall override jerk-limit and spin/slide control to directly apply friction brakes, track brakes (if required), and sand, as required.

2.15.5.3 Emergency brake trainline command signals, activated by placing the master controller into its emergency brake position or activated by the passenger emergency brake devices, shall override jerk-limit control but shall maintain the slide-control function of the braking systems.

2.15.5.4 In single or multiple unit operation, separation of the trainlined electric functions shall cause an emergency brake application on all vehicles in the train. The emergency brake application on trailing vehicles shall be the equivalent to an emergency brake application initiated by the master controller (as defined in Section TP 2.15.5.3, Interchangeability and Comfort).

2.15.6 Full Service Brake Application

2.15.6.1 Trainlines shall be designed and installed to command an irretrievable full-service brake under the following conditions:

a. Overspeed in towing mode

b. Activation of cab signaling penalty braking

c. Activation of deadman feature

2.15.7 Track Brakes (if Required)

2.15.7.1 Automatic application of the magnetic track brakes shall be inhibited when the vehicle is at zero speed. At zero speed, the Operator may apply the track brakes by using the console-mounted momentary switch.

2.15.7.2 Interlocks shall be provided to prohibit positive tractive effort with any brake in the train applied.

2.16 ACOUSTIC NOISE REQUIREMENTS

2.16.1 General

2.16.1.1 This section contains the general requirements for maximum allowable sound levels in passenger spaces, Operator locations, and at the wayside. The Contractor shall submit to SANBAG for approval a plan and analysis to show how the requirements of this section will be met **[CDRL 2-17]**.

2.16.1.2 The Contractor shall devote particular attention to the design of the vehicle and equipment to obtain quiet operation, and shall ensure that the noise criteria specified herein are not exceeded.

2.16.1.3 Enclosures, baffles, seals, acoustical absorption, body panels with adequate sound transmission loss, vibration isolators, or other appropriate methods shall be incorporated into the vehicle design to attenuate noise and vibration generated by wheels, rails, engines, motors, and all elements and equipment, and to ensure that the limitations on interior and wayside noise are not exceeded.

2.16.1.4 All equipment shall be designed to eliminate rattling and resonance at all speeds up to ten percent (10%) above maximum normal operating speed by the use of damping, gaskets, resilient mounts, or similar methods.

2.16.1.5 In general, the noise-control features of the equipment shall last for the useful life of the vehicle.

2.16.1.6 ANSI S1.4, S1.6, S1.11, and S1.13 shall apply. Designs based on ISO 3095 and ISO 3381 will be acceptable.

2.16.2 Definitions

2.16.2.1 Sound pressure level: Sound pressure level (SPL) is defined per ANSI S1.4. All noise levels are expressed in A-weighted decibels (dBA), referenced to 20×10^{-6} Pascal.

2.16.2.2 Measurements: All overall noise levels shall be measured in terms of dBA, in accordance with ANSI S1.13, with a measuring system complying with the Type 2 requirements of ANSI S1.4. “Slow” meter response time shall be used for all static measurements; “fast” meter response time shall be used for all dynamic measurements. Where octave or 1/3-octave band measurements are specified, an analyzer with filters meeting the requirements of ANSI S1.11 shall be used. Narrow-band noise or pure tones shall be identified using filters with a bandwidth not exceeding 1/3 of an octave.

2.16.2.3 Environment: Noise criteria specified herein for a stationary vehicle are based on measurements taken in an essentially free-field environment, such as outdoors away from any reflective surfaces other than ballast and tie track upon which the vehicle is parked/moving. Noise criteria specified herein for a moving vehicle are based on measurements taken on ballast and tie track aligned to 49 CFR Part 213 Class 4 standards.

2.16.2.4 Pure tone or narrow band: If the SPL of any 1/3-octave band from the 250-Hz band to the 4,000-Hz band exceeds the average of levels in two adjacent 1/3-octave bands (containing no pure tones or “tonal” noise) by 5 dBA or more, that band shall be considered to contain pure tone or narrow-band components, and the noise shall be reduced to a level not exceeding the average of the levels in two adjacent 1/3-octave bands.

2.16.2.5 Interior noise control and criteria: The maximum noise level at any position along the centerline of each vehicle shall not exceed the limits set forth in Table 2-3 by more than 3 dBA.

2.16.2.6

Table 2-3: Maximum Interior Noise Levels

Condition	Average Noise Level
Vehicle operating in the open on dry, level, tangent ballast and tie track at any speed up to 79 mph (128 km/h) in any normal mode of acceleration, coasting, or braking, with all auxiliaries operating under normal conditions.	78 dBA
Vehicle stationary with doors closed, in the open on ballast and tie track with all auxiliaries except doors operating simultaneously at maximum capacity, including any propulsion system components capable of operating when the vehicle is stationary.	72 dBA
Operator's cab, in the open on ballast and tie track with all auxiliaries except doors operating simultaneously at maximum capacity, vehicle stationary and at any speed up to 79 mph (128 km/h).	70 dBA

2.16.2.7 Measurements of interior noise levels shall be taken in a fully equipped vehicle with no passengers on board other than the measurement team.

2.16.3 Wayside Noise Control and Criteria: The sound level measurement is defined as the A-weighted sound level energy averaged over the time of the event passby as defined in FTA's *Noise and Vibration Measurement Guidelines* (FTA-VA-90-1003-06) or equivalent. The maximum A-weighted sound pressure level (L_{max}) at the wayside shall not exceed the values shown in Table 2-4 for the specified test condition on dry, level, tangent ballast and tie track. Test results from comparable vehicles may be considered in lieu of carrying out the tests.

2.16.3.1 Measurements shall be made at the specified distance from the track centerline, 5 ft (1,524 mm) above top of rail.

Table 2-4: Maximum Wayside Noise Levels

Condition	Noise Level
All systems operating simultaneously, including air conditioning and propulsion cooling system, vehicle stationary, diesel engines idle	65 dBA at 100 ft
Each auxiliary system operating alone, vehicle stationary	68 dBA at 30 ft
Train empty, on tangent track accelerating from 40 mph (64 km/h) or in maximum dynamic braking or maximum friction braking from 40 mph (64 km/h), whichever is worse).	76 dBA at 50 ft

2.17 ELECTRICAL NOISE CONTROL REQUIREMENTS

2.17.1 To help avoid undesirable effects on external equipment or on other installations along the right-of-way caused by onboard vehicle systems, the electromagnetic emission limits specified herein shall not be exceeded.

2.17.2 Meeting these emission limit requirements is the first level of defining the interface between the vehicle and its intended environment. The Contractor shall be responsible for reducing emission limits, if necessary, to prevent interference with any existing railroad or non-railroad systems, and shall work jointly with SANBAG and others designated by SANBAG to ensure compatibility between the vehicle and any SANBAG equipment and with the operating environment.

2.17.3 The Contractor shall employ design techniques, construction methods, and whatever apparatus is required to keep interference caused by internal sources from affecting the proper operation of the vehicle and external systems.

2.17.4 In addition to coordinating frequencies, electromagnetic compatibility (EMC) levels, and susceptibility levels, the Contractor shall provide the necessary onboard grounding, balancing, filtering, shielding, modulating techniques, and isolation to maintain signal-to-noise ratios within clearly workable limits and to reduce the undesirable effects of interference.

2.17.5 Electrostatic and magnetic electrical shielding methods shall be employed to minimize the effect of stray signals and transient voltages on cables. Power and signal cables shall be physically separated where practicable and shall be shielded where necessary. Suppression devices shall be employed on relay and magnet-valve circuits to protect low-voltage circuits from relay transients.

2.17.6 Components and functional circuits shall be grouped according to their similar sensitivities to electrical interference and power supply needs and grouped to reduce the effects of voltage drops in ground circuits. Power and return leads shall be routed in the same raceway or harness. Suppression devices shall be used on power supply leads where necessary to suppress interference at the inputs to sensitive circuits.

2.17.7 Trainlines shall be located and arranged to minimize voltage induction due to propulsion and auxiliary power.

2.17.8 Radiated Emission Limits

When measured at a distance of 100 ft (30.5 m) and tested in accordance with UMTA-MA-06-0153-85-11 or EN 50121-1-2, equipment shall not exceed the following interference limits:

a. From 0.01 MHz to 30 MHz, the maximum permissible interference limit shall not exceed 20 dBA above the limit of Figure 22 (RE05) of MIL-STD-461A.

b. From 30 MHz to 88 MHz, the maximum permissible interference limit shall be 58 dBA above 1 mV/m/MHz bandwidth.

c. From 88 MHz to 1,000 MHz, the maximum permissible interference limit shall be 68 dBA above 1 mV/m/MHz bandwidth.

2.17.9 Conducted Disturbances

2.17.9.1 The Contractor shall formulate a set of criteria governing both generation and tolerance of electrical disturbances on conductors between assemblies. The criteria shall:

a. Distinguish the basic types of circuits present on the vehicle and define a suitable comprehensive classification of disturbances that could be present in each type of circuit.

b. Ensure that each connected assembly can tolerate the disturbances introduced simultaneously by all of the other assemblies to which it could be connected.

c. Include any required modification of the limits described in the above on conducted interference into the running rails, with levels selected to prevent interference with signal and communication systems that use those circuits for their means of operation and communication.

d. All electronic equipment shall comply with EN 50155.

2.17.9.2 These criteria shall be a part of the EMC control plan (reference Section TP 2.17.13.1, Control and Test Plans).

2.17.10 Inductive Emission Limits

2.17.10.1 The inductive emissions, as measured by the procedures given in UMTA-MA-06-0153-85-8 or EN 50121-3-1 and EN 50500shall be limited to a maximum of 20 mV, root mean square, rail to rail, at rail frequencies between 20 Hz and 20 kHz.

2.17.10.2 These conditions shall be met individually by each power equipment apparatus, as well as during simultaneous operation of all equipment.

2.17.10.3 The root mean square magnetic field strength in the vehicle interior and cabs shall not exceed 0.1 mT.

2.17.11 Inductive Disturbances

2.17.11.1 The Contractor shall formulate a set of criteria governing generation and tolerance of magnetically coupled disturbances on or between assemblies. The criteria shall:

a. Identify the basic types of circuits present on the vehicle and define a suitable comprehensive classification of disturbances that could be present in each type of circuit.

b. Ensure that each connected assembly can tolerate the disturbances introduced simultaneously by all other assemblies to which it is magnetically coupled.

c. Include any required modifications to the limits described above on the inductive interference into the running rails, with levels selected to prevent interference with signal and communication systems that use those circuits for operation and communication.

2.17.11.2 These criteria shall be a part of the EMC control plan, as defined in Section TP 2.17.13.1, Control and Test Plans.

2.17.12 Audio Frequency Interference

2.17.12.1 It is essential that vehicle emissions not interfere with the proper operation of power frequency (PF) track circuits, or cab signals. Therefore, design techniques and construction methods shall be employed that ensure suppression of any interference emissions.

2.17.12.2 In addition, since equipment boxes and cabling will be removed, inspected, and/or replaced on a routine basis, the equipment shall be designed to ensure proper sealing of boxes, cables, and so forth during routine maintenance procedures.

2.17.13 Control and Test Plans

2.17.13.1 The Contractor shall submit to SANBAG for approval an EMC control plan, addressing complete vehicle and vehicle system requirements, before purchase specifications are issued for any carborne apparatus **[CDRL 2-18]**.

2.17.13.2 The plan shall ensure that proper emphasis will be placed on the control of interference, interface design, and FCC requirements from the earliest stages of vehicle design. The EMC control and test plans shall describe the Contractor's approach to ensure that the specified EMC requirements are met.

2.17.13.3 At a minimum, the Contractor's EMC control plan shall include the following:

a. General design and mitigation techniques to be applied to the complete vehicle and all vehicle systems

b. Analysis of the susceptibilities of vehicle systems and the standards and criteria to be applied to system designs

c. Analysis of wayside susceptibilities applicable to vehicle design, as well as overall EMC emission requirements as defined herein

d. Requirements for emission limits for minimum and maximum length trains

e. SANBAG may instruct the Contractor to include in the EMC control plan specific non-railroad entities that might be sensitive to electrical or magnetic interference due to physical proximity to SANBAG's rail lines.

2.17.13.4 The following design requirements shall be included in the EMC control plan:

a. To contain EMC emissions wherever possible, the suppression of transients shall be at the source of the transient.

b. All magnet valve, relay, contactor coils, and other inductive devices shall have transient suppression. The absence of suppression for performance reasons will require approval.

c. The number of suppression devices shall be kept to a minimum.

d. Equipment design, wiring techniques, and enclosures shall shield equipment from any effects resulting from the operation of a SANBAG hand-held transceiver.

e. Equipment design, wiring techniques, and enclosures shall shield equipment from any effects resulting from the operation of cellular telephones, including when cellular telephones are operated within the vehicle or on the passenger platforms.

f. Equipment design, wiring techniques, and enclosures shall shield systems to prevent the vehicle and its systems from causing undesired effects to external equipment and systems, with particular emphasis being placed on safe operation with the wayside signal and communications systems. The Contractor shall ensure that this program confirms that operational sensitivities of the wayside signal and communications systems and interference-free operation are within design parameters.

2.17.13.5 The EMC test plan shall address how the susceptibility and emission limits will be verified **[CDRL 2-19]**.

2.17.13.6 The Contractor shall conduct EMC tests in accordance with UMTA-MA-06-0153-85-6, UMTA-MA-06-0153-85-8, UMTA-MA-06-0153-85-11, or EN 50121-1-3-1 and Section TP 21.0, Vehicle and Systems Testing.

2.17.13.7 SANBAG's approval of the EMC control and test plans does not relieve the Contractor from the requirement to provide equipment that functions safely and properly in the transit environment, provided that the transit environment and the present wayside systems fulfill their corresponding standards, are installed and working properly.

2.18 COMPLIANCE MATRIX

The Contractor shall develop and maintain a compliance matrix **[CDRL 2-20]** demonstrating how the Technical Provisions are validated. The compliance matrix shall clearly identify how compliance is achieved.

2.19 DELIVERABLES

Contract deliverables required by this section of the Technical Provisions are summarized below:

CDRL 2-1 List of onboard emergency equipment and proposed installation location (TP 2.2.5)

CDRL 2-2 Detailed information on passenger safety information signs or decals and their proposed installation location (TP 2.2.6)

CDRL 2-3 List of towing limitations (TP 2.2.11)

CDRL 2-4 Seating layout (TP 2.6.2)

CDRL 2-5 Static and dynamic vehicle outlines of the vehicle (TP 2.7.3)

CDRL 2-6 Equipment interface information (TP 2.9.2)

CDRL 2-7 Weight distribution report (TP 2.11.5)

CDRL 2-8 Environment definition for components mounted in a partially sprung environment (TP 2.12.1.4)

CDRL 2-9 Critical trackwork identification (TP 2.13.2)

CDRL 2-10 Vehicle stability analysis and dynamic model report (TP 2.13.8)

CDRL 2-11 Duty-cycle simulations for propulsion and braking systems (TP 2.14.4.5)

CDRL 2-12 Degraded performance, maximum grade, standing start, and stopping calculations (TP 2.14.5.6)

CDRL 2-13 Identification of the most onerous duty cycle for the propulsion and friction braking systems (TP 2.14.5.6)

CDRL 2-14 Calculations of acceleration performance (TP 2.14.6.2)

CDRL 2-15 Service and emergency braking calculations (TP 2.14.8.4)

CDRL 2-16 Quantified risk assessment for GEBR (TP 2.14.8.4)

CDRL 2-17 Acoustic noise control plan (TP 2.17.1)

CDRL 2-18 EMC control plan (TP 2.17.13.1)

CDRL 2-19 EMC test plan (TP 2.17.13.5).

CDRL 2-20 Compliance matrix (TP 2.18)

END OF SECTION

3.0 CARBODY EXTERIOR

3.1 CITED REFERENCES

49 CFR Part 38	Americans with Disabilities Act Accessibility Specifications for Transportation Vehicles
49 CFR Part 223	Safety Glazing Standards – Locomotives, Passenger Cars, and Cabooses
49 CFR Part 229	Railroad Locomotive Safety Standards
49 CFR Part 231	Railroad Safety Appliance Standard
49 CFR Part 238	Passenger Equipment Safety Standards (FRA)
APTA SS-C&S-007-98	Standard for Fuel Tank Integrity for Non-Passenger-Carrying Passenger Locomotives
APTA SS-C&S-034	Standard for the Design and Construction of Passenger Railroad Rolling Stock
APTA SS-PS-002-098	Standard for Emergency Signage for Egress/Access for Passenger Rail Equipment
ASTM E-119	Standard Test Methods for Fire Tests of Building Construction and Materials
AWS D1.1	Structural Welding Code, Steel
FRA	*Technical Criteria and Procedures for Evaluating the Crashworthiness and Occupant Protection Performance of Alternatively Designed Passenger Rail Equipment in Tier 1 Service* (ETF1)
MIL-STD-1472	Human Engineering Design Criteria
NFPA 130	Standard for Fixed Guideway Transit Systems
SAE J1050	Describing and Measuring the Driver's Field of View

3.2 GENERAL

3.2.1 SANBAG's DMU vehicles will be used in unit consists of two cab cars semi-permanently coupled to middle cars inserted between the two cab cars in sufficient quantities to meet SANBAG's passenger capacity requirements. Body end doors, where required, shall allow passengers and/or crew to walk-through between cars of a single unit. The cab cars shall have an aerodynamically shaped front end. All units shall have automatic couplers at both ends.

All passenger cars shall be accessible to mobility impaired passengers as required by 49 CFR Part 38.

3.2.2 Features important to passenger safety and comfort and to operational requirements on SANBAG's system must govern the carbody design. These features include, but are not limited to:

a. Safety factors, such as overall carbody strength in conformance with the most recent CFR regulations, APTA standards, fatigue resistance, emergency egress openings, resistance to projectiles, crashworthiness (including Operator protection), protection against trip and slipping hazards, car-to-car and train-to-train gap protection, protection against pinch points of any kind, and fire resistance as required by 49 CFR Part 238 Appendix B

b. Passenger interface features and human factors, such as overall styling and aesthetics, window sizes and adequate lighting, threshold heights, door and aisle widths, seat width and comfort, handrail locations, rainwater diversion, climate control, ADA requirements, noise transmission, and ride quality

c. Operation and maintenance concerns, such as durability, corrosion resistance, clearances, lifting points, equipment access (including access to mounting points), ease of repair and cleaning, and appropriate allowances for wear and deterioration such that the required design life is achieved

3.2.3 Skirting to mask undercar equipment may be used where allowed by regulatory requirements. Skirting shall be designed such that free access is provided to any equipment located directly behind the coverings. Skirting shall be designed to accommodate all equipment clearance movements and thermal loads without degradation.

3.2.4 Roof shrouding shall be designed in a manner that does not impede drainage, equipment function, or duty cycle, or cause premature degradation.

3.2.5 Sufficient clearance shall be provided between the carbody and any wayside objects in accordance with Section TP 2.7.1. The Contractor shall be responsible for ensuring that the vehicle will operate within this outline under any and all worst-case operating conditions as defined in Section TP 2.0, Design and Performance Criteria.

3.2.6 The carbody shall have a 40-year design life and shall be watertight with the minimum use of sealant. Metallic conduit, tubing, piping, and fittings shall not require replacement under normal wear and tear for the design life of the vehicle. Additionally, the carbody shall be designed with safety margins commonly used in the railroad industry and as detailed in this Technical Specification.

3.2.7 The cars will be identified with consecutive increasing numbers starting at 120. Cab segments will have an "A" or "B" suffix. Power units will have a "C" suffix.

3.2.8 The design of the carbody and of interior and exterior details shall be approved by SANBAG.

3.2.8.1 The exterior color scheme of the vehicle shall be developed by the Contractor, in consultation with SANBAG, as part of the design process, and shall be submitted to SANBAG for approval **[CDRL 3-1]**.

3.3 STRESS LEVELS AND DESIGN CALCULATIONS

3.3.1 Strength Requirements

The vehicle shall, at a minimum, meet the load requirements specified below. Both CFR regulations and APTA Standards for Passenger Railroad Rolling Stock are referenced. In case of conflict the more stringent requirement shall prevail.

3.3.2 Vertical Load

3.3.2.1 The completely equipped carbody shall be designed to carry the vehicle weight with maximum vertical load (minus truck weight), distributed according to the expected equipment and crew positions, with stresses not exceeding fifty percent (50%) of the guaranteed minimum material yield strength or the buckling strength, whichever is less.

3.3.2.2 For each joint of the carbody structure and attachment joints to the carbody structure, the static stress with full load shall be less than the mean stress that determines the allowable fatigue endurance limit.

3.3.2.3 The fatigue stress range shall be computed by multiplying the static stress at the maximum vertical load by the dynamic factor (fatigue load range). The dynamic factor shall be determined by the Contractor but shall not be less than 0.4 (±20%). The dynamic factor shall be applied to all three directions (lateral, longitudinal, and vertical) separately. The stress range shall be within the allowable fatigue endurance limit obtained from AWS D1.1, with the endurance limit taken at 10 million cycles. The Contractor shall use allowable fatigue stresses from its own tests for joint designs not covered by AWS D1.1 or EN 12663-1, or from another data source subject to approval by SANBAG.

3.3.3 Hoisting and Jacking Loads

3.3.3.1 The vehicle shall be capable of being hoisted or jacked at designated carbody locations without permanent deformation, buckling, or loss of water tightness in carbody seams and joints, to facilitate routine maintenance operations, emergency lifting, or re-railing.

3.3.3.2 Maximum stress level shall be fifty percent (50%) of the yield strength of the base material. Alternatively, EN 12663-1 may be applied.

3.3.3.3 The worst reasonable case of uneven jacking, such as might occur with one jack lower than the others or hoisting by opposite lifting lugs, shall not cause any stress to exceed eighty percent (90%) of yield of the carbody structure, nor any failure, loss of water tightness, or disconnection of attached equipment such as paneling or windows. Alternatively, EN 12663-1 may be applied.

3.3.3.4 Jacking pads shall be designed to preclude the jack from slipping.

3.3.3.5 In addition, reinforced lifting lugs, capable of being used to right an overturned vehicle, shall be provided. Where practical, lifting points shall be masked or styled to match the vehicle aesthetics, but must be readily accessible with simple hand tools. Alternatively, EN 12663-1 may be applied.

3.3.3.6 The Contractor shall provide three (3) sets of any special devices required to hoist or jack the vehicle.

3.3.3.7 Hoisting lugs and jacking pads shall be capable of supporting, without permanent deformation, two times the appropriate proportion of vertical load from an AW0 vehicle, including trucks, plus twenty percent (20%) of this load applied horizontally in any direction. Alternatively, EN 12663-1 may be applied.

3.3.3.8 Link between Coupling Mechanism and Car Structure

The coupler attachments shall be designed and constructed to meet or exceed the requirements of 49 CFR Section 238.207.

3.3.3.9 Anticlimber

3.3.3.9.1 At a minimum, each end of each vehicle shall be fitted with an anticlimber having a minimum of three ribs. The height of the anticlimber shall be sufficient to ensure engagement with differences in floor height due to secondary suspension travel, track geometry, and wheel wear.

3.3.3.9.2 The anticlimbers, their attachments, and their support structure shall be designed to allow sufficient anticlimber engagement between two vehicles in a curve with a radius of 300 ft (91.5 m) or worst-case turnout to prevent overriding during a collision. Compliance with AVT requirements is also acceptable.

3.3.3.9.3 Calculations demonstrating compliance assume two ribs engaged on all possible track alignments. Calculations in accordance with AVT requirements are also acceptable.

3.3.4 Natural Frequency

The complete vehicle shall be fully de-coupled from all potentially damaging excitation frequencies such as those from trucks, track, and equipment so that resonance at the completed vehicle's natural frequency does not occur. The natural frequency of the first body bending mode shall be at least 1.5 times that of the bounce frequency of the truck frame and primary suspension system, unless the Contractor proves through testing, or by comparison with existing test data, that resonance will not occur under any operating condition and that the ride quality requirements of Section TP 2.12.3, Ride Quality and Passenger Comfort, are met. This requirement shall be met at all vehicle speeds, up to and including maximum design speed, and at all occupancy levels.

3.3.5 Stress Analysis

3.3.5.1 The Contractor shall submit a stress analysis of the carbody structure and equipment supports for equipment weighing over 150 lbs. (68.1 Kg) prior to commencing manufacture of any carbody structural parts **[CDRL 3-2]** in accordance with APTA Standard SS-C&S-034-99, Rev. 2, Sections 7.1 to 7.3 or in accordance with AVT requirements. The stress analysis shall be used to design the car structure to obtain the lightest weight vehicle possible within the criteria set by these specifications.

3.3.5.2 The initial stress analysis requires some assumptions about configuration and weights; also, manufacturing and other considerations may require design changes. As these changes are made, the stress analysis shall be revised and submitted for review. The final submitted and approved stress analysis shall be for the vehicle as built.

3.3.5.3 Critical connections that cannot be adequately analyzed shall be prototyped and tested to show their efficacy.

3.3.5.4 The mounting fasteners and support structures for equipment weighing more than 150 lbs. (68.1 Kg) shall be designed and analyzed using design loads as specified by APTA Standard SS-C&S-034-99, Rev. 1, and Section 5.7 or in accordance with AVT requirements.

3.3.5.5 For any portion of the proposed design that is based on a service-proven vehicle, the Contractor may provide data from previous tests, historical data from operations, or stress analyses as required to satisfy the corresponding portion of these requirements.

3.3.6 Stress Analysis Report

3.3.6.1 If a cited reference is not readily available to SANBAG, the Contractor shall provide the reference or copies of the pertinent pages. In addition to the pages that show the cited formula or data, the pages that show the development and interpretation of the formula or data must be included.

3.3.6.2 If tests are conducted to provide the necessary data, the entire test report shall be submitted. This report shall be in English and shall show the test procedure, raw data, reduced data, and summary.

3.3.6.3 For equipment for which structural CEM is incorporated in the design, a time-dependent large deflection analysis shall be performed using a recognized computer program that has a proven record of use for rail vehicle crashworthiness analysis. The following shall be analyzed:

a) Individual energy absorbing structural elements,

b) Individual frangible structural elements (elements in the crush zone that must be designed to quickly fail when overloaded by the forces causing the crushing to not destabilize the crushing action),

c) Each crush zone, consisting of the validated energy absorbing and frangible structural elements, and

d) The global carbody, including representative portions of the remainder of the carbody structure.

3.3.6.4 A report of the crashworthiness analysis shall include computer animations of the results of the time-dependent large deflection analysis in a self-contained format that can be displayed on a PC or on commonly available digital or analog video media.

3.3.6.5 The computer animations shall contain sufficient detail, view directions, and magnifications and shall be of sufficiently high resolution to allow review of the behavior and stability of individual energy-absorbing elements, frangible elements, and, for the global analysis, the crushable zone, the non-crushable structure inboard the crush zones, and the carbody as a whole.

3.3.6.6 The report shall demonstrate that the crushing of energy-absorbing zones of the carbody structure is stable, and that structure inboard the energy-absorbing zones is not permanently deformed during crushing up to the full capacity of the crushable structure. Alternatively AVT requirements shall be applied.

3.3.6.7 The report shall include a description of the model in sufficient detail to show that it is appropriate for the application. This shall include, at a minimum, a description of the structural elements and restraints and the conditions of the simulation. It shall also include the output of the simulation to show that the relevant requirements of APTA Standard SS-C&S-034-99 and of the Technical Specification have been met (including force displacement plots) and an itemization of energy absorbed. Alternatively AVT requirements shall be applied.

3.3.7 Finite Element Analysis

3.3.7.1 The stress analysis shall include a finite element analysis (FEA) of the complete carbody. The FEA shall be performed using a recognized computer program.

3.3.7.2 Stress analysis shall be provided to prove all jacking and hoisting requirements are satisfied. Alternatively AVT requirements shall be applied. **[CDRL 3-3].**

3.3.8 Crashworthiness

3.3.8.1 The vehicle structure shall be designed to sustain collisions with other vehicles, including highway vehicles ranging from large automobiles to commercial tractor-trailer trucks without unnecessary risk of injury to passengers or Operators.

3.3.8.2 SANBAG has a strong preference for a vehicle structure that features a CEM design. In the event that this design does not meet the FRA Tier I crashworthiness and occupant protection standards, including the compressive (buff) strength requirements set forth in 49 CFR Section 238.203, the Contractor shall work with SANBAG to submit a waiver request to the FRA regarding these requirements. The waiver request will follow the format and requirements outlined in FRA's *Technical Criteria and Procedures for Evaluating the Crashworthiness and Occupant Protection Performance of Alternatively Designed Passenger Rail Equipment for Use in Tier I Service* report (ETF1).

3.3.8.3 The end structure shall be designed such that the risk of a collapsed structure penetrating the passenger or Operator compartment is minimized. Operator protection shall also be designed into the carbody structure.

The vehicle ends shall be designed to prevent overriding and telescoping of the vehicle into any passenger area in the event of a collision. The anti-telescoping structure shall include elements such as corner posts, collision posts, anticlimbers, and center sill. The design shall be effective against off-center collisions.

3.3.8.4 Anticlimbers shall engage under all track geometry and possible vehicle-to-vehicle head-on collision scenarios. Alternatively AVT requirements shall be applied.

3.3.8.5 Electrical equipment and wiring shall be configured in a manner that precludes any electrical shock hazard to passengers, Operators, or rescue personnel during and after collisions. Fuel systems, compressed air systems, and associated pipes and hoses for these shall be configured to minimize the possibility of rupture and fire during and after collisions.

3.3.8.6 Components vital to system operations such as fuel tanks, fuel lines, wiring, conduit, tubing, and hoses shall be mounted in a manner that will guard against impact from projectiles, especially in the vicinity of the trucks. Fuel tanks shall be designed, constructed, and installed to meet or exceed the requirements of 49 CFR Sections 229.9 and 238.223 and APTA Standard SS-C&S-007-98. Alternatively AVT requirements shall be applied.

3.3.8.7 The failure of one equipment support point shall not cause the equipment to violate the clearance envelope.

3.4 UNDERFRAME

3.4.1 The underframe is the primary load-bearing structure of the vehicle and typically includes bolsters, center sills, coupler anchors, side sills, floor beams, and end underframe structure (draft sill and end sill).

3.4.2 End Underframe

3.4.2.1 The end underframe structure shall be capable of transferring loads generated from passenger loading, couplers, and equipment under normal service conditions without permanent deformation.

3.4.2.2 The end underframe structure shall also be capable of supporting vertical loads resulting from jacking the vehicle at locations required for re-railing.

3.4.3 Collision Structure

3.4.3.1 The cab ends of the vehicle shall have a collision structure that may include, but is not limited to, full-height corner posts, collision posts, structural shelf, Operator's survival zone, and sheeting. Alternatively AVT requirements shall be applied.

3.4.3.2 Limitation of vehicle penetration shall be the governing parameter for design of the anti-telescoping structure, the end frame, and the end underframe. Of primary importance is the provision of a cab structure that maximizes the survivability of the Operator if a collision occurs.

3.4.4 Underfloor Equipment

3.4.4.1 Equipment mounted to the underframe of the vehicle shall conform to the spatial limits provided in Section TP 2.0, Design and Performance Criteria. Equipment attachments shall follow APTA Standard SS-C&S-034-99, Rev. 1, Section 5.7, requirements. Alternatively AVT requirements shall be applied.

3.4.4.2 The carbody and the attached equipment shall be designed to provide the necessary clearances for the truck and track profiles. The design must allow for 1.6-inch minimum clearance between carbody and all trucks parts, including wiring, hoses, cable, wheels, and chains, under the worst combination of wear, except for any stops attached to the carbody for limiting truck movement or for truck lifting during maintenance. Worst-case conditions may result from horizontal and vertical curves, track super elevation, worn wheels, maximum passenger load, roll, yaw, lateral motion, and suspension system failures.

3.4.4.3 Components vital to system operations such as fuel tanks, fuel lines, wiring, conduit, tubing, and hoses shall be mounted in a manner that will guard against impact from projectiles, especially in the vicinity of the trucks. Fuel tanks shall be designed, constructed, and installed to meet or exceed the requirements of 49 CFR Sections 229.93 and 238.223.

3.4.4.4 The failure of one equipment support point shall not cause the equipment to violate the clearance envelope.

3.5 CARBODY STRUCTURE

3.5.1 Cab Ends

3.5.1.1 The cab cars shall have an aerodynamically shaped front end, and shall be designed and constructed to meet or exceed the requirements of 49 CFR Section 238.209 and APTA Standard SS-C&S-034-99, Rev. 1, or successfully complete the waiver process outlined in FRA's *Technical Criteria and Procedures for Evaluating the Crashworthiness and Occupant Protection Performance of Alternatively Designed Passenger Rail Equipment for Use in Tier I Service* report (ETF1).

3.5.1.2 Suitable framing may be used to support or reinforce the enclosure. The enclosure shall be contoured to provide a profile with a modern, aerodynamic appearance that is aesthetically pleasing.

3.5.1.3 If a "plug-in" cab enclosure is used, the watertight seal between the main carbody and cab shell shall last for a minimum of 15 years under the loading and environmental conditions identified in these Technical Provisions. Joints formed primarily with caulking or sealant shall not be used.

3.5.1.4 The Contractor shall submit design data for proposed cab end configurations for review and SANBAG's approval **[CDRL 3-4]**.

3.5.2 Roof

3.5.2.1 In the vicinity of roof-mounted equipment and where maintenance personnel might stand, the roof shall support a concentrated load of 500 lbf (2,224 N) over an area of 0.75 ft^2 (0.07 m^2) without permanent deformation.

3.5.2.2 The structure shall be capable of sustaining any loads resulting from equipment loading, operating loads, and collision loads as defined in these Technical Provisions or referenced standards and regulations.

3.6 EQUIPMENT ENCLOSURES

3.6.1 Equipment supports and associated structure shall be designed to sustain the loads defined in Section TP 3.3.5.4 when the loads are applied at the center of gravity of the equipment.

3.6.2 Unless explicitly approved, equipment shall not be supported by bolts in tension or shear. Equipment supported by vibration isolators shall have safety straps that prevent equipment from dropping into the clearance envelope or falling from the roof.

3.6.3 Equipment enclosures shall be watertight as required and shall have covers that allow unrestricted access to internal components. Ventilation/drain hole(s) shall be provided to allow air circulation or water drainage but do not allow vermin to enter the enclosure.

3.6.4 Any exposed exterior surfaces of enclosures shall be painted to match the vehicle color scheme and shall comply with Section TP 19.12, Material and Workmanship. Interior surfaces of enclosures shall be painted with a light-colored paint. Potential electrical shock hazards and heated surfaces shall be clearly marked.

3.6.5 Equipment wells, if used, shall be capable of sustaining carbody and equipment loads, and shall be watertight to any interior compartment. Wells shall have proper drainage. Special attention shall be paid to ensure wells are corrosion resistant.

3.6.6 All roof-mounted equipment, if used, shall be masked or covered by a continuous shroud that is consistent with the exterior colors and styling of the vehicle. Shrouds shall be easily removable to enable access to roof-mounted equipment.

3.6.7 Any roof-mounted equipment surfaces that can be walked on shall be covered with an anti-slip coating or surface that will not trap or retain water.

3.6.8 Suitable shields or enclosures, meeting the requirements of 49 CFR Part 238 Appendix B as appropriate, must be provided for all equipment to isolate potential ignition sources from combustible materials and to control fire and smoke propagation.

3.6.9 Roof-Mounted Equipment

3.6.9.1 All control and power cables shall be terminated within enclosures or junction boxes.

3.6.9.2 Cable entry shall be by means of watertight sealing glands.

3.6.9.3 Glands, box covers, and cable terminations shall provide for cable replacement without the removal of lugs, terminals, or connectors from the wires.

3.6.9.4 High velocity air exiting from any ventilation equipment shall be directed away from the roof so as not to disturb dirt and debris.

3.6.9.5 Engine exhaust shall not be directed to the air intake of any other equipment or under a station canopy.

3.6.9.6 Exhaust air from equipment shall not be directed to the air intake of other equipment.

3.6.9.7 The requirement of Section TP 3.5.2.1 regarding loading shall apply to all roof-mounted equipment areas that can be walked on.

3.6.10 Interior Equipment

Equipment location and enclosure construction shall protect the equipment from dirt, conductive dust, and spilled liquids, including corrosive cleaning fluids.

3.7 COUPLING BETWEEN CARS

3.7.1 Strength Requirements

3.7.1.1 The coupler connection between the cars shall be capable of transmitting the peak vehicle loads without permanent deformation.

3.7.1.2 The coupler connection between the cars shall be designed with anti-telescoping and anticlimbing features such that cars remain aligned under collision loading.

3.7.2 Performance

The couplers shall connect the cars, provide support, and allow the vehicles to negotiate all horizontal, vertical, and spiral curves on SANBAG's track without damage, interference, or undue loading.

3.7.3 Gangway

3.7.3.1 An extruded, weather-tight, flexible diaphragm shall seal the passageway between the two cars. The diaphragm shall be water, oil, acid and alkali resistant, and shall comply with the fire safety requirements of Section TP 19.23, Flammability, Smoke Emission, and Toxicity**.**

3.7.3.2 The diaphragm shall be able to accommodate all curving and environmental conditions without interference, degrading, cracking, tearing, or separation from the vehicle. All necessary provisions shall be made to eliminate noise from the equipment.

3.7.3.3 The diaphragm shall maintain a tight seal to the opposing car end diaphragm under all conditions of curvature, turnouts, and crossovers encountered in normal passenger operation. The diaphragm shall not lose its sealing ability under the extreme temperature conditions specified in Section TP 2.0, Design and Performance Criteria.

3.7.3.4 The passageway through the connection shall be normally closed off by sliding doors on each side. These doors shall be self-closing after opening.

3.7.3.5 Pinch points, formation of large gaps during operation, sharp edges, openings, or trip hazards that could cause bodily harm to passengers are prohibited.

3.7.3.6 Walkway plates, hinged to the carbody, shall be provided at each non-cab end of each car to provide a continuous walkway from car to car.

3.7.3.7 The entire diaphragm and walkway arrangement, including construction details, shall be subject to review and acceptance by SANBAG.

3.7.3.8 Flammability and smoke emission of combustible diaphragm components shall be addressed according to 49 CFR Part 238, Appendix B.

3.7.4 Diesel Engine Exhaust

Diesel engine exhaust devices shall be located on the roof such that exhaust gases are not directed toward other intakes or under a station canopy. All engine exhaust stacks shall be constructed to prevent the entry of rainwater or snow whether the engine is running or not.

3.7.5 Rain Drainage

3.7.5.1 The design of the drainage system shall be aesthetically pleasing and shall blend with the overall appearance of the vehicle.

3.7.5.2 The drainage system shall be designed to prevent water from cascading down the side of the vehicle, especially over door openings and cab windows.

3.8 FLOORING

3.8.1 Floor Panels

3.8.1.1 The floor panels shall be constructed to resist carbody, passenger, and equipment loads experienced during normal service.

3.8.1.2 Panels shall be arranged such that joints align with main underframe structural members and shall be large enough to extend the full width of the vehicle.

3.8.1.3 Panel and joint arrangement shall allow for replacement of panels at door areas. Proper sealing and dissimilar metal protection shall be provided at panel-to-carbody joints. Anti-squeak material shall also be provided at these joints.

3.8.1.4 Panels shall be securely attached to carbody structural members. Corrosion-resistant fasteners shall be used on the perimeter of the panel for attachment to the structure. Alternate floor attachment methods may be used, subject to SANBAG's approval.

3.8.1.5 All floor penetrations shall be completely sealed in a manner approved by SANBAG.

3.8.1.6 All panels shall fully comply with 49 CFR Part 238 Appendix B. Under a dead load of AW4 passenger loading, located to produce maximum deflection, floor panels shall deflect no more than 1/250 of short span between supports. Installed panels shall have height variations at panel joints no greater than 0.8 mm (0.03 inch).

3.8.1.7 The fire resistance of the entire floor assembly shall be for a minimum duration of fifteen (15) minutes, and shall meet the fire endurance requirements specified in 49 CFR Part 238 Appendix B and ASTM E-119.

3.8.1.8 Flammability, smoke emission, and toxicity shall meet requirements of Section TP 19.23, Flammability, Smoke Emission, and Toxicity.

3.9 INSULATION

The Contractor shall provide thermal and acoustic insulation on the passenger vehicle as required to meet the interior noise and air-comfort performance requirements of these Technical Provisions. Vertical and horizontal posts shall be properly thermally insulated.

3.9.1 Thermal Insulation

3.9.1.1 Thermal insulation shall be installed against the inboard surface of the vehicle's ceiling/roof, floor ("belly pan"), ends, and sidewall exterior carbody structure.

3.9.1.2 Insulation used in the ceiling, sides, and ends shall be retained in position by approved mechanical fastenings. The individual sheets shall be as large as possible. "Blow-in" insulation will not be acceptable.

3.9.1.3 Underfloor thermal insulation shall be protected by a corrosion-resistant sub-floor of a minimum thickness of 0.030 inches (0.8 mm).

3.9.1.4 Thermal insulation shall not mold, rot, or sustain vermin. Fibers, where used, shall be bonded together with a thermosetting phenolic resin. Insulation shall not corrode any metals or "shake down" under vehicle vibration in long service. It shall not have an odor or be capable of absorbing odors. Insulation shall be light in weight, and type and density shall be approved by SANBAG. Insulation must not support combustion, must not absorb moisture beyond its own weight, and, when wet, must not cause corrosion.

3.9.1.5 Insulation used shall be non-corrosive to adjacent materials and must not require special surface treatment of aluminum.

3.9.1.6 Thermal breaks shall be provided in locations where it is necessary to interrupt an all-metal path between the interior of the carbody and the outside of the carbody skin.

3.9.1.7 Prior to insulating the first production or pilot vehicle, the Contractor shall provide an analysis to SANBAG to demonstrate adequacy **[CDRL 3-5].**

3.9.1.8 The thermal insulation shall meet the smoke and flammability requirements of Section TP 19.23, Flammability, Smoke Emission, and Toxicity.

3.9.2 Acoustical Insulation

3.9.2.1 The vehicle shell structure shall be provided with a vibration and sound-damping material applied to inner surfaces, including sub-floor, car ends, roof, and side frames.

3.9.2.2 All cars shall be well insulated against sound transmission inside the car to the greatest extent practicable. The inside surface of the outer shell of the car, including sides, ends, roof, and floor areas and the underside of all metal steps shall be coated with sound deadener in accordance with the manufacturer's recommendations.

3.9.2.3 The acoustic insulation shall meet the smoke and flammability requirements of Section TP 19.23, Flammability, Smoke Emission, and Toxicity.

3.10 WINDOWS

3.10.1 General

3.10.1.1 Windows shall be capable of withstanding external and internal pressure differentials caused by head-on pressures and passing trains while the vehicles are at maximum operating speed. All window sizes and locations are subject to SANBAG's approval.

3.10.1.2 Passenger compartment side windows shall comply with FRA Type II requirements.

3.10.1.3 All glazing shall meet or exceed the requirements of FRA regulations in 49 CFR Parts 223 and 238.

3.10.1.4 Emergency window exits shall be supplied as required by 49 CFR Section 238.113. Location of these windows is subject to SANBAG's approval.

3.10.1.5 Decals providing instruction for window removal shall be applied to the exterior of the car, adjacent to each window with a pull ring filler strip.

3.10.1.6 The glazing material for the escape sash shall be the same type as used in passenger compartment side windows (reference Section TP 3.10.1.2). Instructions for opening the escape sash shall be posted on the operating bar of each escape sash in high performance photo luminescent material complying with APTA Standard SS-PS-002-98.

3.10.1.7 All windows shall be watertight without the use of sealing compounds and must remain so under normal service loading conditions, including diagonal jacking.

3.10.1.8 Glazing shall be replaceable to a watertight condition. The replacement procedure shall be as simple as possible.

3.10.1.9 All glazing materials shall meet the requirements of Section TP 19.6.5, Glass.

3.10.1.10 The glazing design and replacement procedure shall be submitted to SANBAG for approval **[CDRL 3-6]**.

3.10.2 Cab Side Window

3.10.2.1 The cabs shall have watertight glazing on both sides; windows shall be of the same construction as the passenger compartment side windows. The windows shall be of sufficient size to allow an Operator in the 5th to 95th percentile to:

a) Have a field of view as defined in SAE J1050

b) See a human 3.5 foot (1 m) tall standing 2 foot (610 mm) from the side on a platform and in a plane formed by the back of the Operator's seat

3.10.2.2 A sliding or hinged window shall be provided on each side of the cab. The window shall latch closed from the inside of the cab only. The Operator shall be able to use each side window to look back along the train to verify that the doors are clear and safe to close.

3.10.2.3 The side window assembly shall be integrated with the vehicle design.

3.10.3 Windshield

3.10.3.1 Windshield glazing shall comply with the requirements of 49 CFR Part 223, Type I, and shall have no coloring or tinting. The windshields shall be sized to allow an Operator in the 5th percentile female to 95th percentile male of the general population, as defined in MIL-STD-1472D:

a. The maximum possible amount of view in all directions

b. A minimum vertical upward view of not less than fifteen (15) degrees

c. A downward view sufficient to see a human 3.5 foot (1 m) tall standing 5 foot (1.5m) from the leading surface of the coupler, which (if required) may be achieved using additional means, subject to SANBAG's approval.

3.10.3.2 The cab car's front end shall be cosmetically treated to optically blend the windshield into the overall cab end front shape and design.

3.10.3.3 Visible glare or reflections on the windshield, including reflections from interior lighting during night operation, shall be minimized.

3.10.3.4 Windshields shall be replaceable from the outside of the vehicle.

3.11 SAFETY APPLIANCES AND EXTERIOR HANDHOLDS

3.11.1 The Contractor shall submit to SANBAG detailed drawings of all safety appliances and exterior handholds showing the device, its location on the car, and its method of attachment **[CDRL 3-7].**

Safety appliance construction and location shall comply with the requirements outlined in 49 CFR Part 231.

3.12 DELIVERABLES

The contract deliverables required by this section of the Technical Provisions are summarized below.

CDRL 3-1	Vehicle exterior color scheme (TP 3.2.8.1)
CDRL 3-2	Stress analysis for carbody and supports (TP 3.3.5.1)
CDRL 3-3	Stress analysis for jacking and hoisting provisions (TP 3.3.7.2)
CDRL 3-4	Proposed cab end configuration (TP 3.5.1.4)

CDRL 3-5 Demonstration of thermal insulation adequacy (TP 3.9.1.7)

CDRL 3-6 Glazing design and replacement procedure (TP 3.10.1.10)

CDRL 3-7 Safety appliances' and exterior handholds' location on the car and method of attachment (TP 3.11.1)

END OF SECTION

4.0 COUPLER AND DRAFT GEAR

4.1 CITED REFERENCES

49 CFR Section 238.207	FRA Passenger Equipment Safety Standards – Link between coupling mechanism and carbody
APTA SS-C&S-005-98	Standard for Carbody End Compressive Strength for Railroad Passenger Vehicles

4.2 GENERAL

4.2.1 Each end of each vehicle shall be equipped with a fully automatic mechanical, pneumatic, and electrical coupler system of the symmetrical, automatic, slack-free type. Automatic isolation and shutoff of trainlined air shall be provided during normal coupling and uncoupling operations. It shall also be possible to isolate or shut off the trainlined air manually.

4.2.2 All hardware shall be made of corrosion-proof materials or shall be protected from corrosion.

4.3 COUPLER OPERATION

4.3.1 General

4.3.1.1 The coupler system shall permit vehicles loaded at AW3 to operate over all segments and track configurations of the alignment, as described in Section TP2.8, Wayside Characteristics, in consists of up to 2 maximum length trains, without permanent deformation to the vehicles or couplers.

4.3.1.2 Revenue service operations will include frequent coupling and uncoupling to change train length for peak and off-peak service.

4.3.1.3 The coupler shall be designed and constructed to permit coupled vehicles to negotiate all horizontal and vertical curves specified in Section TP 2.0, Design and Performance Criteria, including operations with maximum mismatch between vehicles due to spring deflection, wheel wear, suspension failure, and track irregularities. Under no conditions shall the couplers interfere with truck parts, wheels, cables, or other equipment.

4.3.1.4 The coupler shall have an indicator that shall show visually that locking of mated couplers has been completed.

4.3.2 Coupling/Uncoupling

4.3.2.1 The operation of the coupler shall be completely automatic when coupling.

4.3.2.2 With one command from the cab or coupling station adjacent to the coupler, uncoupling shall enable sequential electrical and mechanical head uncoupling. Uncoupling shall be possible only when the train is in zero speed condition.

4.3.2.3 Mechanical and electrical coupling at speeds up to at least 2 mph (3.2 km/h) shall be possible from any vehicle end to any adjacent vehicle end (i.e., no “handed” couplers are permitted) without damaging any of the components. Higher allowable coupler speeds are preferred.

4.3.2.4 If a pneumatic uncoupling method is used, a properly sized exhaust choke shall be included in the “uncoupling” pneumatic control line to prevent unrequested uncoupling as a result of leakage past the control valve seats due to pressure buildup. The exhaust choke shall also serve as an audible indicator of both unwanted leakage and of a commanded uncoupling.

4.3.3 Manual Operation

4.3.3.1 Devices shall be provided to permit manual electrical isolation and mechanical uncoupling of the train without requiring a person to stand between the vehicles.

4.3.3.2 Provision shall be made for disconnecting the electrical trainlined connections only, without mechanical uncoupling.

4.3.3.3 When uncoupled and without lubrication, the drawbar and coupler assemblies shall move laterally when a force of not more than 75 lbf (333.6 N) is applied laterally to the face of the coupler head.

4.4 ELECTRIC COUPLER

4.4.1 General

4.4.1.1 The electrical coupler heads shall be either retractable or a combination of fixed electrical head and a separate remotely operated trainline isolator.

4.4.1.2 The electrical coupler shall be capable of making all necessary low-voltage connections between adjacent trains to permit control of all vehicles in a train from the leading cab. Each circuit connected through the electric coupler shall have redundant contacts on each side of the coupler's centerline.

4.4.1.3 It shall be possible to isolate the electrical coupler contacts using a switch at the console (as defined in Section TP 5.8, Console Switches). It shall also be possible to restore the electrical coupler contacts using the same switch.

4.4.1.4 Provisions shall be made for some trainlines to be fixed but manually isolatable through a single switch located at a position subject to SANBAG's approval. Choice of the fixed trainlines shall be subject to SANBAG's approval.

4.4.1.5 The electrical coupler heads, in the coupled configuration, shall maintain positive contact under all permissible operating conditions. The electrical coupler heads shall also be able to sustain impacts from all permissible operating and coupling conditions.

4.4.1.6 Provision shall be made to safeguard the electric coupler heads from damage in case they are improperly aligned during coupling. A gasket shall be provided around the periphery of the insulating block to keep dirt and moisture from entering between mated couplers. The gasket shall be provided with a drain or other approved means so water that may have entered between mated couplers is not retained.

4.4.1.7 The Contractor shall provide a diagram identifying locations of pins and legends for wired trainlines **[CDRL 4-1]**.

4.4.2 Covers

4.4.2.1 Each electric coupler shall be provided with a cover that will protect the coupler contacts when in the uncoupled position under all weather conditions. The cover shall automatically close during the uncoupling cycle and shall open automatically during the coupling cycle.

4.4.2.2 The cover shall be marked "No Step"; however, it shall not be damaged if used occasionally as a step by maintenance personnel. Means to hold the covers open for maintenance shall be provided.

4.5 MECHANICAL COUPLER

4.5.1 Strength

4.5.1.1 All parts of the coupler on which it is possible to stand shall withstand a vertical force of 360 lbf (1,600 N) without deformation.

4.5.2 Gathering Range

4.5.2.1 The minimum gathering range of the mechanical coupler shall be ±4.5 in (±114 mm) in any direction.

4.5.3 Centering

4.5.3.1 The coupler shall have a self-centering device that retains the unconnected coupler head within its gathering range, to enable automatic coupling upon buffing two vehicles together.

4.5.3.2 The self-centering device shall include an override to allow manual movement of the coupler for coupling at track locations outside the gathering range of the coupler.

4.5.3.3 The centering device shall prevent the coupler from swinging transversely when it is not coupled.

4.5.4 Vertical Support

4.5.4.1 The coupler shall be supported in the vertical direction to maintain nominal height above top of rail and to comply with the requirements of 49 CFR Section 238.207, latest revision.

4.5.4.2 The supporting device shall provide a suitable means for vertical height adjustment of the coupler head to compensate for wheel wear and coupler assembly wear.

4.5.5 Anchorage

4.5.5.1 The anchorage and its attachment to the vehicle underframe shall be designed and constructed in compliance with the latest revision of 49 CFR Section 238.207 and the relevant sections of APTA Standard SS-C&S-005-98, and shall withstand any loads the coupler can transmit to them. Alternatively AVT requirements shall be applied.

4.5.5.2 If required to meet the conditions of 49 CFR Section 238.207, a vertical draft gear support may be proposed.

4.5.5.3 Within the specified requirements for anchorage strength, the coupler and draft gear arrangement shall feature a shear/buffer mechanism that will provide additional energy absorption as described in Section TP 4.6.2, Energy Absorption Feature. This equipment is intended to allow compression of the coupler and draft gear arrangement during impact cases that are sufficient to exceed the requirements stated in Section TP 4.6.2.2, but insufficient to buckle or permanently deform the carbody end structure.

4.5.6 Wear

4.5.6.1 Shims, replaceable bushings, wear plates, or other means of compensating for wear shall be installed at locations of high wear.

4.5.6.2 Parts requiring lubrication should be avoided. The use of parts requiring lubrication must be approved by SANBAG. If SANBAG approves use of such parts, they shall require lubrication no more than once every 15,000 miles (24,000 km).

4.5.6.3 The Contractor shall supply six sets of the coupler manufacturer's recommended gages for checking the dimensions and surfaces important for the proper operation of the coupler.

4.6 DRAFT GEAR

4.6.1 General

The coupler shall provide cushioning that is effective in both buff and draft.

4.6.2 Energy Absorption Feature

4.6.2.1 Energy absorption and automatic release capability shall be provided.

4.6.2.2 The coupler system and mountings shall be capable of withstanding all forces caused by coupling a train at AW3 loading and traveling at 2 mph (3.2 km/h) with a stationary train loaded at AW3 and assumed to have parking brakes applied, without automatic release or permanent deformation. Higher allowed coupling speeds will be preferred. Any permanent deformation to or automatic release of the coupler shall be detectable from trackside.

4.6.2.3 The energy absorption feature and anticlimber travel shall be coordinated to optimize coupler energy absorption while ensuring that the anticlimbers engage prior to the end of the energy absorption feature travel.

4.6.2.4 Following automatic release, the coupler shall be retained so that it does not separate completely from the carbody or protrude into the track bed or penetrate the vehicle floor.

4.6.2.5 Neither the released coupler nor any of its components shall prevent the anticlimbers from engaging fully.

4.6.2.6 The Contractor shall submit a description of, and calculations for, the energy absorption release feature **[CDRL 4-2]**.

4.7 DELIVERABLES

Contract deliverables required by this section of the Technical Provisions are summarized below.

CDRL 4-1 Diagram identifying electric coupler pins and legends for wired trainlines (TP 4.4.1.7).

CDRL 4-2 Description of and calculations for the energy absorption and automatic release feature (TP 4.6.2.6).

END OF SECTION

5.0 OPERATOR'S CAB

5.1 CITED REFERENCES

49 CFR Part 229	Railroad Locomotive Safety Standards
49 CFR Section 238.237	Automated Monitoring
APTA RT-S-VIM-026-12	Rail Transit Vehicle Passenger Emergency Systems
APTA SS-C&S-011-98	Standard for Cab Crew Seating Design and Performance
IEEE 1482.1	Standard for Rail Transit Vehicle Event Recorders
MIL-STD-1472	Human Engineering Design Criteria
SAE J1050	Describing and Measuring the Driver's Field of View

5.2 GENERAL

5.2.1 Each vehicle shall be provided with two cabs, one at each end of the vehicle, with a full-width Operator's cab, equipped with an Operator's console, controls, and other apparatus and equipment required to operate a single vehicle or a multiple unit train.

5.2.2 Unless otherwise defined in this Technical Specification, all operating stations shall conform to all applicable FRA, AAR, and APTA standards and recommended practices for cab arrangements.

5.2.3 The cabs and control stations shall be free of sharp edges, protruding objects, safety hazards, and floor obstructions as required by EN 16186, latest revision. No recesses, crevices, joints, or other areas in which liquids, paper, dust, or other debris could accumulate shall be permitted.

5.3 OPERATOR CAB LAYOUT

5.3.1 Each Operator cab shall accommodate an Operator and an Guard.

5.3.2 The cab shall be designed to provide an Operator's and Guard's field of view (windshield and side windows), as specified and measured in accordance with SAE Standard J1050. Glare on the inside of the windshield shall be minimized. Blind spots due to corner posts and similar structural elements shall be kept to an absolute minimum to ensure that Operator and Guard have a clear view of the right-of-way in front of the vehicle.

5.3.3 The cab shall be separated from the passenger compartment by a partition across the entire width of the vehicle. The layout, style, and colors of the partition shall blend with the design of the passenger compartment.

5.3.4 A manually operated hinged door shall be provided in the cab partition. The door shall be equipped with latch and lock, and shall be free from rattles when closed.

5.3.5 The door shall automatically latch and lock in the closed position. The door lock shall be unlocked from the passenger side with a key and with a quick release mechanism from within the cab. Cab doors locks will be subject to SANBAG's approval.

5.3.6 For vehicle coupling, means shall be provided to enable Operators ranging from a 5th percentile female to a 95th percentile male (per MIL-STD-1472) to view the position of the coupler head. The Operator may be in a standing position to achieve this requirement. The Contractor shall submit the proposed design for SANBAG's approval **[CDRL 5-1]**.

5.3.7 All controls in the cab shall be located within easy reach of Operators ranging from a 5th percentile female to a 95th percentile male (per MIL-STD-1472). Alternatively standards TSI LOC PAS RST CR, UIC 612, and UIC 651 may be applied.

5.3.8 The Contractor shall provide an analysis to SANBAG to demonstrate compliance with the principles of human engineering as recommended in the references cited in Section TP 1.6, Industrial Designer/Human Engineering **[CDRL 5-2]**.

5.3.9 Equipment requiring scheduled access more often than once a year shall be readily accessible through hinged access panels, sized and located for convenient opening and access to the equipment.

5.3.10 All ceiling access panels shall be equipped with safety devices to prevent sudden dropping. The number of access panels shall be as small as possible, consistent with functional requirements. Ceiling panels shall be adequately supported to prevent sagging and drumming. Ceiling panels shall be supported by hangers welded to the roof structure.

5.4 OPERATOR'S CONSOLE

5.4.1 The Operator console in the Operator cab shall have non-reflective surfaces on any exposed side.

5.4.2 One-piece console surface designs are preferred. Alternative modular solutions may be proposed for SANBAG's approval.

5.4.3 The console and console modules shall be readily removable to permit access to mounted components, wiring or piping.

5.4.4 All switches, pushbuttons, controls, and indicators required for proper operation of the vehicle shall be located on the Operator's console unless otherwise specified.

5.4.5 Warning indications shall be located in the primary field of vision of the Operator.

5.4.6 Audio signals shall be sufficiently different from each other so the Operator is able to readily recognize each of them.

5.4.7 The console layout and equipment described in this section represent the preferred requirements for these functions. The Contractor shall submit the proposed console design and layout for SANBAG's approval **[CDRL 5-3]**. The submittal shall include technical details, catalog cuts, and samples (where possible) of the proposed console equipment.

5.5 MASTER CONTROLLER

5.5.1 The master controller shall be approved by SANBAG.

5.5.2 A handle shall be provided to control the propulsion and friction braking systems via the propulsion and brake trainlines. The master controller shall operate longitudinally, in a linear manner, with maximum power in the forward-most position and emergency brake in the rear-most position. Rotation is permitted in the vertical plane.

5.5.3 The handle shall be designed to minimize strain and fatigue on the Operator.

5.5.4 Deadman Feature

5.5.4.1 A deadman feature shall be provided.

5.5.4.2 If the master controller handle is not in its operating position, motion shall be prevented in a fail-safe manner, such as disconnection of propulsion and service brake trainlines. It shall not be possible to latch or fasten the master controller handle in its operating position; continuous Operator effort shall be required to hold the handle in its operating position.

5.5.5 Trainline Control

5.5.5.1 The master controller shall provide signal input to the propulsion and braking trainlines, as indicated in Section TP 2.15, Control and Interlock Signals.

5.5.5.2 The master controller shall control track brake and sanding trainlines such that, when in the emergency brake position, all track brakes are applied and sand is dropped in front of the leading wheels of the lead truck of each vehicle.

5.5.5.3 Placing the controller in the emergency brake position shall not cause any momentary reduction in braking effort.

5.5.6 Interlock

5.5.6.1 The master controller shall be interlocked so that the master controller handle cannot be moved from the "Neutral" if the reverser switch is in the "Neutral" position.

5.6 OPERATOR'S CONTROL SWITCH

5.6.1 A three-position switch shall be provided with the following positions: "Neutral," "Forward," and "Reverse."

5.6.2 A key shall be required to move the control switch out of the "Neutral" position. This key shall be removable from the lock only when the control switch is in the "Neutral" position. The vehicle or train parking brakes shall be applied automatically with the control switch in the "Neutral" position. This function shall be trainlined. The key shall enable train operation and automatically locking out other cabs.

5.6.3 The Operator's control switch shall be prevented from moving unless the master controller is in the neutral position and the train is at zero speed.

5.7 SPEED INDICATOR, EVENT RECORDER, AND ALERTER

5.7.1 Speed Indicator System

5.7.1.1 The Contractor shall submit for SANBAG's approval detailed information on the speed indicator system **[CDRL 5-4]**.

5.7.2 Event Recorder

5.7.2.1 One event recorder with hardened (crash) memory shall be installed on each vehicle to record operating parameters of the vehicle. Hardened (crash) memory can be a separate recording module connected to the main event recorder by a high-speed data link, or it can be integral with the recorder. The event recorder equipment shall comply with the requirements of IEEE 1482.1-1999 and with all applicable requirements as defined in 49 CFR Part 229. In case of conflict between the requirements, the more stringent shall prevail.

5.7.2.2 The event recorder system shall be configured to operate in a fail-safe manner, whereby the loss of power shall cause a penalty brake application.

5.7.2.3 The Contractor shall submit for SANBAG's approval complete data on the event recorder design, operation, and functionality, including the finalized list of recorded parameters **[CDRL 5-5]**.

5.7.3 Alerter System

5.7.3.1 An alerter system shall be provided. The alerter system shall monitor the Operator's action.

5.7.3.2 The alerter shall require periodic reset by the Operator as defined below. If the alerter is not reset, flashing lights and increasing levels of audible alarm on the system alarm panel shall be initiated.

5.7.3.3 If the alerter is not reset as required, a penalty brake application shall be triggered.

5.7.3.4 The Contractor shall submit for SANBAG's approval complete data on the alerter design, operation, and functionality **[CDRL 5-6].**

5.8 CONSOLE SWITCHES

5.8.1 The function of each console switch shall be clearly identified. The position and identification of each switch shall be visible at all times, including at night and when the vehicle is operating in direct sunlight.

5.8.2 Switches and controls shall not pose a hazard to the Operator.

5.8.3 Design, arrangement, and location of switches and pushbuttons shall preclude unintended activation.

5.8.4 Gauge, switch, and annunciator illumination shall be adjustable by a console light control switch.

5.8.5 Emergency Stop Pushbutton

5.8.5.1 An emergency stop control shall be provided. It shall be a large, red, illuminated, mushroom-shaped, latching pushbutton.

5.8.5.2 Activation of this pushbutton shall initiate an irretrievable emergency brake application and shall illuminate the button.

5.8.5.3 The emergency stop pushbutton shall be active at all control stations of a train regardless of control switch position.

5.8.5.4 When this pushbutton is pulled back to its normal position (reset) and the zero speed signal is present, emergency braking control shall be reset, so long as no other emergency braking request is active.

5.8.6 Engine Emergency Shutdown

A trainlined emergency engine shutdown switch shall be provided at each control station to rapidly shut down all engines on a vehicle or train upon activation. This switch function shall be latched and shall require manual resetting. The function of this switch shall be replicated by clearly marked switches accessible from the outside of the vehicle, one at each vehicle end, diagonally opposed.

5.9 CONSOLE ANNUNCIATION

5.9.1 Console visual indicators and an audible annunciator shall be mounted on the Operator console. The nomenclature of each indicator shall be readable when the indicator is de-energized. The color coding of all visual indicators shall be presented to SANBAG for approval during Final Design Review.

5.9.2 All indicator lights shall be of the "push-to-test" variety.

5.10 BYPASS AND CUTOUT SWITCHES

5.10.1 Bypass switches shall be provided at a minimum for the following functions:

a. Zero speed bypass, allowing door operation with the zero speed detection circuit inoperative

b. Door/traction interlock bypass

c. Propulsion/friction brake interlock bypass

5.10.2 The following cutout switches, at a minimum, shall be provided in the cab:

a. Sanding cutout (for each truck)

b. Auxiliary power supply (APS) cutout (for each vehicle)

5.11 COUPLER CONTROL

5.11.1 Coupler controls shall be provided to enable a single Operator to uncouple two coupled vehicles from cabs adjacent to the coupler without leaving the cab

5.11.2 Separate controls shall be provided to allow isolation of electrical trainlines through the coupler

5.11.3 The method of achieving single-Operator coupling shall be submitted for approval by SANBAG at Preliminary Design Review.

5.11.4 These requirements need not be met for coupling on curves where the alignment of the couplers is outside of the gathering range specified in Section TP4.5.2, Gathering Range, or where a vehicle is without auxiliary and battery power.

5.12 WARNING DEVICES

5.12.1 Warning Horn

5.12.1.1 Cab cars shall have warning horns installed at each cab end. The horn arrangement shall be subject to SANBAG's approval during Preliminary Design Review.

5.12.1.2 Horn controls shall be provided in each cab. The horn controls shall operate in the active cab only.

5.12.1.3 If pneumatic horns are supplied, provision shall be made for a cutout valve in the air line to each horn. The cutout valve must be located in an easily accessible position.

5.12.1.4 The horn sound shall be railroad style and not easily confused with a truck or automobile horn. The horn shall also be quick-acting so that there is no delay in the buildup to full volume when activated.

5.12.1.5 Activation of the horn shall require minimum movement by the Operator or Guard from the normal operating position and shall be possible without releasing the master controller.

5.12.1.6 The horn system shall have the necessary provisions to interface with the positive train control (PTC system), as described in Section TP 14.0, Positive Train Control System.

5.12.1.7 The horns shall comply with the requirements of 49 CFR Section 229.129.

5.12.2 Warning Bell

5.12.3 Cab cars shall be equipped at each cab end with an electric or pneumatic bell.

5.12.4 Bell control shall be arranged so that the bell can be operated manually at any time or be activated whenever the warning horn is activated.

5.12.5 The warning bell control shall be combined with the alternating flashing auxiliary lights such that the bell rings once with every light alternation. The alternating flashing auxiliary lights shall comply with 49 CFR Section 229.125 (e)(2).

5.13 WINDSHIELD WIPER/WASHER

5.13.1 Windshield wipers shall be provided for the windshield(s) at each cab end.

5.13.2 The wiper shall keep windshield conditions from jeopardizing safe and comfortable vehicle operation.

5.13.3 The wiper blades shall return to the park position at the extreme ends of their sweep in the "Off" position.

5.13.4 The operating mechanism of the drive units shall be enclosed.

5.13.5 The performance of windshield wipers and motors shall be compatible with the maximum rainfall rate defined in Section TP2.10, Environmental Criteria.

5.13.6 The windshield washer shall be located such that it can be filled from ground level outside the vehicle. The washer pump shall be self-priming.

5.14 REARVIEW MIRROR

A rearview mirror shall be provided at the front of each cab sliding sash.

5.15 CLOSED-CIRCUIT TELEVISION CAMERAS

5.15.1 Each end of the vehicle shall be fitted with at least one forward-facing closed-circuit television (CCTV) camera to record pedestrians and road vehicles ahead of the vehicle.

5.15.2 Each end of the vehicle shall be fitted with at least one rearward-facing CCTV camera on each side of the vehicle four () total. These cameras shall be capable of clearly showing the door status lights on all doorways along the side of a train and shall have a sufficient field of view to show the entire area of the doorway closest to the camera.

5.15.3 The cameras shall record images continually while the vehicle is powered. Image recording equipment will be provided in each vehicle sufficient to capture 24 hours of operation before overwriting.

5.15.4 All cameras shall meet the requirements of APTA RT-S-VIM-026-12.

5.15.5 Video monitors

5.15.5.1 A pair of color monitors or a single larger split screen color video monitor shall be fitted in the cab desk directly in front of the Operator for viewing all internal and external camera images.

5.15.5.2 The monitor(s) shall be as large as possible, with a minimum diagonal length of 6 inch (150 mm).

5.15.5.3 The monitor(s) shall be active only in the selected lead cab.

5.15.5.4 Signals from the left-side camera should be displayed on the left-side monitor or the left side of the screen, and signals from the right-side camera should be displayed on the right. The coupling camera should be displayed on the left.

5.16 OTHER EQUIPMENT

5.16.1 Convenience Outlet

A convenience outlet shall be installed in each cab in accordance with Section TP9.6.1, Convenience Outlets.

5.16.2 Burn-Out Detector

A burnout detector shall be provided in an approved location within the control cab. The detector shall indicate when there is a burnout of either headlight or either ditch light.

5.16.3 Sun Visors

5.16.3.1 Two windshield sun visors shall be provided in each cab. They shall be mounted above the windshield, one in front of the Operator position and the other in front of the Guard position.

5.16.3.2 One additional adjustable sun visor shall be provided over each sliding sash in the Operator cabs.

5.16.3.3 The sun visors shall be of a type used previously in a railroad environment, and shall be subject to SANBAG's approval.

5.16.4 Fire Extinguisher

One dry chemical fire extinguisher shall be provided in each operating cab in a readily accessible location that will not result in accidental activation. The fire extinguisher shall be mounted in a quick-release holder in an approved location.

5.16.5 Cup Holders

Both the Operator side and the Guard side of each cab shall be fitted with a single cup holder. The cup holders shall be mounted within easy reach of the seated Operator or Guard in an area where no equipment necessary for the operation of the train could be damaged from an accidental spill.

5.17 OPERATOR'S SEAT

5.17.1 Each cab shall be equipped with an Operator's and Guard's seat of a design that has a history of proven successful transit service.

5.17.2 The seat shall comply with the requirements of APTA Standard SS-C&S-011-98 and shall be adjustable vertically and in a forward/backward direction to allow full visibility for all Operators, as stipulated in Section TP 5.3, Operator Cab Layout. The Operator seat shall swivel 90° from the forward-facing position to the left. The Guard seat shall swivel 90° from the forward facing position to the right. There shall be detents for the forward and the 90° left and right positions.

5.17.3 Seat adjustment controls shall be operable from the seated position.

5.17.4 The Contractor shall submit Operator and Guard seat drawings and samples of seat covering material for review and approval **[CDRL 5-7]**.

5.18 POSITIVE TRAIN CONTROL EQUIPMENT

Each cab shall be designed to include mounting brackets, console space, additional switches and wiring, and other equipment as outlined in Section TP 14.0, Positive Train Control System.

5.19 DELIVERABLES

The deliverables required by this section of the Technical Provisions are summarized below.

CDRL 5-1	Design to enable view of coupler head (TP 5.3.6)
CDRL 5-2	Human engineering analysis (TP 5.3.8)
CDRL 5-3	Operator's console design, equipment, and layout (TP 5.4.7)
CDRL 5-4	Speed indicator system information (TP 5.7.1.1)
CDRL 5-5	Event recorder design information (TP 5.7.2.3)
CDRL 5-6	Alerter system design information (TP 5.7.3.4)
CDRL 5-7	Operator's and Guard's seat drawings and material sample (TP 5.17.4)

END OF SECTION

6.0 DOORS

6.1 CITED REFERENCES

APTA Standard SS-C&S-012-02	Recommended Practice for Passenger Car Door Systems for New and Rebuilt Passenger Cars
APTA Standard SS-PS-002-098	Standard for Emergency Signage for Egress/Access for Passenger Rail Equipment
EN 50155	Electronic Equipment Used on Rolling Stock
MIL-STD-1472	Human Engineering Design Criteria
NFPA 130	Standard for Fixed Guideway Transit Systems
49 CFR 38	ADA

6.2 GENERAL

6.2.1 The door system shall be designed and manufactured for fail-safe operation.

6.2.2 The door system and its components shall meet the requirements of the latest revision of APTA Standard SS-C&S-012-02 and shall comply with the requirements of all applicable standards and regulations referenced therein.

6.2.3 Doors shall be marked as emergency exit in accordance with APTA Standard SS-PS-002-098, latest revision.

6.2.4 The door panels shall maintain both the internal and external vehicle aesthetics to the largest extent possible when closed.

6.2.5 Door system equipment that must be accessed for routine maintenance shall be designed so that a maintenance technician can reach the maintenance points within 3 min using only standard hand tools.

6.2.6 Safe operation of the door system shall not depend on correct functioning of control software. The door control may use microprocessors, but safety-related functions must employ independent hard-wired controls.

6.2.7 The passenger door system control interfaces with other vehicle systems shall be designed and constructed using fail-safe principles and isolation provisions to prevent the door control and status indication system from accepting incorrect signals or commands.

6.2.8 The door controls and all door equipment shall be interchangeable among like doorway positions and among vehicles. The door control system shall be designed in accordance with the safety requirements of Section TP 20.4, Safety and Regulatory Requirements.

6.3 PASSENGER DOOR DESIGN CRITERIA

6.3.1 General

The vehicle and its door system shall comply with the requirements of the ADA and be designed to accommodate a range of people from the 5th percentile female to the 95th percentile male of the general population, as defined in MIL-STD-1472.

6.3.2 Door Panels

6.3.2.1 Door window glass and installation shall conform to the requirements of Section TP 19.6.5, Glass.

6.3.2.2 The door panels shall be of a sealed design and shall not require drain holes in the panel structure.

6.3.2.3 The door panels shall be lightweight, acoustically and thermally insulated, and internally reinforced.

6.3.2.4 The door panels shall be positively retained at both the top and bottom while in the closed position, even during loss of power.

6.3.2.5 The door panel skin, structure, and mounting hardware shall be of an ample gauge to provide proper strength and rigidity to sustain a concentrated load of 200 lbf (890 N) applied perpendicularly to the plane of the door at any location on the panel, with the door panel installed on the vehicle. The load bearing surface shall be 4 in (102 mm) by 4 in (102 mm) for this requirement. The allowable maximum deflection under these conditions with the door simply supported at the top and bottom shall be limited to 3/8 in (9.5 mm) maximum with no permanent deformation after the force is removed.

6.3.3 Door Operator

6.3.3.1 The door operator shall have sufficient power to reliably open and close the doors under the most unfavorable ambient wind and vehicle pressurization conditions.

6.3.3.2 The drive shaft or linkage shall be concealed so that it is not directly visible when the door is in the fully closed position. The linkage and pivot points shall be provided with permanently lubricated bearings and fittings.

6.3.3.3 The door hangers and carriers shall be of a sturdy, service-proven design. Bearings shall be sealed and shall have a minimum service life of 5 years.

6.3.3.4 The door drive and support system shall be designed and constructed to ensure that, over the design life of the door system, the door closed position tolerance remains within the door closed sensing system tolerance.

6.3.3.5 The door operator motors, and gearboxes if required, shall be service-proven on door panels similar to those of SANBAG's vehicle in size and weight.

6.3.3.6 Electrical position sensing devices shall be provided to detect whether each door panel is fully closed and locked.

6.3.3.7 If used, limit switches shall be of a highly reliable service-proven design and shall be sealed. They shall be installed so that they can be replaced without needing adjustment.

6.3.4 Door Seals

6.3.4.1 All doors shall have seals that will keep water, winds, drafts, odors, and wind whistles out of the vehicle interior under all normal vehicle operating conditions.

6.3.4.2 Deleted

6.3.4.3 Replacing leading-edge seals shall not require removing the door panel.

6.3.4.4 The seals shall have a minimum service life of 5 years. They shall comply with the smoke and flammability requirements specified in Section TP 19.23, Flammability, Smoke Emission, and Toxicity.

6.3.4.5 The doors shall remain fully operational under the specified temperature extremes described in Section TP 2.10, Environmental Criteria.

6.4 DOOR OPERATION

6.4.1 Operation

6.4.1.1 Door operation shall be smooth, and damping shall be provided at the end of door travel in each direction to eliminate "bounce back."

6.4.1.2 If door travel is not limited by the door operator, door open and door closed stops in accordance with APTA Standard SS-C&S-012-02 shall be incorporated to facilitate adjustment and to keep doors from over travel.

6.4.1.3 It shall not be possible for the door panels to exert a force on a passenger greater than 30 lbf (133 N), measured statically.

6.4.1.4 The doors shall be held in the open position, without "drift recycling," on grades up to the maximum specified in Section TP 2.8, Wayside Characteristics.

6.4.1.5 The doors shall remain in the fully closed position during accelerations and decelerations of up to the maximum values specified in Section TP 2.14, Performance Requirements.

6.4.1.6 A door lock function shall positively retain the door panel in the closed position without relying on electrical power. The lock shall automatically engage when the door panels at a doorway reach the closed position.

6.4.1.7 A manual release device accessible to passengers shall be provided at each door location to release the door lock and allow the door panels to be manually opened in an emergency. The activation of the manual release shall trigger full service braking, removal of traction power, and appropriate alarms in the cab.

6.4.1.8 The door control system shall feature a time delay for door closing adjustable from 1 to 10 seconds. When a closing command is given, either locally or by trainline, a "door closing" light and voice announcement specified by SANBAG shall be activated immediately. The doors will begin closing in a pre-set time interval after activation of the visual and audible indicators.

6.4.1.9 Adjustment shall be provided to enable door opening and closing times to be maintained throughout the door operator's life.

6.4.1.10 The door operating mechanisms shall be enclosed in a protective heated area accessible from inside the car for adjustment and maintenance of the operators and linkage.

6.4.1.11 A detailed door-operating function matrix shall be submitted for SANBAG's approval **[CDRL 6-1]**.

6.4.2 Door Operator Power Supply

6.4.2.1 The door control system shall operate from the low-voltage power supply (LVPS) and shall be connected to the emergency power supply circuit.

6.4.2.2 Door system electrical equipment shall conform to the requirements of EN 50343, 49 CFR Part 238 Appendix B, EN 50155, and Section TP 15.0, Carbody Interior, as appropriate.

6.5 DOOR CONTROL

6.5.1 Passenger-Activated Door-Opening Buttons

6.5.1.1 The door system shall be equipped with passenger-activated door-opening buttons.

6.5.1.2 Passenger-activated door-opening buttons shall be available on both the interior and exterior of the train at each doorway.

6.5.1.3 When the Operator activates the passenger mode, the door-opening button shall permit a passenger to open the adjacent door panel provided that a zero speed signal is present.

6.5.1.4 The door shall stay open for a predetermined and adjustable period of time, after which the door will close subject to override by the obstacle detection system.

6.5.2 Exterior Crew Switches

6.5.2.1 The exterior crew switches shall be enclosed to blend with exterior finishes and shall be able to withstand the water tightness test described in Section TP 21.7.13, Carbody Watertightness Acceptance Testing without any water infiltration to the interior of the enclosure.

6.5.2.2 The Contractor shall submit to SANBAG for approval a proposal that details the recommended locations of crew switches **[CDRL 6-2]**.

6.5.2.3 The exterior crew switch functions shall operate at all times unless the vehicle battery is discharged or disconnected or the air supply for an air-powered door operator is depleted.

6.5.2.4 The exterior crew switches shall operate under all environmental conditions as described in Section TP 2.10, Environmental Criteria.

6.5.3 Manual Releases

6.5.3.1 Exterior and interior manual door release mechanisms or valves shall be provided at the door openings. A shield shall cover the releases in an approved manner.

6.5.3.2 Each type of manual release shall reset locally.

6.5.3.3 Activation of the manual release shall override the door operator cutout feature specified in Section TP 6.6.3, Door Operator Cutout and Bypass.

6.5.3.4 The manual release (door open) feature shall operate regardless of whether electrical power or pneumatic pressure is available to the door system.

6.5.3.5 The interior and exterior manual release shall be designed to accommodate a range of people from the 5th percentile female to the 95th percentile male of the general population, as defined in MIL-STD-1472.

6.5.4 Fault Tolerance

If a microprocessor-based door control system is used, it shall be fault tolerant and shall incorporate capability for automatic resetting of minor non-repetitive faults. The system shall not respond to trainline noise or voltage spikes. The fault tolerance scheme shall be submitted at Final Design Review for SANBAG's review and approval.

6.6 DOOR SYSTEM INTERLOCKS AND BYPASS SWITCHES

6.6.1 Cutout and Switch Accessibility

All door system cutout devices and bypass switches shall be designed to be accessible by a range of people from the 5th percentile female to the 95th percentile male of the general population, as defined in MIL-STD-1472.

6.6.2 Door Closed Interlock

6.6.2.1 A device shall be provided to detect and provide an electrical indication of when a door panel is in the fully closed and locked position.

6.6.2.2 The device shall detect the presence of the door panel directly, not via its hanger, drive linkage, or other component. Sensing via the door hanger is acceptable if the sensed part of the hanger is intimately and robustly coupled to the door panel.

6.6.2.3 A closed indication shall not be given until the door panel is positively locked in the fully closed position, and shall not be subject to single-point failures.

6.6.2.4 A fail-safe circuit shall be provided to indicate "all doors closed" in the operator's cab in both single- and multiple-unit trains.

6.6.2.5 Each vehicle shall have a closed and locked summary circuit (relay) with contacts that are provided to a trainline Closed and Locked interlock with propulsion and braking.

6.6.2.6 The summary door status relay shall remain open such that it will not be possible to release the brakes or apply power when any door in a train is not closed or locked.

6.6.2.7 There shall be a sealed bypass switch in the cab to override the interlock in Section TP 6.6.2.5.

6.6.3 Door Operator Cutout and Bypass

A device shall be provided that, on a per door operator basis, shall:

a. Mechanically prevent the door panel(s) of the affected door operator from opening

b. Prevent power from being applied to the door operator

c. Bypass the door-closed interlock

d. Deleted

Access to the device shall be restricted by a locked cover that can be opened only with the Operator's key. Alternately, this device may be directly operated by the Operator's key.

6.7 OBSTRUCTION DETECTION

6.7.1 The door operators shall be equipped with obstruction detection for passenger protection during the door-closing cycle. The door system design shall be sufficiently sensitive to detect the presence of either a 3/4-in-diameter bar or a 3/8-in-thick-by-3-in-high bar, when either one is inserted into the door opening.

6.7.2 An obstruction shall be detected either by measuring the door operator motor current by the electronic door control or by using a timer that can be adjusted to from 2 to 5 sec. The timer shall begin timing when the door operator is energized to close, and the presence of an obstruction shall be assumed if the door-closed switches have not all closed before the timer has completed its cycle.

6.7.3 If an obstruction is detected during the second closing attempt, it shall not cause the door to reopen or remove power from the door operators, but shall continue to lock out traction control as described in Section TP 6.6.2.6. The warning chime shall not sound during the second attempt to close.

6.8 DOOR SYSTEM INDICATORS

6.8.1 Door Closed and Opened Indicators

6.8.1.1 An "exterior door open" light-emitting diode (LED) indicator shall be provided, visible from each end of the vehicle (as defined in Section TP 8.5.4, Door Indicator Lights).

6.8.2 Door Out of Service Indicators

6.8.2.1 Indicators or an alternative solution shall be provided on the vehicle interior and exterior to show that the door panel(s) of a cut-out door operator is (are) out of service, and shall be integrated with the vehicle's aesthetic styling. The type, style, and location of these indicators or signs shall be submitted to SANBAG for approval **[CDRL 6-3]**.

6.8.3 Warning Indicators

6.8.3.1 Approved visual and auditory indicators shall be provided to warn of door movement. The visual indicators shall be visible from both the interior and exterior of the vehicle and shall comply with ADA requirements.

6.8.3.2 The visual annunciator described in Section TP 6.8.3.1 shall also indicate when the local interior or exterior manual emergency release has been activated at that location.

6.9 WEATHER STRIPPING

Adequate weather stripping shall be provided where necessary to provide satisfactory seals at all door openings where airtight weatherproof conditions are required.

6.10 DOOR THRESHOLDS

6.10.1 Door thresholds shall be provided at all end doors. Door thresholds shall be designed and constructed to prevent the entry of water between the threshold and door, including entry of water when the vehicle is subject to the horizontal spray jets of the car-washing facility.

6.11 BRIDGEPLATE

6.11.1 General

6.11.1.1 A fixed bridgeplate shall be provided at each side door to help passengers with disabilities board.

6.11.1.2 The bridgeplate shall comply with all requirements outlined in 49 CFR Part 38 Section 83 and include a sacrificial edge.

6.11.1.3 The Contractor shall submit details of the bridgeplate design for SANBAG's approval **[CDRL 6-4]**.

6.12 DELIVERABLES

Contract deliverables required by this section of the Technical Provisions are summarized below.

CDRL 6-1 Detailed door-operating function matrix (TP 6.4.1.11)

CDRL 6-2 Proposed locations of crew switches (TP 6.5.2.2)

CDRL 6-3 Indicators for cut-out door out of service (TP 6.8.2.1)

CDRL 6-4 Bridgeplate design (TP 6.11.1.3)

END OF SECTION

7.0 HEATING, VENTILATION, AND AIR CONDITIONING

7.1 CITED REFERENCES

ASHRAE	Fundamentals Handbook
ASHRAE Standard 37	Methods of Testing for Rating Electrically Driven Unitary Air-Conditioning and Heat Pump Equipment
ASHRAE Standard 62	Ventilation for Acceptable Indoor Air Quality
UL 1995	Heating and Cooling Equipment

7.2 GENERAL REQUIREMENTS

7.2.1 Two independently operating, unitized, roof-mounted heating, ventilation, and air conditioning (HVAC) systems shall be provided for each passenger car. The systems shall be installed and arranged such that if one system fails, the other will continue to supply heating and cooling to the entire car.

7.2.2 All HVAC units of the same type shall be identical and it shall be possible to install any unit on any car without modification or adjustment.

7.2.3 Each HVAC unit shall be removable from the roof as a complete unit. Appropriately sized and placed lifting eyes shall be incorporated in the HVAC structure.

7.2.4 The air conditioning equipment shall be designed and constructed to meet the safety requirements of UL Standard 1995 for Heating and Cooling Equipment. Rating and design of the equipment shall be in accordance with ASHRAE Standard 37 or EN 14750 (passenger compartment) and EN 14813 (operator cab).

7.2.5 Every pressure-containing component of the equipment, except piping, shall be listed as having been pressure-tested and approved by a U.S.-recognized testing laboratory SANBAG has approved. Alternatively, each component shall be designed, constructed, and assembled to have an ultimate strength sufficient to withstand 5 times the nominal design working pressure. All such components shall be factory tested to at least 1.5 times the design working pressure for which they are rated.

7.2.6 The heating and cooling systems shall operate automatically when the ambient temperature range is between 4 °F and +120 °F in normal operation mode. These systems shall perform their function with or without variable internal heat loads such as passengers, lighting, and miscellaneous electrical apparatuses or external factors such as solar heat gain and frequency of door openings.

7.3 HEATING

7.3.1 The heating system shall be able to reach and maintain the interior temperatures required by Section TP 7.7, Interior Temperatures, under the ambient conditions stated therein.

7.3.2 The heating system shall be arranged to provide at least two stages of heat.

7.3.3 All overhead electrical heating systems shall be protected against overheating by at least two independent heat detector systems that, upon sensing overheat conditions, remove power from the heating unit in a fail-safe manner. Alternatively, a single fail-safe unit can be supplied. The allowable maximum temperature within a heater unit shall be determined by the HVAC unit's manufacturer. Sensors shall be located to reliably detect the highest temperature developed in a unit.

7.3.4 If heaters rely on forced air for proper operation, heater power shall be automatically removed from the circuit if the airflow over the heaters drops below a level required to safely avoid overheating.

7.3.5 All electrical heating systems shall be protected by appropriate ground fault detectors as defined in Section TP 9.10.5, Ground Fault Protection.

7.3.6 Detailed descriptions of the heating system design, circuit, and arrangement shall be submitted to SANBAG for approval **[CDRL 7-1].**

7.4 VENTILATION

7.4.1 Fresh air shall be drawn into the HVAC units through openings that are protected from water ingress.

7.4.2 Each system shall deliver to the vehicle interior ten percent (10%) of the total airflow of each HVAC unit as fresh air or as defined in the EN 17450.

7.4.3 The ventilation system shall be balanced so that the carbody, with doors closed, maintains a positive pressure at any speed, with the fresh air dampers open and the evaporator blowers for both systems operating normally.

7.4.4 Disposable pleated filter elements shall be provided in the return and fresh air intake(s) of each HVAC unit.

7.4.5 Detailed descriptions of the ventilation system design, circuit, and arrangement shall be submitted to SANBAG for approval **[CDRL 7-2].**

7.5 AIR COOLING

7.5.1 The HVAC system's capacity shall be sufficient to meet all the requirements of these Technical Provisions and maintain each vehicle's interior temperatures under the conditions defined in Table 7-1.

7.5.2 The air cooling system shall be able to start and operate without damage at any time of the year when the exterior ambient temperature is at or above 50 °F. Means shall be provided to protect the cooling system and its components from damage at exterior ambient temperatures below 50 °F.

7.5.3 The cooling system shall remain in operation, at reduced capacity if necessary, with an ambient temperature of 115 °F at the condenser and fresh air intakes.

Table 7-1: Conditions for Equipment Sizing

Ambient (cooling)	98.6 °F (37.0 °C) dry bulb, 74.7 °F (23.7 °C) wet bulb
Vehicle interior air temperature (cooling)	78 °F (25.6 °C) dry bulb
Ambient (heating)	4 °F (–15 °C) dry bulb
Vehicle interior air temperature (heating)	64 °F (17.8 °C) dry bulb
Maximum vehicle interior relative humidity	55%
Passenger load	AW2 loading, 450 Btu (475 kJ) per passenger with a sensible heat ratio of 0.51
Fresh airflow	The methods prescribed in ASHRAE 62 shall be used to derive the required fresh airflow per person. However, the minimum fresh airflow shall be 10 cfm per person under AW2 loading. Under AW3 conditions, at least 5 cfm (0.00235 m^3/sec) per person must be provided. Infiltration through open doors may be included in the calculation of this figure.
Total airflow	Sufficient to meet the internal temperature, humidity, and vehicle pressurization requirements of these Technical Provisions
Carbody heat transmission	In accordance with the Contractor's approved carbody and insulation design

Lighting load	Total wattage of interior lights
Solar radiation	In accordance with *ASHRAE Handbook—Fundamentals* solar radiation loads for 32° north latitude
Average vehicle speed	The average vehicle operational speed shall be used to assess the effects of convection for heating calculations
Interior equipment heat	In accordance with the Contractor's design data

7.5.4 The controls for each unit are to be separate and independent as specified in Section TP 7.6, Temperature Control. If required for load management, compressor and fan motor starting may be appropriately sequenced between the units.

7.5.5 Corrosion resistant condensate water collection pans under the evaporator section and the condensing section shall be provided.

7.5.6 The drain lines shall be routed to the underside of the car, located so that the condensate shall drain clear of all underfloor equipment and running rails. Drain pipes shall not be routed through compartments or cabinets containing electrical or electronic equipment. The number of fittings and bends shall be minimized. Bends shall be of a large radius for ease of unplugging. The drain piping shall be insulated to preclude condensation. A flexible hose transition shall be provided between the drain pan outlet and the carbody drain line, using approved hose clamps and hose fittings to avoid any leakage.

7.5.7 The Contractor shall provide an air-cooling load analysis for SANBAG's approval, including an analysis of the HVAC unit's capacity and coefficient of performance under nominal and extreme conditions. These calculations shall be conducted in accordance with one of the methods prescribed in *ASHRAE Handbook—Fundamentals*, adapted for rail car applications. Alternatively, EN 14750 (passenger compartment) and EN 14813 (operator cab) may be applied. In addition, detailed descriptions of the air cooling system design, circuit, and arrangement shall be submitted to SANBAG for approval **[CDRL 7-3].**

7.6 TEMPERATURE CONTROL

7.6.1 Deleted

7.6.2 The system temperature sensors shall be located behind the return air grilles in the return air duct.

7.6.3 Automatic fresh air damper controls shall be furnished as part of the temperature control system.

7.6.4 The heating capacity shall be sufficient to raise the fresh air temperature from the winter design day ambient temperature to the required interior temperature as stated within 30 minutes.

7.6.5 The cooling capacity shall be sufficient to lower the fresh air temperature from the summer design day ambient temperature to the required interior temperature as stated within 30 minutes.

7.7 INTERIOR TEMPERATURES

The HVAC system shall have the capacity to reach and maintain the interior temperatures as defined in the EN 14750 (figure A.1).

7.7.1 The fault monitoring system shall indicate the status of all heating and cooling equipment.

7.7.2 The fault monitoring system shall indicate which stages of heating or cooling have been called for by the settings of the climate controls and thermostats, and shall indicate whether the heating or cooling being called for is properly functioning.

7.7.3 Spatial Temperature Variation

During stable HVAC system operation, the spatial temperature variation within the passenger compartment shall remain within the limits specified by EN 14750-1 for the conditions described below.

7.7.3.1 At any point in the vehicle at below the ceiling

7.7.3.2 At any given time, between all points in the same horizontal plane from vehicle end to vehicle end

7.7.3.3 At any given time, between all points in the same vertical plane from vehicle end to vehicle end

7.7.3.4 During a door opening of 30 seconds or less, on one side of the vehicle at any point on the vehicle's centerline, 4 inches into the passenger seating area from the vertical planes between the left and right side door wind screens and between 6 inches and 66 inches above the floor. Following door closing, the interior temperature shall stabilize within a time period not to exceed 4 minutes, or as defined in the EN 14750-1.

7.7.4 Detailed descriptions of the temperature control system design, circuit, and arrangement shall be submitted to SANBAG for approval **[CDRL 7-4].**

7.8 OPERATOR CAB CLIMATE CONTROL

7.8.1 The Operator cab shall be connected to the vehicle's main air comfort system by appropriately sized ducts, with air diffused into the cab through manually adjustable ceiling-mounted diffusers. If needed to ensure sufficient airflow, the diffusers may incorporate quiet booster fans. An independent cab climate control system shall be permitted.

7.8.2 A combined cab ventilation and window defogging system shall be provided in each cab. The system shall be manually controlled and shall provide at least three air speed settings. This system shall deliver air through direction-adjustable nozzles appropriately placed along the bottom of windshield and cab side windows.

7.8.3 Detailed descriptions of the cab climate control system design, circuit, and arrangement shall be submitted to SANBAG for approval **[CDRL 7-5].**

7.9 DELIVERABLES

Contract deliverables required by this section of the Technical Provisions are summarized below.

CDRL 7-1 Detailed descriptions of the heating system design, circuit, and arrangement (TP 7.3.6)

CDRL 7-2 Detailed descriptions of the ventilation system design, circuit, and arrangement (TP 7.4.5)

CDRL 7-3 HVAC capacity calculations and detailed descriptions of the air cooling system design, circuit, and arrangement (TP 7.5.5)

CDRL 7-4 Detailed descriptions of the temperature control system design, circuit, and arrangement (TP 7.7.4)

CDRL 7-5 Detailed descriptions of the cab climate control system design, circuit, and arrangement (TP 7.8.3)

END OF SECTION

8.0 LIGHTING

8.1 CITED REFERENCES

49 CFR Part 221	Rear-End Marking Device – Passenger, Commuter, and Freight Trains
49 CFR Section 238.115	Emergency Lighting
49 CFR Section 229.125	Headlight and Ditch Lights
APTA RP-E012-99	Recommended Practice for Normal Lighting System Design for Passenger Cars
APTA Standard SS-E-013	Standard for Emergency Lighting System Design for Passenger Cars
APTA Standard SS-PS-004	Standard for Low-Location Exit Path Marking
SAE J1132	32Sealed-Beam Headlamp Units for Motor Vehicles

8.2 PASSENGER COMPARTMENT LIGHTING

8.2.1 General

8.2.1.1 The interior lighting system shall comply with APTA RP-E012-99 or EN 13272, latest revision, unless otherwise specified in these Technical Provisions.

8.2.1.2 The Contractor shall submit the interior lighting layout for SANBAG's approval **[CDRL 8-1]**.

8.2.1.3 In advance of design reviews, the Contractor shall submit for SANBAG's approval specifications and data sheets for all interior lamps, ballasts, and lights, including LEDs **[CDRL 8-2]**.

8.2.2 Interior Lighting Control

8.2.2.1 The interior lighting shall be trainline-controlled by a switch on the console of each cab.

8.2.2.2 Interior lighting shall be arranged in one main circuits and one emergency circuit.

8.2.3 Intensity Requirements

8.2.3.1 The intensity of illumination for all interior lighting arrangements shall be as defined in APTA RP-E012-99 or EN 13272, latest revision.

8.2.4 Power

8.2.4.1 The non-emergency lights shall be powered from the LVPS or from the battery.

8.2.4.2 Emergency lighting shall operate from the battery.

8.2.4.3 The power circuit shall be arranged so that upon failure of one circuit the remaining lights are distributed as evenly as possible.

8.3 OTHER INTERIOR LIGHTING

8.3.1 Cab Lighting

8.3.1.1 One ceiling-mounted incandescent or LED light fixture shall be provided and shall be controlled by a switch with a dimming control located on the center console.

8.3.2 Operator's Control Panel Lighting

8.3.2.1 Backlighting, with dimming control, shall be provided for all analog instruments.

8.3.2.2 Low intensity, diffuse lighting shall be provided to illuminate all console controls.

8.4 EMERGENCY LIGHTING

8.4.1 Emergency lighting levels shall conform to the requirements of 49 CFR Section 238.115 and APTA Standard SS-E-013-99, latest revision. At a minimum, emergency lights shall be located in all doorways and toilet rooms (if applicable) and above all escape sash locations.

8.4.2 Emergency lighting and light levels shall be available for a minimum of 120 minutes after the loss of auxiliary power.

8.4.3 The vehicle shall be equipped with a low-level exit path marking that satisfies APTA Standard SS-PS-004-99, latest revision, to illuminate the emergency exit path. A passive or active solution may be presented to SANBAG for approval.

8.5 EXTERIOR LIGHTING

8.5.1 General

8.5.1.1 The exterior lighting shall include headlights, ditch lights, end markers, cab signal cutout indicators, door indicator lights, fueling station light, engine shut-off switch light, and other indicator lights as set forth in these Technical Provisions.

8.5.1.2 Exterior lights shall conform to the requirements set forth in 49 CFR Part 221 and 49 CFR Section 229.125, latest revision.

8.5.1.3 All exterior indicator lights shall be LED lamps. In specific cases, if an LED cannot satisfy the requirements of this section, a rail-service-proven incandescent lamp shall be provided, subject to SANBAG's approval.

8.5.1.4 The Contractor shall submit for SANBAG's approval an exterior lighting layout and function **[CDRL 8-3]**.

8.5.1.5 The Contractor shall submit for SANBAG's approval specifications and data sheets for all exterior lamps and lights, including LEDs **[CDRL 8-4]**.

8.5.2 Headlights and Ditch Lights

8.5.2.1 The cab car shall be equipped at each cab end with headlights and auxiliary lights in accordance with 49 CFR Section 229.125, latest revision.

8.5.2.2 The headlights shall be adjustable up to ±4° in all directions.

8.5.2.3 The ditch lights shall be continuously illuminated as required by 49 CFR Section 229.125 (f), latest revision, unless the alternating flashing feature is activated.

8.5.2.4 The ditch lights shall operate in one of the following modes: steady, flashing, or flashing after horn or bell only.

8.5.2.5 The fixtures and lamps shall be suitable for railroad service.

8.5.2.6 The main headlight shall have its own control circuit breaker, independent from the ditch headlight breaker.

8.5.2.7 Lights shall be removable and adjustable and shall be adjusted and aimed in accordance with SAE J1132, latest revision.

8.5.2.8 Replacement of a headlight or ditch light shall not require readjustment of its aiming position.

8.5.3 Rear-End Marking Device

8.5.3.1 Rear-end marking devices shall be installed at each cab end of each cab car in compliance with the requirements of 49 CFR Part 221, latest revision.

8.5.4 Door Indicator Lights

8.5.4.1 A “one door open” red LED pilot light shall be installed on the exterior adjacent to each set of side entrance doors on the upper portion of the upper window deadlight. These lights shall be operated on battery voltage.

8.5.5 Fueling Station Light

8.5.5.1 Each fueling station shall be equipped with an explosion-proof light to illuminate the fuel fill port and its immediate vicinity. The fueling port light shall operate on battery power and shall provide adequate lighting to allow nighttime re-fueling. The lighting configuration shall be submitted to SANBAG for approval.

8.5.6 Engine Shut-off Switch Light

8.5.6.1 The engine shut-off switch shall be illuminated in a way that will allow it to be seen by train personnel in low ambient lighting conditions.

8.5.6.2 The engine shut-off switch may be illuminated by an external light source or illuminated internally.

8.5.6.3 The engine shut-off switch light shall operate on battery power.

8.5.6.4 If the engine shut-off switch is near enough to the fueling station so that the fueling station light provides adequate lighting to illuminate both items, a separate engine shut-off switch light can be omitted.

8.6 DELIVERABLES

The contract deliverables required by this section of the Technical Provisions are summarized below and shall be incorporated as part of the Final Design Review.

CDRL 8-1	Interior lighting layout (8.2.1.2)
CDRL 8-2	Specifications and data sheets on all interior lamps, ballasts, and lights, including LEDs (TP 8.2.1.3)
CDRL 8-3	Exterior lighting layout (TP 8.5.1.4)
CDRL 8-4	Specifications and data sheets on all exterior lamps and lights, including LEDs (TP 8.5.1.5)

END OF SECTION

9.0 AUXILIARY ELECTRICAL EQUIPMENT

9.1 CITED REFERENCES

NEMA MG-1	Motors and Generators
NFPA 130	Standard for Fixed Guideway Transit Systems
UL 1682/1686	Standards for plugs, receptacles, and cable connectors

9.2 GENERAL

9.2.1 This section specifies the requirements for auxiliary electrical equipment, including power generation, LVPS, batteries, low-voltage circuit breaker panels, protection devices, and grounding methods.

9.2.2 All auxiliary electrical equipment shall be designed, selected, and installed to operate successfully and reliably in the intended SANBAG commuter railway operating environment.

9.2.3 Generators, alternators and electric motors shall comply with the requirements of NEMA MG-1 or IEC 60034-30 and IEC 60034-2-1.

9.3 CONFIGURATION

9.3.1 The Contractor shall submit, for SANBAG's approval, auxiliary power generation design and performance data and complete electrical circuit diagrams prior to construction **[CDRL 9-1]**.

9.3.2 The Contractor shall submit, for SANBAG's approval, calculations to verify the capability of the propulsion engine and APS system to produce power at the required levels **[CDRL 9-2]**.

9.4 CIRCUIT REQUIREMENTS

9.4.1 Electrical materials and installation methods used to fabricate auxiliary electrical equipment including wire, cable, printed circuit boards, and circuit protective devices shall comply with the applicable requirements of Section TP 19.0, Material and Workmanship.

9.4.2 Maximum allowable voltage drop for LVDC circuits according to the EN 50155.

9.4.3 Deleted

9.4.4 Circuit Protection Coordination

9.4.4.1 Adequately rated overvoltage protection, current sensing, ground fault sensing, and any other circuit protection the Contractor deems necessary shall be provided to protect the onboard electrical system components from the effects of faults, overcurrent, overvoltage, and ground fault conditions.

9.4.4.2 All circuits shall be protected by circuit breakers. Fuses may be used only where specified in these Technical Provisions and where applicable circuit breakers are not commercially available. The Contractor may propose alternate solid state protection, provided the feeder circuit is always protected by a coordinated upstream circuit breaker or fuse.

9.4.4.3 Fuses, circuit breakers, and current monitoring shall be coordinated to provide correct operation and protection. Coordination shall ensure that circuit interruption localizes the fault, that protective devices act to back up the downstream devices, and that protective devices are capable of interrupting the maximum fault currents, as well as the minimum operating currents. The Contractor shall submit, for SANBAG's approval, a circuit protection coordination analysis **[CDRL 9-4]**.

9.4.5 Shop Power Receptacle

9.4.5.1 Two three-pole shop power receptacles, matching in voltage and power rating the onboard APS, shall be provided for each vehicle.

9.4.5.2 The shop power receptacles shall be interlocked so that:

a. Neither can be electrically connected if the onboard power generation equipment is operating

b. On-board power generating equipment cannot be energized if any receptacle is in use

c. Propulsion power cannot be applied and brakes cannot be released if any shop power connector is mechanically engaged

9.5 DUTY CYCLE

9.5.1 Normal Operation

9.5.1.1 The auxiliary electrical system shall be rated for the performance cycles and parameters applicable to the operating environment of the vehicle as specified in Section TP 2.0, Design and Performance Criteria, and in this section.

9.5.1.2 The auxiliary power generation equipment shall have sufficient capacity to start and operate loads individually and to simultaneously supply loads of auxiliary systems without load shedding.

9.5.1.3 The Contractor shall submit for approval calculations to verify the capability of the auxiliary power generation and distribution system to handle the normal and worst-case environmental and performance parameters **[CDRL 9-5]**.

9.5.1.4 The Contractor shall provide a load start/stop sequence analysis, including verification that worst-case load starting does not trigger any inverter protection devices. If the analysis proves that load start sequencing is required, each start delay device shall be adjustable, with 5 seconds being the default delay setting **[CDRL 9-6]**.

9.5.2 Train Rescue

9.5.2.1 The auxiliary electrical system on one vehicle shall be capable of supporting control, communication, and emergency loads, including all emergency lighting, on a separate vehicle that has failed. Shedding of non-essential loads is acceptable. The system shall be rated to complete at least one end-to-end journey (starting at University of Redlands campus), followed by a return to the maintenance facility out of revenue service.

9.5.2.2 The Contractor shall submit, for SANBAG's approval, calculations to verify the capability of the auxiliary electrical system's train rescue capability **[CDRL 9-7]**.

9.6 AC POWER DISTRIBUTION

9.6.1 Convenience Outlets

9.6.1.1 Hospital-grade convenience outlets, as defined by UL 1682 and 1686, with spring-loaded hinged covers shall be installed for service of 120 V of alternating current (VAC), single phase, 60 Hz, 20 amps in each car.

9.6.1.2 Outlets shall be protected by a ground fault interrupter (GFI).

9.6.1.3 As part of the Final Design Review, the Contractor shall submit detailed information on the location of the duplex outlets for SANBAG's approval.

9.6.1.4 Convenience outlets shall not be accessible to passengers.

9.6.2 Feeder Breakers

9.6.2.1 Feeder breakers shall be crew and maintenance accessible from inside the vehicle and shall be located behind a cover in a compartment approved by SANBAG.

9.6.2.2 Feeder breakers shall be rated to provide overcurrent protection to feeder cables from the alternator according to EN 50343.

9.6.3 Branch Circuit Breakers

9.6.3.1 One branch circuit breaker shall be provided for each AC load circuit and shall be rated to provide short-circuit and overload protection. All branch circuit breakers shall be accessible from inside the vehicle.

9.6.4 Contactors and Starters

9.6.4.1 Contactors and starters shall be provided as specified in Section TP19.20, Electrical Components.

9.7 LOW VOLTAGE POWER DISTRIBUTION

9.7.1 Location

Low voltage power shall be distributed from circuit breaker panels located in enclosures separate from other circuits.

9.7.2 Circuit Breakers

9.7.2.1 Circuit breakers shall be provided for each low-voltage load circuit.

9.7.2.2 The circuit breaker rating shall be sized for the current capacity of branch circuit wiring and load requirements.

9.7.2.3 A minimum of ten percent (10%) of the total number of circuit breakers shall be provided as spare spaces.

9.7.2.4 Control locations shall be grouped logically, according to function.

9.7.2.5 All circuit breakers shall be crew and maintenance accessible from inside the vehicle.

9.7.3 Load-Shed Contactor

9.7.3.1 A contactor shall be provided in series with non-emergency circuit breakers.

9.7.3.2 This contactor shall be energized whenever the LVPS is operating within its design limits, and de-energized 10 seconds after the LVPS fails, unless normal output is reinstated within the 10-second period.

9.7.4 Performance Requirements

All low-voltage equipment shall operate satisfactorily within a voltage range of -30% to +25% of nominal.

9.7.4.1 A load application, shedding, and reapplication system shall be provided as an integral part of the AC APS. The load management system shall maintain the essential vehicle operating systems online for as long as possible during primary power anomalies. The Contractor shall submit, for SANBAG's approval, details on the load management system **[CDRL 9-8]**.

9.7.5 Protection

9.7.5.1 Filters shall be provided as required to ensure transient voltage protection, to filter power frequency components, and to suppress all high frequency transients, as required.

9.7.5.2 Bleeder resistors shall be provided as required to discharge filter capacitors to less than 50 V within 2 minutes when disconnected from line voltage.

9.7.5.3 Warning labels of an approved design shall be provided on filter capacitors.

9.7.6 Cooling

9.7.6.1 LVPS and battery charger(s) shall be cooled by natural convection or forced air.

9.7.6.2 If forced-air cooling is used, and a redundant LVPS unit is not available, the devices must be able to function, in the event of a failed cooling fan, for one end-to-end journey, followed by a return to the maintenance facility out of revenue service. Shedding of non-essential loads is acceptable.

9.8 LOW-VOLTAGE POWER SUPPLY

9.8.1 Power Source

9.8.1.1 The LVPS shall supply control power to all vehicle systems, power all emergency lights, charge batteries, and power other vehicle loads as may be defined in the course of the vehicle design.

9.8.1.2 The LVPS shall be of sufficient capacity to charge the batteries and maintain constant voltage for traction control, friction brake control, auxiliary control, and all sustained battery circuit power requirements. The Contractor shall submit to SANBAG for approval a load analysis and description of operating characteristics **[CDRL 9-9]**.

9.8.1.3 The LVPS output shall be current-limited.

9.8.1.4 In case of LVPS failure or loss of input power, LVPS loads shall be transferred instantly to the emergency storage battery.

9.8.2 Capacity

The LVPS capacity shall be rated to supply one hundred ten percent (110%) of all connectable loads while simultaneously recharging fully discharged batteries to fifty percent (50%) within two hours.

9.8.3 Regulation

9.8.3.1 LVPS regulation shall be as required by the loads, including the batteries.

9.8.3.2 Temperature compensation of voltage shall be required as necessary to meet battery servicing requirements.

9.8.3.3 The LVPS shall include circuitry to detect LVPS and battery charger (if separate) failures.

9.8.4 Protection

9.8.4.1 The LVPS shall have overload protection.

9.8.4.2 For load or fault conditions of very low load resistance (such as a dead short), the LVPS control shall "fold back" (limit both current and voltage), disconnect the output, or shut off.

9.8.4.3 Normal operation shall automatically resume when the overload or short circuit is removed if a circuit breaker has not tripped.

9.8.4.4 Overvoltage protection shall be provided.

9.8.4.5 Reverse input and output polarity protection shall be provided.

9.8.5 Battery Charging

9.8.5.1 All independent batteries shall be charged independently of each other. The Contractor shall coordinate the charging characteristics of each battery with the battery supplier.

9.8.5.2 The battery temperature shall be measured to adjust the charging voltage accordingly. A separate temperature sensor for each battery shall be used. For accurate compensation, the temperature of the battery electrolyte should be measured as directly as possible. The sensor shall be connected by use of screened leads.

9.8.5.3 In the case of excessive battery temperature or a fault in the sensor, the converter shall switch automatically to a minimum charging voltage. This condition shall be annunciated.

9.8.5.4 The appropriate charging characteristic shall be programmable in the LVPS.

9.9 BATTERIES

9.9.1 General Description

9.9.1.1 Engine start and emergency power shall be provided by separate transit-type batteries. The engine starter batteries shall be selected to handle the high starting currents associated with repeated diesel engine starting at low temperatures.

9.9.1.2 An undervoltage protection scheme shall be provided to protect the batteries from deep-cycling.

9.9.1.3 For an initial emergency battery condition with the cells at eighty percent (80%) of full charge and an ambient temperature of 20 °F (–7 °C), the battery capacity shall be able to carry all of the loads listed in Section TP 9.9.1.4 for a period of 120 minutes.

9.9.1.4 The emergency battery shall be sized to provide at least the following loads, with associated duty cycles, concurrently in the event of loss of LVPS:

a. Emergency lighting as defined in Section TP 8.4, Emergency Lighting (continuous)

b. Door control (cycle doors open for 20 seconds every 5 minutes)

c. Communications (operate public address [PA] system 20 seconds every 105 seconds)

d. Train radio (transmit for 20 seconds every 105 seconds, receive continuously)

e. Propulsion and braking control (as required)

f. Operator's console indicators and interlocks (as required)

g. Horn (on for 10 seconds every 75 seconds)

h. Bell (on for 10 seconds every 75 seconds)

i. Coupler control (one couple and uncouple cycle)

j. deleted

k. Deleted

l. Event recorder (continuous)

m. Track brake (four applications).

9.9.1.5 The engine starter battery system shall have the capacity to start two traction diesel engines sequentially. It shall be possible to restart each engine three times for 10 seconds with a 1-minute recovery phase in between.

9.9.2 Design Requirements

9.9.2.1 The Contractor shall perform a load analysis for the batteries and associated circuits. This analysis shall take into account the charge/discharge curves of the battery, charging requirements, and battery load requirements during emergency and engine start operation under worst-case high and low temperatures. The Contractor shall submit this analysis for SANBAG's approval **[CDRL 9-10]**.

9.9.2.2 Batteries shall be provided with cell cases of an approved high-temperature, fire-retardant-rated material.

9.9.2.3 Deleted.

9.9.2.4 The emergency storage battery shall be rated for emergency duty cycle service in the indicated operating environment for a normal service life of not less than 10 years.

9.9.2.5 The battery shall be maintained at rated charge by connection to the battery charging circuit described in Section TP 9.8.5, Battery Charging.

9.9.3 Battery Enclosure

9.9.3.1 Batteries shall be installed in a ventilated battery box that meets the requirements of 49 CFR Part 238 Appendix B.

9.9.3.2 The battery box shall comply with the strength and mounting requirements of Section TP3.4.4, Underfloor Equipment.

9.9.4 Battery Circuit Breaker

9.9.4.1 The battery circuit breaker shall be mounted adjacent to the battery box or in a location easily accessible by maintenance personnel, clearly marked for maintenance personnel.

9.9.4.2 The location, rating, and design of the breaker shall be subject to SANBAG's approval.

9.10 GROUNDING

9.10.1 Safety

9.10.1.1 The Contractor shall submit, for SANBAG's approval, a grounding plan, including details on, and a functional diagram of, the proposed grounding scheme **[CDRL 9-11]**.

9.10.1.2 Grounding conductors shall be provided in accordance with EN 50343,

9.10.2 Carbody Ground

9.10.2.1 The car structure shall not be used as a normal circuit return path for any electrical equipment.

9.10.2.2 Safety ground wiring design shall be coordinated with the engine, transmission, final gear, and truck design to ensure that all bearings are protected against stray current flow.

9.10.2.3 The carbody ground shall comply with the requirements for use of dissimilar metals specified in Section TP 19.0, Materials and Workmanship.

9.10.2.4 All ground bonds shall be accomplished using appropriately sized studs and ring terminals.

9.10.3 Low Voltage Ground

9.10.3.1 The low-voltage system negative return wiring shall be insulated from the carbody.

9.10.3.2 An insulated ground-plate, if required, shall be provided within the low-voltage circuit breaker panel enclosure. The ground-plate shall provide one stud for each branch circuit return and one stud for low-voltage feeder return.

9.10.3.3 A ground wire, if required, shall be provided between the ground-plate and the carbody.

9.10.4 Shielded Circuits

9.10.4.1 Shielded circuits shall have continuous unbroken shields the full length of the circuit, and shall be grounded only at one point of the circuit to the nearest convenient point on the carbody ground.

9.10.4.2 Shields shall not be connected at the coupler. Trainline circuit shields shall be grounded to the carbody ground through connections at the trainline switch.

9.10.5 Ground Fault Protection

9.10.5.1 A ground fault detection system shall be provided for the AC APS and the propulsion inverter (if supplied) to protect against the return of electric current through other than the intended paths. When a ground fault is detected, the system shall remove electrical power from the effected circuits.

9.10.5.2 The detection level shall be as sensitive as necessary, consistent with the avoidance of nuisance trips.

9.10.5.3 The Contractor shall submit, for SANBAG's approval, a ground fault analysis. This analysis shall demonstrate that all ground faults will be detected, regardless of where in the circuits they occur. The analysis shall also demonstrate that the fault protection system is capable of interrupting the maximum ground fault current **[CDRL 9-12]**.

9.11 DELIVERABLES

Contract deliverables required by this section of the Technical Provisions are summarized below.

CDRL 9-1 Auxiliary generator/alternator design, performance data, and circuit diagrams (TP 9.3.1)

CDRL 9-2 Calculations to verify the capability of the propulsion engine and APS system to produce power at the required levels (TP 9.3.2)

CDRL 9-3 Deleted

CDRL 9-4 Circuit protection coordination analysis (TP 9.4.4.3)

CDRL 9-5 Calculations to verify the capability of the auxiliary power generation and distribution system (TP 9.5.1.3)

CDRL 9-6 Load start/stop sequencing analysis (TP 9.5.1.4)

CDRL 9-7 Calculation to verify auxiliary electrical system's failed-train rescue capability (TP 9.5.2.2)

CDRL 9-8 Load application and shedding analysis (TP 9.7.4.1)

CDRL 9-9 Operating characteristics and a load analysis for the LVPS (TP 9.8.1.2)

CDRL 9-10 Load analysis for battery and associated circuits (TP 9.9.2.1)

CDRL 9-11 Grounding plan (TP 9.10.1.1)

CDRL 9-12 Ground fault system analysis (TP 9.10.5.3)

END OF SECTION

10.0 PROPULSION SYSTEM

10.1 CITED REFERENCES

49 CFR Sections 229.93–97	Internal Combustion Equipment
49 CFR Section 238.105	Train Electronic Hardware and Software Safety
49 CFR Section 238.223	Locomotive Fuel Tanks
40 CFR Section 1039	Control of Emissions from New and In-Use Nonroad Compression-Ignition Engines
ABMA 9:1990	Load Ratings and Fatigue Life for Ball Bearings
APTA SS-C&S-007-98	Standard for Fuel Tank Integrity for Non-Passenger-Carrying Passenger Locomotives
EN 50155	Electronic Equipment Used on Rolling Stock
IEC 60077	Rules for Electric Traction Equipment
IEC 60322	Tests on Electric and Optical Fibre Cables Under Fire Conditions
IEC 60349	Electric traction – Rotating Electrical Machines for Rail and Road Vehicles
IEC 61071	Power Electronic Capacitors
IEC 61133	Electric Traction Rolling Stock Test Methods for Electric and Thermal/Electric Rolling Stock on Completion of Construction and Before Entry into Service
IEC 61287-1	Railway applications – Power convertors installed on board rolling stock
IEC 61377	Railway applications – Rolling Stock Equipment Shock and Vibration Tests
IEEE 11	Rotating Electrical Machinery for Rail and Road Vehicles
IEEE 112	Standard Test Procedure for Polyphase Induction Motors and Generators
NFPA 130	Standard for Fixed Guideway Transit Systems

10.2 GENERAL

10.2.1 An efficient, reliable drive configuration shall be provided.

10.2.2 The traction system shall be diesel-engine powered.

10.3 EQUIPMENT THERMAL CAPACITIES

10.3.1 The Contractor shall submit the normal and abnormal duty cycle analysis for approval **[CDRL 10-1]**. The Contractor may also propose restrictions in the abnormal duty cycle to restrict thermal loading to the normal duty level. Such restrictions will be subject to SANBAG's approval.

10.3.2 Normal Duty

The continuous thermal rating of all propulsion system components shall exceed the rating that is necessary to operate with the duty cycles specified in Section TP 2.0, Design and Performance Criteria. All propulsion system components shall function as specified and without damage under normal and abnormal conditions. Component life and reliability shall exceed the specified minimum overhaul cycles and reliability requirements, respectively.

10.3.3 Abnormal Duty

The abnormal duty cycle shall be based on the towing requirements of Section TP 2.14.5, Degraded Performance Operation.

10.3.4 Equipment Temperature Control

10.3.4.1 Diesel engine, charge air, and transmission cooling shall be provided on an individual system basis so that continued operation is possible in the event of one cooling system or one propulsion system failure.

10.3.4.2 Either hydraulic or three-phase induction motors shall drive radiator fans.

10.3.4.3 All propulsion equipment shall be protected from damage due to cooling failure. Detection of cooling failures shall illuminate the appropriate propulsion fault indicators in the cab and automatically disable the affected components.

10.4 PERFORMANCE CHARACTERISTICS

The diesel-powered traction system shall provide the train acceleration rates specified in Section TP 2.14, Performance Requirements.

10.4.1 Load Compensation

The traction and braking system shall adjust tractive and braking effort to compensate for varying passenger loads by measuring passenger loading.

10.4.2 Friction Brake Control Interface

The friction brake system shall interact with the traction control system to coordinate dynamic brake supplementation of train braking commands. It shall also coordinate wheel slide correction with the traction system.

10.4.2.1 Rollback Prevention

Means shall be provided to allow vehicle start on all upgrades in SANBAG's rail system without rollback. If such rollback prevention uses delayed brake release until positive traction power has been developed, it shall be possible to motor against applied brakes for at least eight seconds. If the friction brakes do not release within eight seconds of a motoring command, the motoring command shall be removed and full service brakes shall be applied.

10.4.2.2 Emergency Brake Control

The traction control system shall respond to the emergency brake trainlines by inhibiting the drive mode and producing a fixed load weighed braking effort so that the vehicle achieves the braking performance specified in Section TP 2.0, Design and Performance Criteria. The Contractor shall submit a report on the emergency brake control scheme for SANBAG's review and approval **[CDRL 10-2]**.

10.4.3 Mode and Rate Selection

10.4.3.1 The traction system shall directly use the trainlined traction command signals generated by the master controller as specified in Section TP 5.0, Operator's Cab. Response to trainline control signals shall be linear and proportional throughout the command ranges for acceleration and braking. This requirement can be relaxed during gear shifting to allow for the characteristics of hydraulic transmissions. The achievable performance during such transitions shall be subject to SANBAG's approval.

10.4.3.2 The traction control equipment in each vehicle shall passively interpret the trainlined commands without loading the trainlines beyond their design limits in all possible train configurations.

10.4.3.3 The traction mode shall be inhibited by the following:

- Friction brake applications, on a timed basis
- Emergency brake applications
- Parking brake applications
- Low brake system reservoir pressure
- Illegal trainline combination
- Connection of shop or yard power

10.4.4 Direction Change

10.4.4.1 Direction change shall be provided by a control lever in the operating cab. A change of direction shall be possible only if no tractive effort is present and no motion is detected.

10.4.4.2 A detection circuit shall compare the trainlined vehicle direction to the achieved direction. Failure of the vehicle direction to correspond to the trainline direction commands shall prevent the traction system from moving the vehicle.

10.4.5 Propulsion Isolation

It shall be possible to cut out the propulsion system on a per truck basis. The appropriate local and trainlined "Traction Fault" indicators shall be illuminated in the cab when any truck in the train is isolated.

10.4.6 Speed Sensing

10.4.6.1 Speed sensing devices shall be provided to measure all wheel speeds. They shall be installed on the axles or wheel assemblies, or shall be incorporated as an integral part with transmissions or gearboxes. The number of speed sensors shall be sufficient to continue operation with one speed sensor failed on each powered truck.

10.4.6.2 Axle-mounted speed sensor types and mountings shall be identical among trucks as practical. Mounting shall be arranged to minimize the need for mechanical adjustments.

10.4.6.3 All speed sensing gears, toothed wheels, and similar devices shall be mounted on their shafts via keys, splines, or press fits. The mounting method shall be selected to guarantee that the speed measuring device cannot indicate speeds other than the actual axle speed.

10.4.6.4 Speed sensor wiring shall be enclosed in a conduit on the vehicle body and shall be run to a terminal box or connectors, located above the speed sensor location on the truck. Speed sensor cables shall be shielded and terminated in waterproof multi-pin connectors.

10.4.6.5 All speed sensors shall be easily accessible for inspection, adjustment, and replacement from the car sides, over a maintenance pit or on jacks, with trucks attached to the vehicle.

10.4.6.6 The sensors may be of active or passive magnetic pick-up type. The face of each speed sensor shall be smooth with no protruding elements. The sensor shall be hermetically sealed in a stainless steel case. The face of each speed sensor shall be encased in a seamless stainless steel cover unless the sensor is guaranteed, and has been proven in service, to be immune to damage or inaccurate operation caused by continuous exposure to the intended lubricating fluids and temperatures.

10.4.6.7 Odometer

An electronic odometer with permanent non-volatile memory or non-resettable electro-mechanical odometer shall be provided for each vehicle and shall be installed in the cab for cab cars and in an interior locker to display the total number of miles accumulated by the vehicle.

The odometer shall register to the nearest mile and shall have a minimum of 8 digits. The odometer shall be incremented by the propulsion or friction brake system control unit.

10.4.6.8 Wheel Diameter Correction

Wheel diameter correction shall be provided for each vehicle. The wheels on one un-powered axle shall be selected to serve as the reference wheel diameter. It shall be possible to adjust the reference wheel diameter with a portable test unit. All other wheel diameters shall be self-calibrating, requiring no manual adjustment to compensate for all wheel diameter variations from fully worn to new wheels. Under worst-case conditions, calibration shall not take longer than 10 seconds in coast at a speed of 20 mph (30 km/h).

10.4.7 Vehicle Overspeed Protection

10.4.7.1 Vehicle overspeed protection shall be provided for each vehicle separately.

10.4.7.2 The overspeed protection logic shall remove propulsion tractive effort in all vehicles coupled to form a train when the vehicle speed exceeds the overspeed protection set point. Power shall be restored when the speed drops 1 mph (1.6 km/h) below the set point, or as recommended by the propulsion supplier.

10.4.7.3 The overspeed protection set point for the system shall be 79 mph ±1 mph (127 km/h ± 1.6 km/h).

10.4.8 Fault Annunciation

All traction system faults, including cut out, general faults, and overheating, shall be annunciated on a local basis.

10.4.9 No-Motion Detection

10.4.9.1 A system shall be provided to detect vehicle no-motion for use by other vehicle systems. The no-motion detection system shall monitor the speeds of all axles on a vehicle and shall interface safely with other vehicle systems. The system, including any bypass circuitry, shall comply with all specified safety requirements.

10.4.9.2 The system sensitivity shall permit reliable detection of all vehicles speeds down to, and including, 2 mph (3 km/h) or less. The no-motion relay shall be de-energized when the vehicle speed is above 2 mph (3 km/h).

10.5 DIESEL TRACTION ENGINES

10.5.1 General

10.5.1.1 All traction-power diesel engines on like cars shall be identical and fully interchangeable with one another.

10.5.1.2 Diesel engine modifications, if required for a specific vehicle application, shall be designed or specifically approved by the diesel engine's original designer and manufacturer. SANBAG will not accept custom diesel engine modifications by distributors or the Contractor.

10.5.1.3 The Contractor shall provide diesel engines capable of delivering power sufficient to meet the performance requirements in Section TP 2.0, Design and Performance Criteria. Auxiliary power shall be derived from the traction diesel engines; therefore, the maximum power demand of the APS must be added to the performance requirements in TP 2.0. The engine lubricating and cooling systems shall be designed for continuous operation at full engine rated output.

10.5.1.4 The contractor shall install the diesel engines in compliance with the mounting requirements of the diesel engine manufacturer. The finalized mounting arrangement, including the resilient mounts, shall be approved by the diesel engine manufacturer and submitted to SANBAG for review.

10.5.1.5 The diesel engines shall have the following basic design features:

- Water cooled
- Turbo-charged
- Electronically fuel injected
- Self-protected
- Low temperature starting capable

10.5.1.6 Diesel engines shall be of a service-proven design as defined in TP 2.0. The diesel engines shall not need a major overhaul (engine disassembly) within fewer than 9,000 service hours when operating the vehicle according to the load cycle as specified in TP 2.0.

10.5.1.7 Each diesel engine shall have its own operating hour meter.

10.5.1.8 Use of drive belts shall be minimized. Drive belts shall be replaced only during major overhauls.

10.5.1.9 Each diesel engine shall be resiliently mounted to the underframe or in the engine compartment of the vehicle. The diesel engine and its mounting arrangement shall be designed to meet the restraint criteria of TP 2.0. Safety straps, tabs, or hangers shall be provided, as required, to prevent dropping the engine, transmission, or drive shaft below the vehicle clearance line in the event of an engine or transmission mount failure. The engine compartment shall be insulated for both acoustic and thermal efficiency.

10.5.1.10 Combustion air intake locations shall be approved by SANBAG. If the air intake location is below the floor level, then measures shall be taken to ensure the intake air is adequately filtered and filter replacement intervals are no less than once every 60 days. Air filters shall have a contamination indicator and be easily accessible.

10.5.1.11 All serviceable parts of the engine shall be easily accessible. Complete access shall be provided through removable access panels on either side of the vehicle and from below. Provisions shall be made to easily collect samples of engine oil and coolant. All handling of polluting components such as oil, grease, and water shall be done from the outside of the vehicle. A test location to measure exhaust temperatures near the turbo charger shall be provided.

10.5.1.12 At a minimum, the following items shall be easily serviced through side access doors:

- All fuel, engine oil, transmission oil, crankcase ventilation, and coolant filter elements
- Transmission breather elements
- Engine oil level dipstick and oil fill port
- Engine start panel
- Water and lubricating oil pumps
- All visual indicators, gauges, protective devices, and test connection points for engine coolant, lubricating oil, fuel oil, and combustion air

10.5.1.13 All engine connections to vehicle wiring shall conform to the requirements of Section TP 19.17, Material and Workmanship.

10.5.1.14 Diesel engine performance and maintenance data shall be submitted to SANBAG for approval **[CDRL 10-3]**.

10.5.2 Engine Cooling Systems

10.5.2.1 Each engine shall have its own cooling unit. The cooling unit shall handle engine and transmission/retarder cooling.

10.5.2.2 The cooling unit shall consist of the radiator, expansion tank, temperature sensors, control valves, and fans to regulate the cooling air volume. The cooling controls shall keep the engine temperature in the specified optimum operating range under all operating conditions.

10.5.2.3 The cooling media shall consist of a mixture of water and corrosion inhibitor/antifreeze. Filling and draining valves shall be easily accessible.

10.5.2.4 Coolant shall be conveyed by means of stainless steel, copper, or brass piping. No flexible hoses shall be used except for direct connection to the engine and radiator to allow stress-free expansions. Swivel-threaded, hydraulic-type hose assemblies shall be used for such applications.

10.5.2.5 The radiators shall be of service-proven design, made of brass, copper, or aluminum. Connections shall be provided with couplings to facilitate removal and replacement. The radiator shall be sized for a ten percent (10%) contamination of the cooling surface. The Contractor shall list all the materials used in the cooling water flow and assure that the materials used match the corrosion prevention requirements.

10.5.2.6 The Contractor shall demonstrate, by calculation, that the cooling system heat rejection, pressure drop, flow rates, venting, and de-aeration design meet the engine suppliers' requirements and recommendations. Such calculations shall be approved by both the engine and transmission suppliers and a report shall be submitted to SANBAG for approval **[CDRL 10-4]**.

10.5.2.7 A preheat unit shall heat the coolant to the temperature needed to start the engine safely, as specified by the engine supplier. The preheat unit shall be powered electrically by the shop or yard power.

10.5.2.8 The engine supplier shall determine whether the charge air needs to be pre-heated to avoid excessive exhaust emissions during the engine start at the lowest temperature specified in Section TP 2.0, Design and Performance Criteria.

10.5.2.9 The engine supplier shall state the lowest temperature at which it is possible to start the engine without preheating in case of an emergency.

10.5.2.10 The charge air cooler shall be dimensioned according to the diesel engine requirements. The cooling surface shall be sized for a minimum of a ten percent (10%) contamination. The cooler and the turbo charger connections shall be equipped with service-proven compensators that can decouple the masses independent of the charge air pressure. If the charge air cooler is mounted as a separate unit, the diesel engine manufacturer shall approve the mounting arrangement. The finalized arrangement shall be submitted to SANBAG for review **[CDRL 10-5]**.

10.5.3 Engine Exhaust System

10.5.3.1 The exhaust pipes and silencers shall be constructed of stainless steel. The exhaust piping system shall allow for heat expansions. All connections shall allow an easy exchange of the exhaust system parts.

10.5.3.2 Approved, non-asbestos, high-temperature insulation shall be applied where required to minimize thermal radiation to heat-sensitive equipment or where the exhaust tubes may present a safety hazard to passengers, service personnel, or equipment.

10.5.3.3 The exhaust gases shall be released to the environment in a suitable location on the roof. Exhaust gases shall not interfere with any fresh air or other cooling air intake under all vehicle operating conditions, nor shall exhaust gases be blown under station canopies.

10.5.4 Fuel System

10.5.4.1 Fuel tanks, fuel lines, and related equipment shall be designed, manufactured, and installed in compliance with 49 CFR Section 238.223, 49 CFR Sections 229.93 to 229.97. Alternate fuel tank designs not meeting all of the referenced standards and/or regulations may be proposed for SANBAG's approval, subject to FRA agreement. The Contractor shall be solely responsible for obtaining any FRA waivers required through SANBAG.

10.5.4.2 Fuel tanks shall be detachable from the car. Tanks shall be of welded steel or aluminum construction, and provisions shall be made for draining and cleaning the tanks.

10.5.4.3 The fuel system shall consist of a fuel tank, common to all engines on a car, two fuel filler pipes (one on each side) equipped with SANBAG's approved fuel level switches for the automatic fuel pump shut-off valve, two fuel level gauges (one per side) adjacent to the filler pipe, fuel filters, and interconnecting piping.

10.5.4.4 If electrical fuel pumps are used to pump fuel to the diesel engines, the drive motors for such pumps shall be of the brushless type. The location for the intake of the fuel line within the tank shall allow the operation of the vehicle on five percent (5%) grades with five percent (5%) or less diesel fuel left in the tank. The fuel line shall have a safety shut-off valve easily accessible from either side of the vehicle and in each cab in compliance with 49 CFR Section 229.93.

10.5.4.5 Each fuel tank shall be fitted with a sump. The sump outlet shall be fitted with a plug that, will uncover portholes when partially opened, thus ensuring easy control of the amount and direction of the fuel discharge.

10.5.4.6 The tanks' net capacity (usable fuel) shall be sufficient to allow an operating range of 500 miles (805 km) under all operating conditions.

10.5.4.7 Fuel tank and pipes shall be grounded in accordance with Section TP 9.0, Auxiliary Electrical Equipment.

10.5.4.8 Fuel tank venting shall be in accordance with 49 CFR Section 229.95.

10.5.4.9 The Contractor shall submit a complete fuel system description and fuel capacity analysis to SANBAG for approval **[CDRL 10-6]**.

10.5.5 Engine Control System

10.5.5.1 The engine operation shall be controlled by an electronic control unit equipped with an integrated fault code display. The control unit shall have a connector for a portable test unit (PTU) to permit static testing, access to diagnostics, and monitoring of the traction system during vehicle operations.

10.5.5.2 The control unit shall continuously monitor the engine conditions and protect the engine from failures caused by out-of-tolerance conditions such as, but not limited to, charge air pressure, cooling water and charge air temperatures, and low oil and water conditions.

10.5.5.3 It shall be possible to sequentially start or shut down all engines from any activated cab in a train consist. It also shall be possible to start each engine manually at the engine controls for testing.

10.5.5.4 All traction engines shall be controlled simultaneously by trainlined commands. The control unit shall be capable of reducing fuel injection and engine speed immediately if a spin condition is detected on the corresponding truck. If the spin is corrected, injection shall increase in a controlled manner to minimize further spins.

10.5.6 Fire Protection System

10.5.6.1 The Contractor shall provide a fixed fire suppression system covering the engines and shall determine the proper type and size of the fire suppression system for each location.

10.5.6.2 The fire suppression system analysis shall be submitted to SANBAG for approval **[CDRL 10-7]**.

10.5.7 Emission Control

The Contractor shall propose diesel engines that comply with the requirements of 40 CFR Part 1039, as further described in Section TP 2.14.2.

10.5.8 Engine Removal

10.5.8.1 The Contractor shall provide two engine removal fixtures. The fixture shall allow the engine and transmission to be removed as one assembly and to be reinstalled beneath the vehicle. The removal fixture shall be compatible with SANBAG's service facilities. The fixture shall consist of a rolling dolly that is guided by tubular dolly rails. The rolling dolly assembly shall have screw-type jacks that are interconnected so that all jacks may be operated simultaneously with a single jack turn crank. The jacks shall have a sufficient independent adjustment capacity to allow for out-of-plane adjustment.

10.5.8.2 Corresponding jacking pads shall be provided on the engine/transmission assembly. The mounting interface between the dolly and engine/transmission jacking pads shall promote safe and positive mounting of the assembly on the dolly. The size and location tolerance of the jack pad target centers of the assembly shall be carefully coordinated with the jack contact head size and dolly jack location tolerances to assure proper line-up with each engine/transmission assembly. The jacking brackets' location and arrangement shall allow the assembly to be safely supported on the removal dolly without imposing unacceptably high stresses on the engine or transmission support points.

10.5.8.3 The Contractor shall submit the design and arrangement of the engine removal dolly and its interface with the engine/transmission assembly to SANBAG for review and approval **[CDRL 10-8]**.

10.5.8.4 The engine/transmission/carbody and engine removal dolly shall be designed to allow engine removal by two persons in no more than four hours.

10.6 DIESEL-ELECTRIC PROPULSION EQUIPMENT

10.6.1 General

10.6.1.1 The system shall be fully coordinated with the friction braking and APS.

10.6.1.2 Propulsion and dynamic braking shall be by two AC traction motors per powered truck. Mono-motor arrangements, with a motor powering two axles, are not permitted. Each traction motor shall drive its associated axle through a parallel gear drive.

10.6.1.3 Separate and independent spin/slide control for each inverter circuit shall be provided, as specified in Section TP 12.3.14, Wheel Spin and Slide Correction.

10.6.2 System Performance

10.6.2.1 Power modulation in both propulsion and dynamic braking shall be accomplished by solid-state AC inverter equipment controlled by microprocessor.

10.6.2.2 The propulsion system for each powered truck shall perform its functions, including propulsion, dynamic braking, and wheel spin/slide correction, independent of whether other inverters are functioning.

10.6.2.3 If power generation, filtering, and primary protection equipment is shared among inverters, the primary protection and isolation equipment shall be coordinated so that power is automatically restored to all functioning systems after fault clearance and isolation of faulty propulsion or auxiliary inverter, LVPS, and/or heating circuit.

10.6.2.4 Brake blending shall be in accordance with Section TP 12.3.5, Emergency Brake Application.

10.6.2.5 The propulsion system shall be designed and tested in accordance with IEC 61287-1 and IEC 61377, and shall be tested as part of the complete vehicle in accordance with IEC 61133 (as defined in Section TP 21.0, Vehicle and Systems Testing).

10.6.2.6 The Contractor shall perform voltage step and interrupt tests, as specified in TP 21.0.

10.6.2.7 The thermal rating of the propulsion system shall be based on the duty cycles specified in Section TP 2.14, Performance Requirements. All propulsion system components shall function as specified and without damage under these conditions.

10.6.2.8 The propulsion system shall provide dynamic braking.

10.6.2.9 Both motored and non-motored trucks shall be used for brake blending.

10.6.2.10 The Contractor shall submit to SANBAG for approval details of the design for power generation and modulation, traction motor, dynamic braking, brake blending, and spin/slide control **[CDRL 10-10]**.

10.6.3 Control

10.6.3.1 The propulsion system shall limit jerk, shall control wheel spin and slide, and shall control effort demand according to load-weigh.

10.6.3.2 The propulsion system shall provide train acceleration and deceleration rates as specified in TP 2.14.

10.6.3.3 The system shall incorporate automatic resetting where the fault occurrence is not critical. Repeated faults shall be detected and lead to permanent shutdown. As part of the Final Design Review, the Contractor shall submit to SANBAG for approval detailed information on the number and types of faults allowed before a shutdown occurs.

10.6.4 Control Logic

10.6.4.1 Independent control logic units and logic power supplies shall be provided for each inverter.

10.6.4.2 The control logic units shall provide self-diagnostic routines, fault monitoring of internal and external devices, and user-programmable operating characteristics.

10.6.4.3 Control programs shall be stored in flash memory.

10.6.4.4 Discrete logic control systems are prohibited.

10.6.4.5 Electronic control equipment shall be segregated from power equipment, except for insulated gate bipolar transistor (IGBT) gate circuits, which may be located where required to achieve necessary gate current rise time.

10.6.4.6 Control circuitry and control voltage sources shall be isolated from power circuitry and high voltage sources.

10.6.4.7 The control unit shall provide continuous monitoring of critical parameters, including motor currents, switching device currents, and component temperatures.

10.6.4.8 The control unit and all related software and devices shall be sufficiently responsive to detect and remedy all erroneous or potentially damaging conditions so that equipment damage is prevented or minimized.

10.6.4.9 The propulsion control electronics shall provide zero speed function, as specified in Section TP 2.14.12, Zero Speed Detection.

10.6.5 Load-Weigh System

10.6.5.1 The propulsion control system shall adjust tractive effort to compensate for varying passenger load.

10.6.5.2 Sensors and associated circuits shall be continuously or periodically checked to verify that they are functioning properly.

10.6.5.3 Load compensation shall use signals independently processed by the propulsion control, or signals that have been processed by the friction braking system.

10.6.6 Direction Control

10.6.6.1 A change of direction shall be possible only when zero speed is detected, friction brakes are applied, and the traction motor power circuits are de-energized.

10.6.7 Propulsion Cutout

10.6.7.1 Cutout switches shall be provided in the cab to isolate each or all inverter propulsion subsystems on the vehicle from power. Cutout shall be automatically applied by the propulsion electronics in the event of repeated or major faults.

10.6.7.2 Cutout shall allow the system to be freewheeled in either direction.

10.6.7.3 Deleted.

10.6.7.4 Propulsion electronics shall normally be configured for automatic resetting of faults.

10.6.8 Power Circuit

10.6.8.1 Power to the traction motors shall be modulated by inverters utilizing variable voltage, variable frequency (VVVF) three-phase AC control, complying with IEC 61287-1.

10.6.8.2 Provision shall be made to preclude torque pulsations at all speeds.

10.6.8.3 The power semiconductor assemblies shall be functionally grouped, keyed, and mounted in modular form to facilitate repair and replacement.

10.6.8.4 Deleted.

10.6.9 Equipment Ventilation

10.6.9.1 External, filtered forced air may be used where required for heat sink temperature stabilization, but shall not be used to ventilate the inside of the equipment cabinets.

10.6.9.2 Cooling air shall be routed through channels free of high voltage stress, to avoid arc-over at dirt buildup zones.

10.6.9.3 The reliability of fans shall be such as to have negligible effect upon propulsion system availability.

10.6.9.4 The cooling arrangement, control system, and propulsion system design shall be such that failure of the cooling system shall not cause damage to the devices being cooled.

10.6.9.5 The detection of a cooling system failure shall be annunciated in the lead cab.

10.6.9.6 The Contractor shall provide product data for blowers and associated motors, controllers, and power supplies for approval to SANBAG **[CDRL 10-11]**.

10.6.9.7 Air intakes shall be screened and positioned on the vehicle so as to preclude the entry of water or debris.

10.6.9.8 Equipment ventilation blowers shall be of a service-proven, directly-motor-driven design using AC motors, powered by the main AC APS.

10.6.10 Contactors and Circuit Breakers

10.6.10.1 Adequately rated sensing and fault clearing devices shall be provided to protect propulsion system circuits and components from faults, overcurrent damage, and ground faults, and shall provide any other circuit protection deemed necessary.

10.6.10.2 A contactor shall be provided for each inverter to enable automatic and separate isolation in the event of fault.

10.6.10.3 A high-speed circuit breaker (HSCB) shall be provided, capable of safely interrupting the maximum load and fault current. Alternative methods may be considered, subject to SANBAG's approval.

10.6.10.4 HSCBs and contactors shall be capable of interrupting at all current levels.

10.6.10.5 Adequate ventilation of arcing products shall be provided to prevent buildup during normal or fault duty.

10.6.10.6 Current-carrying and arcing contact material shall discourage welding.

10.6.10.7 Where HSCBs are ventilated to the outside, the Contractor shall ensure that other devices, especially auxiliary contact blocks, are adequately protected against dust and other contamination.

10.6.10.8 HSCBs and contactors shall comply with IEC 60077.

10.6.10.9 Use of contactors for propulsion control shall be minimized.

10.6.10.10 Electro-pneumatic contactors shall not be used.

10.6.10.11 Contactors shall be capable of safely interrupting the maximum possible load current in case of a control malfunction, unless such is precluded by the device design. Contactors need not be rated to interrupt fault-level currents.

10.6.11 Capacitors

10.6.11.1 Capacitors shall comply with IEC 61071, or IEC 61881-1.

10.6.12 Inductors

10.6.12.1 Filter inductors may be air or iron core and shall be suitably shielded and oriented on the vehicle to minimize inductive coupling with onboard equipment and magnetic fields in the passenger compartment and cabs.

10.6.13 Dynamic Brake Resistors

10.6.13.1 Brake resistors shall be edge wound ribbon, flat wound ribbon, or stamped sheet metal types, complying with 49 CFR Part 238 Appendix B and with IEC 60322.

10.6.13.2 Brake resistors shall be type-tested for short-circuit-withstand tests. Where appropriate, the resistors shall be type-tested for hygroscopic and rain tests (as specified in Section TP 21.0, Vehicle and Systems Testing).

10.6.13.3 Brake resistors shall have sufficient capacity to provide full power dissipation during operation at full service braking over the specified profile and passenger loading up to and including AW2.

10.6.13.4 Resistor grids shall be electrically isolated from their frames, and the frames electrically isolated from the carbody and heat shield, with high-temperature insulation.

10.6.13.5 Resistor grids shall be convection cooled without using fans.

10.6.13.6 All resistor components shall be selected for both their thermal and mechanical properties and their corrosion resistance.

10.6.14 Traction Motors

10.6.14.1 AC traction motors shall be:

1. Ventilated; there shall be no ventilation grilles or ducts on the vehicle sides
2. Thermally rated in accordance with the duty cycles as defined in Section TP 2.14.4, Duty Cycle Requirements

3. Compliant with IEC 60349 or IEEE 11 except as otherwise specified, and with IEEE 112 as applicable. Motor insulation shall be IEEE 11, Class H insulation system or better.

10.6.14.2 Grade 8 hardware shall be used to mount traction motors to the truck frame.

10.6.14.3 Each traction motor shall be resiliently mounted, either directly to the truck frame or to both the truck frame and the gear unit.

10.6.14.4 Safety straps, tabs, or hangers shall be provided as required to prevent damage if motor or gear unit mounting fails.

10.7 FINAL DRIVE GEAR UNITS

10.7.1.1 Each final drive gear unit shall be designed and manufactured for bi-directional service. The Contractor shall propose a gear ratio that optimizes vehicle acceleration for a maximum vehicle operating speed of 79 mph (127 km/h).

10.7.1.2 Gear performance and maintenance data shall be submitted to SANBAG for approval **[CDRL 10-12]**.

10.8 DRIVE SHAFTS

10.8.1.1 The drive shafts shall have a double universal, splined arrangement, and shall be torsionally resilient to cushion torsional shocks between the truck and the transmission. The damping characteristics and power rating selected shall meet the transmission manufacturer's recommendations.

10.8.1.2 Drive shafts between transmission and final drive gear shall be designed for a minimum curve radius as specified in Section TP 2.0, Design and Performance Criteria.

10.8.1.3 The drive shaft safety hangers shall be provided and shall meet the requirements of 49 CFR Section 229.99.

10.9 CONTROL ELECTRONICS AND DIAGNOSTICS

10.9.1 General Requirements

The train electronic hardware and software for propulsion and braking systems shall be designed, developed, integrated, manufactured, installed, and tested to meet the requirements of 49 CFR Section 238.105. The Contractor shall develop and maintain a written hardware and software safety program. This safety program shall be submitted to SANBAG for approval **[CDRL 10-13]**.

10.9.2 Control Electronics

10.9.2.1 All logic units controlling traction and/or braking functions shall be based on service-proven microprocessors and associated peripherals and input/output (I/O), as required to meet all of the specified functions and performance criteria. The control units shall provide self-diagnostic routines, fault monitoring of internal and external devices, and user-programmable operating characteristics. Control programs shall be stored in flash memory cards. Microprocessor-based controls shall comply with the requirements of EN 50155 and Section TP.19.22, Material and Workmanship.

10.9.2.2 The control unit shall provide continuous monitoring of critical parameters. All related software and devices shall be sufficiently responsive to detect and remedy all erroneous or potentially damaging conditions so that equipment damage is prevented or minimized.

10.9.2.3 The control units shall provide a fault monitoring system that permanently records critical vehicle and traction system parameters prior to the detection of a fault. Data for a minimum of 100 fault events including useful environmental data shall be recorded. The Contractor shall submit data on design and functionality, data logging capabilities, and storage capacity of diagnostics to SANBAG for approval **[CDRL 10-14]**.

10.9.2.4 Each control logic shall include (a) monitor panel(s) with visual displays indicating which fault(s) have occurred and other general system conditions.

10.9.2.5 The monitor panel shall also provide an output connection so that the PTU can read contents of the fault monitor memory, and other controller unit conditions. The monitor panel(s) shall be functional at all times the traction control logic is powered.

10.9.2.6 Each control logic unit shall be arranged for the connection of a PTU to permit static testing, diagnostics, and monitoring of the traction system during vehicle operations.

10.9.2.7 Each control logic unit shall provide the interface signals required by the event recorder specified in Section TP 5.0, Operator's Cab.

10.9.3 Test Equipment (PTU)

10.9.3.1 Two PTUs shall be provided for each type of diesel engine and transmission to allow maintenance personnel to isolate and correct failed devices on the engine/transmission and its control systems. The PTUs shall be designed to simulate all electrical control system input signals and verify the proper system output response. The PTU shall be designed to test the status of all engine and transmission control sensors and control devices. The PTU shall be capable of verifying the open or closed status of switch control devices and the open, shorted, or normal status of various solenoid control devices.

10.9.3.2 The PTUs shall be rugged, suitable for railroad use, and completely housed in a sturdy metal carrying case that shall easily accommodate the PTU, power supply, download cable, and instruction procedures. PTU design and software applications shall be submitted to SANBAG for approval **[CDRL 10-15]**.

10.9.3.3 The Contractor shall provide all software and software licenses.

10.10 ELECTROMAGNETIC INTERFERENCE

The Contractor shall ensure electromagnetic compatibility of safety-critical systems with their environment. The electric equipment shall not produce electrical noise that affects the safety or performance of train control, communication, or wayside signaling systems.

10.11 DELIVERABLES

Contract deliverables required by this section of the Technical Provisions are summarized below.

CDRL 10-1 Propulsion system duty cycle analysis (TP 10.3.1)

CDRL 10-2 Emergency brake control scheme (TP 10.4.2.2)

CDRL 10-3 Diesel engine performance and maintenance data (TP 10.5.1.14)

CDRL 10-4 Cooling system performance report (TP 10.5.2.6)

CDRL 10-5 Charge air cooler arrangement (TP 10.5.2.10)

CDRL 10-6 Fuel system description and fuel capacity analysis (TP 10.5.4.9)

CDRL 10-7 Fire suppression system analysis and description (TP 10.5.6.2)

CDRL 10-8 Engine removal dolly and interface description (TP 10.5.8.3)

CDRL 10-9 Transmission performance and maintenance data, if applicable (TP 10.6.1.9)

CDRL 10-10 Details of the design for power generation and modulation, traction motor, dynamic braking, brake blending, and spin/slide control, if applicable (TP 10.7.2.10)

CDRL 10-11 Data for blowers and associated motors, controllers, and power supplies, if applicable (TP 10.7.9.6)

CDRL 10-12 Final gear drive performance and maintenance data (TP 10.8.1.2)

CDRL 10-13 Software and hardware safety program (TP 10.10.1)

CDRL 10-14 Data on design and functionality, data logging capabilities, and storage capacity of diagnostics (TP 10.10.2.3)

CDRL 10-15 PTU design and software application description (TP 10.10.3.2)

END OF SECTION

11.0 TRUCKS

11.1 CITED REFERENCES

49 CFR Part 213	FRA Track Standards
49 CFR Part 229	Railroad Locomotive Safety Standards
49 CFR Part 238	Passenger Equipment Safety Standards
AAR	Manual of Standards and Recommended Practices, Section A: Miscellaneous AAR Standards
AAR	Manual of Standards and Recommended Practices, Section G: Wheels and Axles
AAR M-101	Axles, Carbon Steel, Heat-Treated
AAR M-107	Wheels, Carbon Steel
AAR M-114-90	Specification for Helical Springs, Heat-Treated Steel
AAR M-127	Forgings, Alloy Steel
AAR M-201	Steel Castings
ADA	Americans with Disabilities Act
AISI 5160H	Alloy Steel
APTA RP-M-001-98	Recommended Practice for Passenger Car Axle Design
APTA RP-M-009-98	Recommended Practice for New Truck Design
APTA SS-M-012-99	Standard for the Manufacture of Wrought Steel Wheels for Passenger Cars and Locomotives
ASME Section VIII	Boiler and Pressure Vessel Code
ASTM A275	Magnetic Particle Examination of Steel Forgings
ASTM E94	Practice for Radiographic Testing
ASTM E142-64	Standard Guide for Radiographic Examination
ASTM E164	Standard Practice for Contact Ultrasonic Testing of Weldments
ASTM E709	Recommended Practice for Magnetic Particle Examination
AWS D1.1	Structural Welding Code, Steel
FRA	Technical Criteria and Procedures for Evaluating the Crashworthiness and Occupant Protection Performance of Alternatively Designed Passenger Rail Equipment in Tier 1 Service (ETF1)
MSS-SP-55-2001	Manufacturers Standardization Society of the Valve and Fittings Industry's Visual Method for Evaluation of Surface Irregularities

11.2 GENERAL

11.2.1 The truck assembly includes truck framing, bolsters (if used), wheel/axle sets, and all components related to the suspension system, but excludes transmissions, gear units, friction braking equipment, train control equipment, and their support brackets. Interfaces requiring welding or the removal of metal on structural members, including suspension components mounted to the carbody, shall be considered part of the truck.

11.2.2 Trucks shall use service-proven designs, components, and configurations designed to operate on SANBAG's system, including track geometry, track quality, and special track work. The use of designs that closely replicate existing designs, operating in similar environments, similar track geometry, and track quality may permit relaxation of the proof of design requirements of Section TP 11.3, Design Validation, at SANBAG's sole discretion. Evidence of design and operating environment similarity will be a prerequisite to approval of any such concessions.

11.2.3 Truck assemblies shall have a service life of 30 years without structural repairs under SANBAG's maintenance practices and service, excluding equipment subject to overhaul. Elastomeric elements, dampers, and other consumable truck-mounted components shall have a minimum service life of 5 years.

11.2.4 Truck designs shall comply with the requirements of this section of the Technical Provisions with the lowest possible truck weight and unsprung mass to meet the ground-borne vibration criteria identified in Section TP 2.0, Design and Performance Criteria.

11.2.5 All trucks shall be designed with an adequate margin against lateral or rotational instability up to the maximum operating speed, under worst-case vehicle and track wear conditions.

11.2.6 The contractor shall provide a truck assembly that resists hunting at all speeds and that is sufficiently free to swivel.

11.2.7 The truck systems shall safely function at all speeds up to and including the safe design speed as defined in Section TP 2.13, Vehicle Dynamic Performance, without any loss of stability, under all conditions of track and vehicle wear on SANBAG's system as defined in Section TP 2.0, Design and Performance Criteria.

11.2.8 The truck design shall minimize flange contact in curves.

11.2.9 All trucks shall have components that are interchangeable to the largest extent possible.

11.2.10 Lifting eyes shall be provided to permit truck assemblies to be lifted once removed from the vehicle. Appropriate means shall be provided to prevent primary or secondary suspension elements from over-extending during jacking or lifting actions.

11.2.11 Trucks shall be configured such that equipment is positioned and oriented in a manner that facilitates access for maintenance.

11.2.12 There shall be at least 2.5 inches (63 mm) clearance between the lowest element on the truck and the top of the rail under conditions of maximum loading and maximum wheel and suspension system component wear, including creeping or settling, when the clearance is measured on track with vertical curves as identified in Section TP 2.8, Wayside Characteristics.

11.2.13 There shall be sufficient clearance (but not less than 1 inch [25 mm]) between truck and carbody to allow the vehicle to operate with a deflated secondary suspension system such that damage does not occur at maximum operating speeds under conditions of maximum loading and maximum wheel and suspension system component wear, including creeping or settling.

11.2.14 Vulnerable equipment such as conduit, wiring, and piping shall be located as far as possible above the clearance plane.

11.2.15 All trucks shall be designed and manufactured by a contractor having a history of producing service-proven trucks similar to those to be used for SANBAG's vehicle.

11.2.16 Truck assemblies shall be easily removable from the carbody for maintenance without use of any special tools. Carbody to truck connections shall not contain any press fit joints. Any joints on the truck that could become frozen or locked over time shall be sealed from moisture, and appropriate materials shall be used to prevent such conditions from occurring.

11.2.17 Truck-mounted equipment shall be designed to operate satisfactorily in the environment specified in Section TP 2.10, Environmental Criteria.

11.2.18 The design of all trucks shall follow APTA RP-M-009-98, latest revision, as practical.

11.2.19 The truck design and its installation shall permit wheel-truing operations to be performed without the need for detrucking or disassembly of any parts from the truck or the carbody (bearing end cap plugs).

11.2.20 The arrangement of the trucks must provide for maintaining the design center bearing height for any condition of normal wheel and suspension system wear. The Contractor shall be allowed to shim to correct car height or lean only when approved by SANBAG. In no case will the Contractor be allowed to shim on the journal housing.

11.3 DESIGN VALIDATION

11.3.1 Approval of Design Data

The Contractor shall submit for approval by SANBAG design data and calculations for all truck components including, but not limited to, the truck frame, bolster (if used), wheel/axle sets, bearings, and primary and secondary suspension systems. The data shall include a general description of system operation and drawings or layouts with components clearly identified **[CDRL 11-1]**.

11.3.2 Stress Analysis Requirements

11.3.2.1 A structural finite element analysis of the proposed truck design, including truck frame, bolster, and radius rods, as well as these items' attachments, shall be submitted to SANBAG for review. This shall include data on stresses under static and dynamic conditions.

11.3.2.2 Allowable stress values including endurance limit data for base material and connections shall be clearly identified for the material proposed. The material strength data shall be substantiated by citation of published sources.

11.3.2.3 The stress analysis shall demonstrate that the truck frame members and structural connections comply with the requirements of Section TP 11.4.2.1 and shall be submitted for SANBAG's approval before truck production commences **[CDRL 11-2].**

11.3.2.4 If existing truck designs are used, the Contractor may demonstrate the integrity of the truck frames and bolsters through previously conducted stress analyses and static and fatigue testing. In such a case:

a. The Contractor shall categorically demonstrate that analyses and tests have input load values, load combinations, and allowable stress and fatigue life criteria closely comparable to those proposed for SANBAG.

b. The Contractor shall demonstrate that the truck assembly design is compatible with the collision requirements of these Technical Provisions.

c. SANBAG reserves the right to request a new stress analysis and static and dynamic tests if previous tests are deemed by SANBAG to be inappropriate.

11.3.3 Truck Frame Stress and Fatigue Testing

Truck frame static and fatigue load tests shall be performed as specified in Section TP 21.0, Vehicle and Systems Testing.

11.3.4 Dimensions and Tolerances

11.3.4.1 The Contractor shall ensure that wheel diameters are matched on each axle to 0.125 inch (3 mm) and between axles on a truck.

11.3.4.2 At least 2 inches (76 mm) of wear on the diameter shall be possible before the wheel is condemned.

11.3.4.3 The treads of each mounted wheel set shall be concentric with journal surfaces within 0.030 inch (0.8 mm) total dial indicator reading, and flange throats of each wheel shall be in plane within 0.060 inch (1.5 mm) total dial indicator reading.

11.3.4.4 All wheels shall be statically balanced to within the equivalent of 8 oz (227 grams) at the outside diameter of the rim or balanced by other means as approved by SANBAG. The unbalance value shall be marked on the inside of the rim at the heaviest point.

11.3.4.5 The Contractor shall submit drawings to SANBAG detailing the wheel and axle set dimensions for review and approval. Additionally, drawings detailing wheel set position and contact points at the wheel/rail interface on tangent, curved, and special track work shall be submitted for SANBAG's review and approval **[CDRL 11-3]**.

11.4 TRUCK FRAME AND BOLSTER

11.4.1 Construction

11.4.1.1 The truck frames and bolsters shall be service-proven designs.

11.4.1.2 Welded structures shall be fabricated to the requirements of AWS D1.1. Casting shall conform to all applicable AAR, or EN 15085 requirements.

11.4.1.3 Appropriate heat treatment or stress relief, if required, shall be done after fabrication to ensure strength requirements are met, unless otherwise approved by SANBAG.

11.4.1.4 All welding on the truck, including application of brackets, pads, and other attachments, shall be entirely completed prior to stress relieving. Drilling, tapping, and machining of finished surfaces shall be accomplished only after stress relief.

11.4.1.5 Post-casting welding is allowable provided that the Contractor meets the requirements of Section TP19.5, Metals.

11.4.1.6 Where pockets or partially enclosed spaces exist, adequate drainage must be provided such that no moisture collects.

11.4.1.7 A critical welds drawing shall be submitted for SANBAG's approval **[CDRL 11-4]**.

11.4.1.8 If alternative fabrication standards are used, the Contractor shall demonstrate equivalence with the standards referenced in this Technical Specification.

11.4.2 Materials

11.4.2.1 The Contractor shall supply specifications for the steel to be used for the truck frame and bolster **[CDRL 11-5]**.

11.4.3 Strength Requirements

11.4.3.1 In addition to those loads identified elsewhere in this Technical Specification, the truck frame and all truck parts, including gear unit and friction brake equipment supports, shall be capable of withstanding the maximum static and dynamic loads imposed by the forces acting on the frame. The basis for determining maximum loads shall include forces resulting from passenger load, track shocks, transmission loads, friction brake loads, suspension-induced pitching and rolling loads, and any possible combination of these forces when operating under all possible conditions on track meeting the minimum requirements of the FRA Class 3 "Track Safety Standards," according to 49 CFR Part 213, or EN 13749 and EN 12663-1, at speeds up to and including 90 mph (145km/h).

11.4.3.2 Minimum static load conditions shall be equaled or exceeded, as follows, without exceeding ninety percent (90%) of the yield strength and the endurance limit (either or both) of the base material for the specified materials, or the allowable static stress in welded connection listed in AWS D1.1 or the FKM guidelines for the appropriate connection type and loading direction as applicable:

a. Vertical load = 2.0 J

b. Lateral load = 0.5 S

c. Longitudinal load = 3.0 T or two times the maximum force generated under ideal braking conditions, using two times the coefficient of adhesion, whichever is less.

d. Transmission reactions corresponding to maximum torque and 0.5 coefficient of adhesion

e. Braking reactions corresponding to deceleration at 3 mph/sec (1.34 m/sec^2)

Where:

A = Weight of axle and axle-mounted components

J = Journal reaction per truck (W – A)

S = Sprung weight per truck (W – T)

T = Weight of one truck

W = Weight on truck (truck reaction) based on aligned AW4 load plus five percent (5%)

The loads specified in (a) through (e) above shall be logically combined to produce maximum stresses.

11.4.3.3 The design fatigue loads shall be, according to the EN 13749 and EN 12663-1 or as listed below:

Vertical component = S' ± 0.35S'

Lateral component = ± 0.25S'

Longitudinal components = ± 0.15S'

Propulsion torque reaction = 3.0 mphps (1.34 m/sec2) acceleration or deceleration

Brake torque reaction = 3.5 mphps (1.56 m/sec^2) deceleration

Where:

S' = Sprung weight per truck (W – T)

T = Weight of one truck

W' = Weight on truck (truck reaction) based on AW2 loading

Phasing of the load components specified above shall be combined to produce the maximum stress in each structural item, as approved by SANBAG. Design life shall be taken as ten million cycles minimum.

The Contractor shall select the appropriate fatigue allowable stress based on materials, geometry, loading magnitude, and direction, and shall submit these data along with other truck design data to SANBAG for approval **[CDRL 11-6]**.

The fatigue allowable stresses for welded structures shall not exceed the requirements of AWS D1.1 or FKM guideline for non-redundant structures. The design data shall list the selected

fatigue classification and allowable stress ranges for all welded joints. The Contractor may propose an alternative standard provided that equivalence is demonstrated for each joint class.

11.4.3.4 The truck shall be capable of withstanding a lifting load at the appropriate carbody attachments of at least two times its weight without suffering permanent deformation.

11.4.3.5 All lifting eyes and jacking points and any tie down features shall be designed to carry 2 times their worst-case design load.

11.4.4 Crashworthiness

11.4.4.1 In addition to ensuring the truck and bolster loading identified in this section, the Contractor shall ensure that the trucks are capable of surviving collisions without detaching from the vehicle or deforming in a manner that will penetrate the passenger compartment. Equipment supports shall also be designed to prevent equipment from becoming projectiles.

11.4.4.2 The carbody connection to the truck shall be designed, manufactured, and installed in conformance with 49 CFR Section 238.219. The Contractor shall ensure that the truck assembly does not permanently deform or separate from the vehicle under all worst-case operating conditions and collision scenarios.

11.4.4.3 Acceleration and braking forces shall be transmitted through the truck in such a manner that wheel unloading and load fluctuations are minimized. Loading shall be properly distributed to avoid excessive stresses and displacements and to avoid undue wear on components or rail.

11.4.5 Frame Inspection

11.4.5.1 All castings shall be carefully inspected for Defects by radiographic, magnetic particle, or ultrasonic methods using an approved inspection plan **[CDRL 11-7]**.

11.4.5.2 During initial production, the soundness of truck frame castings and major structural welds shall be verified, particularly in areas of potential stress concentration. Groove welds in tension or compression or under fatigue loading shall be inspected following the requirements of AWS D1.1. Welds shall also be inspected in accordance with AWS D1.1 in support of the joint fatigue classification selected. Critical areas of welds shall be inspected using magnetic particle, dye penetrant, or ultrasound in accordance with ASTM E142-64. An agreed upon minimum number of truck frames shall be radiographically inspected according to an approved inspection plan **[CDRL 11-8]** based on the requirements of ASTM E94. If more than one type of truck frame is used, each type of frame shall be inspected at a ratio equal to the number of that type supplied to the total number of truck frames supplied. All inspection results shall be submitted to SANBAG **[CDRL 11-9]**. Alternative inspection methods may be proposed.

11.4.5.3 Casting Defects shall be repaired in accordance with AAR requirements. Magnetic particle inspection or radiography shall be used to verify the quality of repairs of Defects that might impair casting strength, and the results shall be submitted to SANBAG **[CDRL 11-10]**.

11.4.5.4 All castings shall be visually inspected using Manufacturers Standardization Society of the Valve and Fittings Industry's (MSS's) Standard MSS-SP-55-2001 or current revision as pass/fail criteria.

11.4.6 Frame Testing

The first truck frame and truck bolster (if used) shall be tested as described in Section TP 21.6.2.8.

11.4.7 Tram and Axle Parallelism

The truck frame assembly, when loaded with its proportion of AW2 weight minus the weight of unsprung equipment, shall maintain the axles parallel to within ±0.06 inch (±1.5 mm) at the journal centers and shall limit the difference between diagonally opposed bearing locations to 0.12 inch (3 mm), both as measured with the vehicle stationary on level tangent track.

Permanent truck frame tram marks shall be provided and shall be located within 0.005 inch (0.12 mm) of their true positions. Shims shall not be required to maintain parallelism of the axles when axles are replaced.

11.5 SIDE BEARINGS

Side bearings, if used, shall be designed to permit rotation of the truck and transmit vertical loads (frame to bolster or bolster to carbody). Bearing surfaces shall be manganese steel or approved synthetic self-lubricating material. Wearing surfaces shall have a minimum life of 5 years. Design data for the side bearing shall be submitted for review and comment. The data shall include the coefficient of friction between bearing pads at all expected loads **[CDRL 11-11]**.

11.6 CENTER BEARING

The bearing shall be designed to eliminate shimmy and truck binding. The center bearings must be designed for ease of maintenance and shall not require lubrication for the life of the bearing. The bearing design life shall be a minimum of ten years. The Contractor shall submit to SANBAG for review and approval design data for the bearings **[CDRL11-12].**

11.7 SUSPENSION

11.7.1 General

11.7.1.1 All trucks shall have primary and secondary suspension systems designed to meet the requirements of this section of the Technical Provisions, and in compliance with 49 CFR Section 238.227. Suspension components shall have characteristics optimized to perform with the track geometry defined in Section TP2.8, Wayside Characteristics, and shall achieve the ride quality identified in Section TP 2.12.3, Ride Quality and Passenger Comfort, without causing undue rail, wheel, or vehicle component wear.

11.7.1.2 Elastomeric springs shall have a minimum amount of creep. Elastomeric springs shall be subject to an approved program of preloading or exercising during assembly of each truck to compensate for the deflection caused by initial creep of the elastomer. Provision shall be made in the truck design to compensate for creep and keep the truck properly leveled and trammed.

11.7.1.3 Coil springs, if used, shall meet the requirements of AAR M-114, or EN 13906.

11.7.2 Primary Suspension

11.7.2.1 The primary suspension shall consist of elastomeric elements, such as chevrons, or of coiled steel springs.

11.7.2.2 Coil spring designs shall employ vibration and sound-deadening inserts as described in Section TP 19.15, Insulation, and the springs themselves shall conform to AAR M-114 and AISI 5160H, or EN 13906.

11.7.2.3 Elastomeric primary suspension system designs shall include creep adjustment provisions that require minimal truck disassembly and can be accomplished with standard rail car maintenance equipment.

11.7.2.4 Equalizer bars, if used, shall be drop-forged alloy steel and shall conform to AAR M-127, Grade A, latest revision, or EN 15049. The equalizer must be normalized and tempered as called for in that specification.

11.7.2.5 Equalizer spring seats, if used, shall be made from low-carbon cast steel conforming to AAR M-201, Grade B, latest revision. The design must provide ample strength and all fillets and corners shall have sufficiently large radii. Equalizer spring seats shall be a good fit on the equalizer and be attached thereto with adequately sized tight-fit bolts and lock units.

11.7.2.6 The suspension components shall be positively retained when the truck is lifted in any manner or if a derailment occurs.

11.7.3 Secondary Suspension

11.7.3.1 All truck assemblies shall have a pneumatic or hydraulic secondary suspension system.

11.7.3.2 The secondary suspension system shall have supplemental resilient stops capable of supporting the appropriate proportion of an AW4-loaded vehicle in the event of a failure.

11.7.3.3 Resilient stops shall be designed to allow continued operation of the vehicle without wheel climb, as noted in Section TP 11.7.8, Derailment Safety.

11.7.3.4 The pneumatic suspension system shall have readily accessible, clearly labeled, vented cutout valves.

11.7.3.5 Alternate secondary suspension systems may be proposed for SANBAG's consideration and approval.

11.7.4 Vehicle Leveling

11.7.4.1 The suspension system shall be capable of maintaining a pre-set vehicle floor height within the limits required by ADA under all passenger load and distribution scenarios.

11.7.4.2 Loss of pressure due to component failures or leakage on any one side of a truck shall be rapidly equalized such that the vehicle remains upright and safe operation can continue.

11.7.4.3 A choke and cutout cock shall be provided in the supply line to the leveling valves to each truck. The choke shall be sized to prevent rapid air loss from the vehicle and a consequent brake application in case of spring rupture. Cutout cocks shall be capable of being wire-sealed in the open position.

11.7.4.4 Self-excitation or oscillation of the leveling system shall be avoided through proper configuration and/or placement of height control devices.

11.7.4.5 All height control devices shall have an appropriate range of mechanical insensitivity so that frequent cycling of the system is avoided. Devices equipped with internal fluid dampening or whose primary failure mode does not result in a loss of pneumatic pressure shall not be used.

11.7.4.6 Height control devices shall have indicators that relate the floor height to the state or position of the device, clearly visible to maintainers.

11.7.4.7 Leveling valves shall not be damaged by any possible normal movement of the truck.

11.7.4.8 The normal failure mode of the leveling valves shall be deflation of the air springs.

11.7.5 Natural Frequency

11.7.5.1 The vertical natural frequency of the primary suspension system shall not exceed 10 Hz. When measured as a total system, including the primary and secondary elements, the vertical natural frequency of the suspension shall not exceed 1.5 Hz.

11.7.5.2 Other suspension frequencies will be considered provided the Contractor can demonstrate that the natural frequencies of the vehicle body and primary and secondary suspension systems are sufficiently different, do not coincide under any operating conditions, and have no adverse effect on ground-borne vibration.

11.7.6 Reservoirs

11.7.6.1 Reservoirs shall be designed, tested, and stamped in accordance with ASME Section VIII, Division I Boiler and Pressure Vessel Code for Unfired Pressure Vessels.

11.7.6.2 External vessels shall be provided with manual drain valves.

11.7.6.3 Sections of the truck frame or bolster structure that are designed to act as reservoirs shall be capable of sustaining 1.5 times the maximum operating pressure in conjunction with maximum static and dynamic loads.

11.7.6.4 The inside surfaces of pressurized structures shall be properly cleaned to remove all chips, burrs, mill scale, weld slag, and any other debris that could potentially foul height-control devices. Inside surfaces of pressurized structures shall be coated with a corrosion-inhibiting paint system.

11.7.7 Motion Damping

Vertical and horizontal non-adjustable hydraulic damping devices shall be provided on each truck. The characteristics of the dampers shall be optimized to function with the primary and secondary suspension such that the ride quality specified in Section TP2.12.3, Ride Quality and Passenger Comfort, is achieved throughout the life of the damper. Dampers shall be readily accessible for replacement.

11.7.8 Derailment Safety

The design of the truck, including the wheel profile, shall prevent the generation of high lateral to vertical force (L/V) ratios on any wheel that could result in derailment under all track conditions defined in Section TP 2.0, Design and Performance Criteria. In addition, at all permitted vehicle speeds over the SANBAG alignment and at up to ten percent (10%) above the maximum speed permitted, the L/V ratio shall not exceed Nadal's limit under railhead coefficient of friction conditions up to and including 0.5. Yard operation and deflated secondary suspension conditions shall also be considered.

Nadal's limit is the limiting L/V ratio for a single wheel and is defined as:

$$\frac{L}{V} = \frac{Tan(\delta) - \mu}{1 + \mu\,\mathrm{Tan}(\delta)}$$

Where:

L is the lateral force component exerted by the single wheel on the rail

V is the vertical force on a single wheel

δ is the flange angle of the wheel relative to the rail

μ is the wheel-to-rail coefficient of friction.

11.7.9 Dynamic Modeling

The Contractor shall submit a detailed dynamic model report in accordance with Section TP2.13.3.

11.7.10 Displacement Criteria – Body Roll

11.7.10.1 The truck suspension systems shall be designed to minimize carbody roll within the entire system clearance envelope defined in Section TP2.7, Clearance Requirements, including stations.

11.7.10.2 The vehicle shall be capable of negotiating all system horizontal curves without violating the system clearance envelope defined in Section TP2.7. Self-centering systems may be employed. The suspension system design shall take into consideration lateral loading causing carbody roll, such as pressure waves from passing vehicles traveling in opposite directions and the wind loading specified in Section TP 2.0, Design and Performance Criteria.

11.7.11 Adjustment Provisions

11.7.11.1 Provisions shall be made to enable adjustment of the vehicle height to compensate for wear or settlement of any truck component. The minimum amount of adjustment provided shall equal the amount of wheel wear allowable up to condemning limits.

11.7.11.2 Adjustment increments shall be sized such that sufficient height can be added to the vehicle to comply with ADA platform interface requirements.

11.7.11.3 Adjustments shall be readily accomplished with standard maintenance shop tools. All shims shall be positively retained once applied to the vehicle.

11.7.11.4 Active height control devices within the suspension system shall not be used to compensate for height loss due to wear.

11.7.11.5 The Contractor shall submit to SANBAG design and maintenance data describing the method of height adjustment **[CDRL 11-13]**.

11.7.11.6 For elastomeric suspensions, creep adjustment shall be necessary no more than once in the life of the primary suspension components. Shims shall be positively retained.

11.7.12 Suspension Stops

11.7.12.1 Lateral and vertical stops shall be provided on all truck assemblies, and must be designed to carry the loads generated during normal service and to produce progressive rates of resistance. Contact shall not be made with stops except under abnormal dynamic conditions.

11.7.12.2 Metal-to-metal stops shall back up the elastomeric stops to positively maintain the carbody within the dynamic clearance envelope under all conditions. No metal-to-metal contact between the truck and carbody shall occur under normal operating conditions.

11.7.12.3 Contact with suspension stops shall not bypass suspension elements such that wheel unloading or excessive lateral forces occur.

11.7.12.4 Wear surfaces and/or resilient elements on all stops shall be readily accessible and shall be replaceable using simple tools and without the need to de-truck.

11.7.13 Equalization

11.7.13.1 Any truck assembly with all wheels resting on level track under AW0 load, with either a functional or a failed secondary suspension system, shall be capable of having any wheel lifted or dropped 2 inches (51 mm) vertically without changing the weight on any wheel of that truck by more than fifty percent (50%).

11.7.13.2 Raising or lowering any wheel (under AW0 load) up to 2.5 inches (63.5 mm) shall not result in loss of contact between any of the other wheels and the rail.

11.8 RADIUS RODS AND TRACTION LINKS

11.8.1 Radius rods and traction links shall be capable of sustaining, at a minimum, the traction and maximum braking forces generated under an AW4 load and specified track conditions without permanent deformation or fatiguing.

11.8.2 In no case shall the strength of the truck-to-carbody attachments be less than that required by 49 CFR Section 238.219 or FRA's *Technical Criteria and Procedures for Evaluating the Crashworthiness and Occupant Protection Performance of Alternatively Designed Passenger Rail Equipment for Use in Tier I Service* report (ETF1) if a CEM design is used.

11.8.3 Adequate clearance shall be provided between the radius rods/traction links and all parts of the carbody, truck, and apparatus.

11.8.4 The Contractor shall submit for SANBAG's approval a detailed analysis demonstrating compliance with the requirements of Sections TP 11.8.1, TP 11.8.2, and TP 11.8.3 **[CDRL 11-14]**.

11.9 TRUCK-TO-CARBODY CONNECTION

11.9.1 The truck-to-carbody connection including center pin assembly shall be designed to withstand a minimum of 250,000 pounds of loading in all directions. The arrangement shall provide for lifting of trucks when the carbody is lifted without disengagement. The entire arrangement shall be in accordance with 49 CFR Part 238.

11.9.2 Connections shall be accessible and detachable with conventional hand tools to permit de-trucking. Provision shall be made for de-trucking in areas of limited headroom, such as under bridges.

11.9.3 The truck shall operate freely over all curves and turnouts. Truck rotational stops shall be provided, if needed.

11.9.4 Threaded fasteners, adjustment points, and structurally critical locations shall be accessible for inspection and work using conventional means.

11.10 TRUCK ELECTRICAL CONNECTIONS

The vehicle shall be equipped with quick disconnects for all power and control leads from the truck to the carbody. The quick disconnects shall be keyed to prevent accidental miss-wiring.

11.11 SAFETY HANGERS

11.11.1 For designs in which failure of a truck-mounted equipment support may allow the equipment to intrude into the safety clearance (i.e., the area outside of the dynamic envelope), safety supports shall be provided. These shall be designed to support twice the static load of the equipment to be supported without yielding.

11.11.2 Safety hangers shall be provided for emergency support of major components, including cardan shafts and gear units, so they maintain the safety clearance if the primary mount fails.

11.11.3 Safety hangers shall be an integral part of the truck frame and shall not support any weight until a failure has occurred.

11.11.4 Failure of any long bolts or links shall not cause these items to drop and intrude into the safety clearance. Appropriate safety devices shall be provided to prevent this from occurring if the potential for such failures exists.

11.12 JOURNAL NUMBER PLATES

11.12.1 The trucks of all cars shall be provided with cast number plates applied on truck frames, centered above the journal boxes.

11.13 WHEEL AND AXLE ASSEMBLIES

11.13.1 Axles

11.13.1.1 The design of the axle shall comply with APTA RP-M-001-98 as applicable.

11.13.1.2 The axles shall be AAR Class F with the center portion turned to a diameter larger than the wheel seat to the extent determined by the drive requirements or as defined in the EN 13260 and EN 13261.

11.13.1.3 Calculations of axle static and fatigue strength shall be submitted for SANBAG's approval for all axle designs **[CDRL 11-15].**

11.13.1.4 Axles shall be of hot-rolled steel, normalized and tempered after rough machining, shall provide suitable strength, and shall have a fatigue life of at least 30 years, in accordance with the requirements of the AAR Manual of Standards and Recommended Practices, Section G: Wheels and Axles or EN 13260 and EN 13261.

11.13.1.5 Finished axles shall, at a minimum, conform to the physical property requirements of AAR Manual of Standards and Recommended Practices, Section G: Wheels and Axles, Grade F, unless otherwise approved.

11.13.1.6 Axles shall have a fine-grain structure.

11.13.1.7 A record of all heat numbers shall be included in vehicle serial records. A certified copy of chemical and physical tests as specified in AAR M-101, latest revision, Grade F, Item 17, must be made and the results must be sent to SANBAG.

11.13.1.8 Axles shall be appropriately protected against corrosion during shipping and storage.

11.13.1.9 Machined surfaces on finished axles shall undergo magnetic particle inspection in accordance with ASTM A275, and any axles detected to have laps, seams, or cracks shall be rejected. Steel shall undergo tests and ultrasonic inspection in accordance with AAR requirements.

11.13.1.10 Axles shall be serialized and marked in accordance with the applicable AAR requirements. Axles shall have standard AAR end stamping for passenger car roller bearing axles.

11.13.2 Axle Sets

11.13.2.1 Wheels shall not be mounted on tapered axles. Wheels, axles, gears, roller-bearing journals, and so forth shall be mounted using cold pressure and fits as specified in the AAR Manual of Recommended Practices, Section G: Wheels and Axles. A wheel and axle mounting procedure, complying with AAR requirements, shall be submitted for SANBAG's review and approval **[CDRL 11-16]**.

11.13.2.2 Wheel and axle data, including pressure graphs required for installation, shall be submitted as part of the corresponding Vehicle History Book (Section TP20.26, Vehicle History Book).

11.13.2.3 Mounted wheels shall be concentric between bearing seat diameters and tread at the plane of the taping line within 0.02 in (0.5 mm) total indicator reading (TIR) and shall be parallel to each other and to a plane perpendicular to the center line within 0.02 in (0.5 mm) TIR.

11.13.2.4 Before wheel and axle sets are assembled, the tape size of the pairs of wheels must be matched according to AAR Manual of Recommended Practices, Section G: Wheels and Axles, and all operations of boring the wheels, their assembly and pressing on the axle, and press tonnages obtained, must be in accordance with recommendations in AAR Manual of Recommended Practices, Section G: Wheels and Axles. Radial, plane, and parallelism for the mounted wheels shall be according to AAR requirements.

11.13.2.5 Axles that are galled or scarred during the pressing on of wheel or other components shall be rejected. In addition to the visible evidence of such damage, any excessive or abrupt change in pressing force shall be taken as cause for rejection of the assembly. Axle sets shall be straight within 0.003 inch (0.0762 mm) TIR.

11.13.2.6 The impedance measured wheel-tread-to-wheel-tread on any installed axle set shall not exceed 0.06 ohm.

11.13.2.7 The wheel seats shall be machined in accordance with AAR Manual of Recommended Practices, Section G: Wheels and Axles.

11.13.3 Journal Bearings

11.13.3.1 Roller bearing races, fingers, seal rings, cones, spacers, and other parts placed on axles must be properly assembled or pressed in place, in accordance with bearing manufacturer's and AAR recommendations.

11.13.3.2 Journal bearings shall have not less than a ninety percent (90%) probability of an expected life of at least the equivalent of 1 million miles (1.62 million km) at the AW3 vehicle weight. The Contractor shall submit for SANBAG's review and approval all design data, loading assumptions, and life calculations for the journal bearings **[CDRL 11-17]**.

11.13.3.3 A bearing housing appropriate for the design of the truck shall be provided.

11.13.3.4 The bearings shall be grease lubricated in accordance with latest AAR specifications, and shall require no field lubrication between scheduled bearing overhauls.

11.13.3.5 Journal bearings shall be numbered in accordance with AAR requirements.

11.13.4 Wheels

11.13.4.1 Wheels shall be wrought steel, multiple wear, and heat-treated, and shall conform to AAR Specification M-107, latest revision, with rim thickness of at least 2.5 inch, in accordance with the AAR K-36 wheel, as specified in the AAR Manual of Standards and Recommended Practices, Section G: Wheels and Axles. Mill scale shall be removed from the entire wheel so the wheel can be inspected before it is applied, or EN 13260, EN 13262, EN 13979-1. Tread shall be AAR 1B, 1 in 20 taper. No "rim stamping" shall be allowed.

11.13.4.2 The wheel shall be manufactured in compliance with APTA Standard SS-M-012-99 or the EN 13260, EN 13262, EN 13979-1.

11.13.4.3 The Contractor shall submit the wheel configuration drawings, including details of the wheel profile, for SANBAG's approval **[CDRL 11-18]**.

11.13.4.4 Identification

The Contractor shall legibly identify and serialize all wheels and tires in accordance with AAR requirements.

11.14 TRUCK GROUNDS

11.14.1 All parts of the carbody and trucks shall be grounded to the rails.

11.14.2 No connection shall be made between the truck frame and the journal bearing housing. Electric current shall be prevented from flowing through any journal bearing.

11.14.3 Flexible safety ground leads shall be provided between the carbody and all parts of the trucks, including the gearboxes. These ground leads shall ultimately connect to the safety ground brushes to ensure that all truck parts are at rail potential. Grounding arrangement shall prevent current from flowing through journal or gearbox bearings.

11.15 INSPECTIONS

11.15.1 The first two vehicle sets of trucks are to undergo a comprehensive ultrasonic inspection in accordance with ASTM E164 or EN 15827. Any truck produced thereafter with a design change shall undergo a complete ultrasonic inspection of the critical area(s) affected by the design change.

11.15.2 All critical welds shall be inspected ultrasonically at a sampling rate determined by the Contractor and approved by SANBAG. If any areas of the sample units fail to comply with the requirements, the failed unit shall be subject to ultrasonic inspection. An additional number of units, with the proposed quantity to be approved by SANBAG, shall be subject to ultrasonic inspection of critical areas to determine whether the failure is an isolated case or the result of a change in material or manufacturing process.

11.15.3 All major welds of each fabricated truck frame and bolster shall be magnetic particle inspected using the wet process in accordance with ASTM E709, or EN 15085.

11.16 WHEEL TRUING PROVISIONS

11.16.1 Provisions shall be made to allow for wheel truing without removing the trucks or axles. Access to axle centers shall be available if necessary for truing alignment.

11.16.2 Details for wheel truing interface requirements shall be submitted for SANBAG's approval **[CDRL 11-19]**.

11.17 PILOT BARS

11.17.1 The cab end of each vehicle shall be provided with a pilot bar arrangement in accordance with 49 CFR Section 229.123. The Contractor shall propose strength requirements for the pilot bar and mounting structure for SANBAG's review and approval **[CDRL 11-20]**. The pilot bar shall be mounted to deflect objects away from the area beneath the trucks. The pilot bar shall be mounted between the leading axle and the end of the vehicle, and shall cover the full width of the truck.

11.17.2 Pilot bars shall be made of continuous sections, and shall be height adjustable as a unit.

11.18 TRAIN CONTROL EQUIPMENT

Truck assemblies shall have provision for mounting all train control equipment identified in Section TP 14.0, Positive Train Control System. The signaling antennae mounts shall be designed to fail before any permanent deformation to the truck frame occurs.

11.19 IDENTIFICATION

All truck assemblies shall have a serial number plate permanently installed on the truck frame in an area that is visible (with skirting removed) from the side of the vehicle but is not detrimental to the integrity of the frame under static or cyclical loading.

11.20 SANDING SYSTEM

A sanding system shall be provided in accordance with Section TP12.9, Sanding System.

11.21 DELIVERABLES

Contract deliverables required by this section of the Technical Provisions are summarized below.

CDRL 11-1	Truck design validation data (TP 11.3.1)
CDRL 11-2	Truck design validation stress analysis requirements (TP 11.3.2.3)
CDRL 11-3	Wheel and axle drawings (TP 11.3.4.6)
CDRL 11-4	Critical weld drawing (TP 11.4.1.7)
CDRL 11-5	Truck frame and bolster steel specifications (TP 11.4.2.1)
CDRL 11-6	Fatigue strength data (TP 11.4.3.3)
CDRL 11-7	Casting inspection plan (TP 11.4.5.1)
CDRL 11-8	Truck frame inspection plan (TP 11.4.5.2)
CDRL 11-9	Truck frame inspection reports (TP 11.4.5.2)
CDRL 11-10	Casting Defects repair report (TP 11.4.5.3)
CDRL 11-11	Design data for side bearings (TP 11.5)
CDRL 11-12	Design data for carbody supports/ center bearings (TP 11.6)
CDRL 11-13	Design data for suspension height adjustment (TP 11.7.11.5)
CDRL 11-14	Radius rods and traction links analysis (TP 11.8.4)
CDRL 11-15	Axle static and fatigue strength calculations (TP 11.13.1.3)

CDRL 11-16 Wheel and axle mounting procedure (TP 11.13.2.1)

CDRL 11-17 Journal bearings design data (TP 11.13.3.2)

CDRL 11-18 Wheel configuration drawings (TP 11.13.4.3)

CDRL 11-19 Wheel truing interface requirements (TP 11.16.2)

CDRL 11-20 Proposed strength requirements for the pilot bar and mounting structure (TP 11.17.1)

END OF SECTION

12.0 FRICTION BRAKE SYSTEM

12.1 CITED REFERENCES

49 CFR Part 229	Railroad Locomotive Safety Standards
49 CFR Part 238	Passenger Equipment Safety Standards
AAR S-400	Brake Equipment – Installation Specifications
AAR S-471	Brake Pipe Restriction Test
APTA PR-M-S-006-98	Standard for Parking Brakes for New Passenger Locomotives and Cars
APTA SSS-M-011-99	Standard for Compressed Air Quality for Passenger Locomotive and Car Equipment
ASME Section VIII	Boiler and Pressure Vessel Code
ASTM A-53	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

12.2 GENERAL

12.2.1 This section describes the hardware and operating requirements of the friction braking systems. Components described here include those related to operation of wheel slide protection. The Contractor shall be responsible for the proper integration and function of the propulsion, air supply, wheel slide protection, and friction brake systems.

12.2.2 Each vehicle shall be provided with the equipment and functions specified in this section such that complete, fully integrated friction brake and pneumatic system functions are produced. The friction brake system shall be compliant with all applicable FRA regulations and specified APTA requirements.

12.2.3 The friction brake system, as installed, shall meet the inspection requirements of 49 CFR Section 238.231 (b). Solutions requiring regular in-shop, over an inspection pit, or other special inspection means are not acceptable.

12.2.4 The friction brake system shall be capable of providing the total service braking effort and maintaining normal revenue operation without degradation of service.

12.2.5 The brake system shall integrate and blend the braking efforts of the transmission's hydraulic retarder or the dynamic brake and the friction brake system to produce the required or demanded braking effort.

12.2.6 The brake equipment shall be provided on a per truck basis.

12.2.7 Emergency brake equipment and function shall be provided on a per vehicle basis.

12.2.8 The Contractor shall submit to SANBAG a detailed brake system, brake distribution, control, and blending description, including all interfaces, for review and approval **[CDRL 12-1].**

12.2.9 The vehicle electronic hardware and software for propulsion and braking systems shall be designed, developed, integrated, manufactured, installed, and tested to meet the requirements of 49 CFR Section 238.105. The Contractor shall develop and maintain a written hardware and software safety program. This safety program shall be submitted to SANBAG for approval **[CDRL 12-2]**.

12.3 FUNCTION, NORMAL OPERATING MODE

12.3.1 The friction brake system shall perform as indicated over the full range of vehicle loading from AW0 to AW3. The system shall be designed to allow for weight differences between trucks due to uneven passenger loadings and vehicle weight distribution.

12.3.2 The friction brake system shall have the thermal capacity to provide continuous operation when operating without hydraulic retarder braking and with an AW3 passenger load with the duty cycle specified in Section TP 2.14.4, Duty Cycle Requirements. During this operation the system shall maintain accuracy and time response requirements as specified, and disc or wheel temperatures shall not exceed the design limit determined by the wheel, disc, or friction material manufacturer.

12.3.3 The capability of providing this performance shall be verified by calculation and proven by a test run as specified in Section TP 21.0, Vehicle and Systems Testing. The calculation shall be submitted to SANBAG for review and approval [CDRL 12-3].

12.3.4 Service Brake Application

12.3.4.1 Service brake applications shall be initiated from the master controller and shall be regulated by the control handle position.

12.3.4.2 Brake cylinder pressure in service braking shall be controlled on a per truck basis by a closed-loop control system.

12.3.4.3 The closed-loop control shall function by comparing commanded brake cylinder pressure with actual brake cylinder pressure.

12.3.4.4 Load-weighing, blending, and adjustment for speed taper shall be incorporated in the friction brake effort command. Blending shall be accomplished on a per truck basis, using dynamic brake feedback.

12.3.4.5 Service friction brake application and release shall be jerk-limited as specified in Section TP 12.3.10, Jerk Limiting Performance. Jerk-limiting shall be controlled by the logic with a maximum value controlled by a fixed orifice.

12.3.4.6 Passenger load shall be measured by means of spring pressure by a load-weigh transducer. This component shall convert spring pressure to an electrical signal suitable for use by the propulsion control logic and friction brake logic. The resulting signal shall be used to adjust friction-braking effort such that the commanded deceleration rate is met regardless of passenger loading.

12.3.5 Emergency Brake Application

12.3.5.1 Emergency brake application shall be independent of proper functioning of either the propulsion control logic or the friction brake controls.

12.3.5.2 The controls shall be configured such that an emergency brake command takes precedence over any service friction brake command then in effect.

12.3.6 Service Brake Application, Blended Braking

12.3.6.1 Service brake applications shall be provided by a blended system of both regenerative braking (or hydraulic retarder) and friction braking. Friction braking shall be supported by the regenerative brake or hydraulic retarder brake as needed to achieve the brake demand.

12.3.6.2 The service brake effort shall be supplied entirely by the friction brake system in speed ranges in which the regenerative brake or hydraulic retarder is ineffective. A smooth transition shall be provided between blended braking and friction-only braking.

12.3.6.3 Upon absence of retarder or dynamic braking effort, at any point in the speed range, the friction braking system shall provide the full commanded braking effort.

12.3.6.4 There shall be no modulation of brake cylinder pressure relative to speed during service friction-only braking.

12.3.7 Emergency Brake Application

Emergency brake applications shall be provided entirely by the friction brake system.

12.3.8 Service Brake Application, Performance

12.3.8.1 The service brake rate shall be sufficient to allow a fully loaded train (AW3) to meet the required round trip times, including station dwell times, as described in Appendices A through C to this document.

12.3.8.2 The net rate is the rate developed by dynamic braking supplemented by the friction brake without the beneficial retarding effects of train resistance.

12.3.8.3 Instantaneous variation in braking rates shall be within ± twenty percent (20%) of the nominal value.

12.3.8.4 Modulation of brake cylinder pressure by a wheel slip correction system shall be employed to maximize adhesion.

12.3.9 Emergency Brake Application, Performance

12.3.9.1 Under an emergency brake application, the brake system shall supply a nominal net braking rate of no less than 2.5 mphps, and no greater than 3.2 mphps throughout the speed range from 65 mph down to zero. Instantaneous variations in the emergency brake rate shall be within ± twenty percent (20%) of the nominal value.

12.3.9.2 There shall be no modulation of brake cylinder pressure with speed during an emergency application.

12.3.10 Jerk Limiting Performance

12.3.10.1 Changes in propulsion and brake effort shall develop smoothly.

12.3.10.2 Decreases in accelerating tractive effort arising from interruptions in the primary power supply shall not be jerk limited. However, re-application of accelerating power after an interruption shall be jerk limited.

12.3.10.3 Emergency brake applications shall not be jerk limited.

12.3.10.4 Removal of power and brake effort under wheel slip conditions shall be on a per truck basis and shall not be jerk limited. The reapplication of power and brake effort shall be jerk limited.

12.3.11 Command Response Times

12.3.11.1 Command response times include response to modulation within a mode (power, coast, and brake), and transitions from one mode to another, including emergency braking.

12.3.11.2 Modulation of tractive effort within a mode shall be jerk limited. If the rate change is less than the jerk limit, then modulation of tractive effort shall follow the command.

12.3.11.3 The command response time within a mode shall not exceed 500 ms.

12.3.11.4 The command response time shall be measured from the time the change is initiated until the acceleration or deceleration transitions to ten percent (10%) of the requested change. The balance of the transition shall be controlled by the jerk limit.

12.3.11.5 Mode change dead times for transitions from one mode to an adjacent mode (propulsion to coast, coast to brake, brake to coast, and coast to propulsion) shall not exceed 500 ms, exclusive of jerk limiting.

12.3.12 Propulsion Interlock

Brake pipe pressure sensing shall be provided to inhibit propulsion and to force emergency braking whenever the brake pipe pressure drops below that required for an emergency brake application on a crush-loaded vehicle.

12.3.13 Main Reservoir Equalization

12.3.13.1 Apparatus shall be provided on each vehicle to charge the main reservoir on the vehicle from the brake pipe. The rate of main reservoir charging shall be limited to prevent brake pipe pressure from dropping rapidly enough to cause an emergency brake application.

12.3.14 Wheel Spin and Slide Correction

12.3.14.1 A wheel spin and slide correction system shall be provided as an integral part of the friction brake control system. The spin and slide performance requirements of this section shall be met with or without hydraulic retarder brake effort being available, or as defined in the UIC 551-05 or EN 15595.

12.3.14.2 The spin/slide correction system shall use axle speeds, acceleration rate, and deceleration rate information to modulate individual brake cylinder pressures independent of the service brake command to optimize available wheel/rail adhesion and enable the train to reliably meet the specified braking and acceleration rates for service and emergency braking.

12.3.14.3 The friction brake system shall provide appropriate interface signals to the propulsion system to control wheel spin conditions.

12.3.14.4 The friction brake system shall share the speed sensor information from the motor and trailer trucks with the propulsion system, but shall not require a functioning propulsion system for accurate speed information.

12.3.14.5 The wheel spin and slide correction system shall detect all spins and slides, whether they are random or synchronous, under all adhesion conditions and at all speeds.

12.3.14.6 A failure of the spin and slide correction system shall not in any way prevent the application of emergency brakes.

12.3.14.7 The detection shall work based on measuring axle acceleration and axle speed difference. All wheel speeds of a vehicle shall be used to compute the vehicle speed. The wheel spin/slide correction system shall function properly with maximum wheel diameter differences between trucks.

12.3.14.8 A safety circuit or software monitor shall be used to override the slide protection system. If braking effort is reduced to below twenty-five (25%) of the commanded level for more than 5 seconds, this circuit shall act to disable slide protection and any associated braking effort reduction until the vehicle reaches zero speed or experiences a transition from brake to power mode. Dump valves shall fully release the brakes for no longer than 3 seconds continuously. The time values and levels shall be adjustable by maintenance personnel in a safe manner.

12.3.14.9 The design and operation of spin and slide and brake-blending systems shall minimize the number of speed sensors, consistent with reliable and safe operation and consistent with the requirements of these technical provisions.

12.3.14.10 At a coefficient of adhesion of 0.05 or greater, the efficiency of the wheel spin and slide system shall be at least eighty percent (80%) in acceleration and braking over the speed range between maximum and 5 mph (8 km/h).

12.3.14.11 System efficiency shall be defined as follows, or by another applicable, approved, service-proven method:

a. For the purposes of these technical provisions, system efficiency is the ratio of total tractive effort achieved to total tractive effort possible, expressed as a percentage.

b. Spin or slide correction action results in a series of peaks and valleys in vehicle acceleration or deceleration rates. When the vehicle acceleration is graphed versus time, the area under the curve created by these peaks and valleys shall be termed “the total tractive effort achieved.”

c. A line can be drawn connecting the peaks of the curve described above. The area under this line shall be termed "the total tractive effort possible."

d. System efficiency shall only be measured in this way during the time that tractive effort reduction is required to prevent wheel spinning or sliding.

12.3.14.12 The Contractor shall submit to SANBAG for review and approval a detailed description of the slip and spin correction system to SANBAG [CDRL 12-4]**.**

12.3.14.13 A simple means shall be provided to deactivate the wheel slide correction system in emergency braking in the future, should SANBAG decide to do so.

12.3.15 Load Weigh System

12.3.15.1 A load weigh compensation system shall be provided that measures the passenger load using load weigh pressure transducers on each truck, averages the two trucks, and determines the braking effort required for that passenger load to meet the specified deceleration rates and adjust the friction brakes to meet that demand.

12.3.16 Diagnostic and Test System

12.3.17 The Contractor shall submit to SANBAG for review and approval a detailed description of the friction brake system's diagnostic functionality **[CDRL 12-5].**

12.4 PARKING BRAKE

12.4.1 The parking brake system shall meet the requirements of 49 CFR Section 238.231(h)(2) and shall conform to APTA Standard PR-M-S-006-98, latest revision.

12.4.2 The parking brake shall be able to hold any train configuration consist loaded to AW3 on a four percent (4%) grade.

12.4.3 Operation of the parking brake shall remain the same in both modes of operation.

12.5 CAB BRAKE CONTROLS AND INDICATORS

12.5.1 Master Controller

The friction brake system shall be Operator-controlled through the master controller described in Section TP 5.5, Master Controller.

12.5.2 Air Gauges

A duplex air gauge shall be provided on each control console to indicate main reservoir pressure, brake pipe pressure, and brake cylinder pressure.

12.5.3 Application and Release

12.5.3.1 Trainlined application and release indications shall be provided on the cab console.

Applied: The "brakes applied" indication shall be illuminated when all trucks in the train have friction brakes applied. Application shall be defined as a brake cylinder pressure of greater than eighty percent (80%) of the full service application pressure for an AW0 vehicle.

Released: The "brakes released" indication shall be illuminated when all trucks in the train have friction brakes released. Release shall be defined as a brake cylinder pressure of less than a pressure proposed by the Contractor and approved by SANBAG.

12.5.3.2 Local "brakes applied" and "brakes released" indicators shall be provided for each truck on the exterior on each side of the vehicle.

12.6 COMPRESSOR AND AIR SUPPLY EQUIPMENT

12.6.1 General

The compressed air supply system shall meet the requirements of APTA Standard SS-M-011-99.

12.6.2 Compressor

12.6.2.1 The air compressor unit shall be mounted on a frame to permit replacement as a unit.

12.6.2.2 The unit frame shall be so arranged that the unit can be handled with a lift truck and placed upright on a flat surface without damage to any part of the unit.

12.6.2.3 Deleted.

12.6.2.4 The compressor shall be protected against damage from incorrect direction of rotation. If the motor rotation depends on carbody wiring connections external to the unit, the lubrication pump shall be arranged so as to provide adequate lubrication in either direction of motor rotation.

12.6.2.5 The proper direction of compressor rotation shall be clearly and permanently marked on the exterior of the case.

12.6.2.6 The compressor overhaul interval shall not be less than six years.

12.6.2.7 The compressor shall be sized to meet the worst-case air consumption requirements with a duty cycle of eighty percent (80%).

12.6.2.8 The compressor motor shall not be overloaded in starting the compressor with a main reservoir pressure of 160 psig and at any ambient condition reasonably to be expected in SANBAG's operational environment.

12.6.2.9 Filters/filter elements shall not need replacement more frequently than once every 30,000 miles, or every six months, whichever is longer.

12.6.2.10 The air compressor shall use an approved lubricating oil suitable for year-round operation under the climatic conditions present at SANBAG without the need for seasonal oil changes.

12.6.2.11 A sight glass shall be provided to permit easy determination of the oil level. The sight glass shall be suitably rugged in design and located so as to minimize any chance of breakage. Permanent markings for maximum and minimum oil levels shall be provided.

12.6.3 Safety Valve

A safety valve shall be supplied to prevent the main reservoir air pressure from exceeding 15 psi above the maximum working pressure of the system.

12.6.4 Main Reservoir

12.6.4.1 The capacity of the main reservoir shall be sufficient to supply all systems with sufficient air for three consecutive emergency brake applications without requiring the air compressor to come on line.

12.6.4.2 Supply reservoirs shall be provided as part of the friction brake system. Only braking air shall be supplied by the supply reservoirs; all other air requirements shall be taken from the main reservoir.

12.6.4.3 The main reservoir shall be protected against air line failure between the compressor and the main reservoir by a check valve.

12.6.4.4 Main reservoirs shall be provided with a manual, self-locking drain cock. Reservoirs shall be installed with a downward slope toward the drain end to permit gravity draining.

12.6.4.5 An analysis of air usage, along with reservoir sizing calculations, demonstrating suitability and compliance with this specification shall be provided. The analysis shall consider worst-case temperature conditions, system leakage, and the duty cycle requirements

12.6.4.6 Main reservoirs shall be tested and certified as conforming to 49 CFR Section 229.31(c). All other reservoirs shall be designed with a safety factor of 4 times the normal working pressure in accordance with ASME Section VIII, Boiler and Pressure Vessel Code for Unfired Pressure Vessels.

12.6.4.7 Filter Dryer & Drain Valve

12.6.4.8 A regenerating-type, dual-chamber air dryer shall be provided. The air dryer inlet shall be fitted with a coalescing filter that protects desiccant beads against oil contamination.

12.6.4.9 The air dryer must be capable of operating efficiently during periods in which the air compressor is run continuously, without reaching saturation of the desiccant material.

12.6.4.10 The desiccant's useful life shall be a minimum of one year.

12.6.4.11 The air leakage of the dryer, if any, shall be included in the allowable system leakage.

12.6.4.12 The drain valves shall operate satisfactorily under all pressure conditions.

12.6.4.13 The drain valves shall discharge air at a sufficient rate to prevent compressor motor stalling due to rapid compressor restarting, if required.

12.7 BRAKE SYSTEM EQUIPMENT

12.7.1 General

The Contractor shall ensure that airbrake system components are of a type that FRA regulations do not require be cleaned, repaired, and tested more frequently than once every three years. The brake system supplier shall support SANBAG in an application to the FRA to extend the test interval of valves as requested.

12.8 TRACK BRAKE

12.8.1 The track brake assembly shall consist of a spring-mounted or pneumatic electromagnetic track brake suspended above the rail between the wheels of all trucks.

12.8.2 The track brake assembly shall provide additional braking force for the vehicle independent of adhesion between wheel and rail.

12.8.3 Any mechanical failure of the track brakes shall not lead to derailment conditions on any part of the SANBAG alignment.

12.8.4 Track brake assemblies, including all electrical connections, shall be fully waterproof.

12.8.5 Electrical connectors shall not be placed or installed at or near a track brake assembly, but shall be secured at an area of the truck frame where they are protected from wheel splash and flying debris.

12.8.6 Magnet coils shall be isolated electrically from all grounds.

12.8.7 Track brakes shall be fed from a separate circuit breaker.

12.8.8 Track brakes shall be applied and released using "per truck" controls.

12.8.9 Track brake forces shall be transmitted to the truck through bonded rubber elements or by another approved system.

12.8.10 Track brake shoes shall be designed to maximize contact with the rail, to minimize damage to the rail, and to be readily renewable.

12.9 SANDING SYSTEM

12.9.1 Each vehicle shall be provided with sandboxes, pneumatic sand traps, and sanding nozzles, arranged to deposit sand on both rails immediately in front of the leading wheels of the lead truck in either direction of travel.

12.9.2 The sandboxes shall be designed to permit the free flow of sand to the nozzles under all conditions of environment and truck rotation and to prevent sand clogging due to humidity.

12.9.3 If air for the sanding system is provided by the vehicle air supply system, cutout valves for the sanders of each truck shall be provided.

12.10 BRAKE PIPING

12.10.1 Brake pipe shall be 1-1/4-inch AAR-standard extra-heavy pipe, ASTM A-53, as specified in AAR S-400. Brake pipe can be fabricated with materials other than steel only when the AAR has specifically approved that material for use as a brake pipe.

12.10.2 The main reservoir equalizing pipe shall be 1-inch AAR-standard pipe.

12.10.3 All branch air piping shall be AAR-standard pipe or type "K" copper tubing.

12.10.4 All fittings shall be of AAR-type malleable iron or copper to suit the particular pipe application requirements and shall be socket weld type.

12.10.5 Prior to installation of any air brake system valves and accessories, the piping shall be cleaned.

12.10.6 After all cutting, fabrication, and bending is complete, piping must be deburred, blown out with steam, and simultaneously pounded to remove scale or dirt before application to car. All pipe openings must be capped or plugged until connected into the system.

12.10.7 During application to the car prior to connection to brake equipment, all piping must be ensured to be clean.

12.10.8 All pipe routes shall be designed to eliminate water traps.

12.10.9 AAR-standard test gauge fittings for single vehicle testing shall be supplied in the brake cylinder pipe, one at each end of the vehicle.

12.10.10 The brake pipe installation on the car shall pass the brake pipe restriction test described in AAR S-471.

12.11 DELIVERABLES

Contract deliverables required by this section of the technical provisions are summarized below.

CDRL 12-1	Friction brake system description (ref. TP 12.2.8)
CDRL 12-2	Brake control hardware and software safety program (ref. TP 12.2.9)
CDRL 12-3	Friction brake system thermal capacity analysis (ref. TP 12.3.3)
CDRL 12-4	Spin/slide correction system description (ref. TP 12.3.14.12)
CDRL 12-5	Friction brake system diagnostic system functionality description (ref. TP 12.3.17)

END OF SECTION

13.0 COMMUNICATIONS

13.1 CITED REFERENCES

AAR	Communications Manual
APTA RT-S-VIM-026-12	Rail Transit Vehicle Passenger Emergency Systems
EIA-SE-101A	Amplifiers for Sound Equipment
EIA-SE-102	Telecommunications, Land Mobile Communications
EIA-SE-103	Speakers for Sound Equipment
EIA-SE-104	Engineering Specifications for Amplifiers for Sound Equipment
EIA-SE-105	Microphones for Sound Equipment
EIA-160	Sound Systems
IEEE 1477	Standard for Passenger Information System for Rail Transit Vehicles
IEEE 802.11	WLAN Communication

13.2 PASSENGER INFORMATION SYSTEM

13.2.1 The Contractor shall meet industry typical communication system requirements and shall be responsible for design and interface coordination and for installing and testing the entire vehicle communications system.

13.2.2 The system components shall be modular and shall be removable for servicing, without affecting other functions or devices.

13.2.3 The communications system shall include the following functions:

a. Train radio

b. One-way announcements from the train crew or cab control station to passengers (PA system, paging)

c. GPS-location-triggered automatic audio and visual announcements to passengers

d. Two-way, private communication between the passenger intercom stations and the train crew (intercom function)

e. Deleted.

f. Passenger compartment surveillance cameras and associated hardware

g. Interior and exterior speakers and associated hardware.

13.2.4 The passenger information system design shall meet all requirements outlined in IEEE Standard 1477 and APTA Standard RT-S-VIM-026-12.

13.2.5 The Contractor shall verify through testing that all required inter-vehicle communications are totally functional through the entire train and through the couplers when two vehicles are coupled together.

13.2.6 All electrical materials, components, and installation methods used in the fabrication of the communication system, including wire, cable, printed circuit boards, and circuit protective devices, shall conform to the requirements of Section TP 19.17 to TP 19.22, Material and Workmanship.

13.2.7 All circuits shall be isolated and properly protected against inductive and conducted electrical interference. Likewise, the communication equipment shall not cause any undue interference in any other onboard or wayside equipment.

13.2.8 The PA and intercommunication equipment shall meet all applicable environmental requirements of the EN 50155 and EN 60268-16 (RASTI or STI-PA) or equivalent.

13.2.9 The Contractor shall submit for approval by SANBAG data sheets and/or specification sheets for all communications system components **[CDRL 13-1]**.

13.2.10 The Contractor shall submit for approval by SANBAG system functional description and block diagrams **[CDRL 13-2]**.

13.2.11 Structured programming techniques, as specified in Section TP 18.0, Software Systems, shall be used for all software-driven communications subsystems.

13.2.12 All communications equipment shall be operable when auxiliaries are "ON."

13.2.13 Power Supply

13.2.13.1 All communications shall be powered from the LVPS and storage battery.

13.2.13.2 The communications system shall be configured with a separate circuit breaker for each major component.

13.3 AUTOMATIC PASSENGER COUNTING SYSTEM

13.3.1 The Contractor shall design, provide, install, and test a fully automatic passenger counting (APC) system on each vehicle, covering doors. In addition, matching wayside station identification equipment and yard located data processing equipment shall be provided. The Contractor shall provide details of the proposed system for The T's review and approval **[CDRL 13-3]**.

13.3.2 The proposed system shall be service-proven in a commuter rail or rail transit application.

13.4 WI-FI SYSTEM

13.4.1 The Contractor shall provide a wireless local area network (WLAN) for passenger use that complies with the latest IEEE 802.11 requirements to ensure maximum compatibility with existing devices.

13.4.2 The system architecture shall be upgradable to allow for future changes required to maintain compatibility with mobile devices.

13.4.3 If the proposed architecture excludes connectivity with certain versions of 802.11 legacy devices, the Contractor shall submit for approval by The T a study that shall identify the services and the generation of devices that will not be supported by the new onboard Wi-Fi equipment.

13.4.4 The system shall provide a data rate per stream that is no less than 54 Mb/second, assuming an average of 10 devices per car on each vehicle.

13.4.5 The Contractor shall provide adequate hardware and associated wiring to ensure that the required data rate can be maintained everywhere in the passenger compartment.

13.4.6 The Contractor shall ensure that the WLAN signal does not interfere with other vehicle signals and equipment.

13.4.7 The Contractor shall perform measurements or other assessments to insure signal availability along the entire route of the SANBAG system.

13.4.8 The Contractor shall submit a detailed proposal for SANBAG review that includes technical details of the system, performance capabilities, and interface with other vehicle systems **[CDRL 13-4]**.

13.5 DELIVERABLES

Contract deliverables required by this section of the Technical Provisions are summarized below.

CDRL 13-1	Data sheets/specification sheets for all communications system components (TP 13.2.9)
CDRL 13-2	Communications system functional description and block diagrams (TP 13.2.10)
CDRL 13-3	Details of the proposed APC system (TP 13.3.1)
CDRL 13-4	Details of the proposed passenger Wi-Fi system (TP 13.4.8)

END OF SECTION

14.0 POSITIVE TRAIN CONTROL SYSTEM

14.1 CITED REFERENCE

49 CFR Part 236	Rules, Standards, and Instructions Governing the Installation, Inspection, Maintenance, and Repair of Signal and Train Control Systems, Devices, and Appliances

14.2 GENERAL

14.2.1 SANBAG intends to use a Wabtec V-ETMS system as a means of providing the positive train control (PTC) function for SANBAG's rail vehicles in compliance with 49 CFR Part 236.

1.1.1 The Contractor shall furnish provisions for the installation of the required equipment by SANBAG, including brackets, conduits, cabinets, and mounting space, as required, to support the installation of the specified PTC system.

1.1.2 The Contractor shall coordinate and cooperate closely with SANBAG to ensure that all operational, functional, performance, and physical interfaces are defined and resolved satisfactorily.

1.1.3 The Contractor shall prepare a detailed design review package that includes drawings, schematics, data sheets, and other information for approval by SANBAG **[CDRL 14-1]**.

14.3 ETHERNET SYSTEM

14.3.1 The Ethernet system shall consist, at a minimum, of the following equipment:

a. An Ethernet switch in each cab
b. An Ethernet cable that interconnects the two switches in each cab

14.3.2 The Ethernet switch shall have five ports available, at a minimum, to support the required inputs/outputs for the PTC system.

14.3.3 The Ethernet connections shall use M12 connectors and standard 4x22AWG CAT5 XC S RW cables.

14.3.4 The Ethernet network shall be completely isolated from the PIS Ethernet network, if one is provided.

14.3.5 The equipment on the Ethernet network shall receive a fixed IP address. The exact IP address will be defined at a later stage. The protocol shall be based upon cyclic UDP telegrams of byte-oriented raw data format.

14.3.6 The signals that will be transmitted over the Ethernet and the update rates of these signals shall be defined at a later stage. The Contractor shall support this activity with any required software changes required to commission the PTC system.

14.4 DISCRETE SIGNALS

14.4.1 Discrete signals shall be wired from the source to a terminal board near the PTC equipment.

14.4.2 The signals shall be read by the PTC equipment using an optically isolated input. To allow this, an appropriate signal ground wire(s) shall be provided as part of the interface. The discrete wires shall be assumed to follow the convention below, unless otherwise identified by SANBAG:

1 (on): > 14 Vdc
0 (off): < 5 Vdc

14.4.3 The initial as-delivered list of interface signals shall be:

a. Activation of Cab A
b. Activation of Cab B
c. Driving direction signal Cab A

d. Driving direction signal Cab B
e. Master controller position
f. Driver brake lever position
g. Maximum brake initiated by driver
h. Moving direction forward
i. Moving direction backward
j. Tractive effort
k. Actual dynamic brake effort
l. Brake pressure motor truck, one for each powered axle
m. Train speed
n. Wheel spin/slide alarm
o. Date/time
p. Three additional discrete signals

14.5 MOUNTING BRACKETS

14.5.1 Based on the Wabtec equipment outline drawings, the Contractor shall determine the mounting location of each piece of equipment and design, manufacture, and install the brackets/adapters for such equipment listed below.

14.5.2 At a minimum, provisions for the following equipment will be supplied:

a. PTC power supply (to be provided by Wabtec in the future) under console in A Car
b. PTC power supply (to be provided by Wabtec in the future) under console in B Car (if required)
c. Train management computer under console in A Car
d. PTC data recorder under console in A Car
e. Communication management computer under console in A Car
f. PTC data radio under console in A Car
g. GPS1 under console in A Car
h. GPS2 under console in A Car
i. GPS1 antenna on the roof of A Car
j. GPS2 antenna on the roof of A Car
k. 802.11 antenna on the roof of A Car
l. Cell antenna on the roof of A Car
m. 220-MHz antenna on the roof of A Car

14.6 CONSOLE DISPLAY

14.6.1 Provisions to accept a Wabtec central diagnostic unit (CDU) shall be made in the console design. The Contractor shall work with the PTC supplier to define the exact space and placement requirements.

14.6.2 Sonalert Alarm

14.6.2.1 The Contractor shall mount the Wabtec sonalert alarm in the console of each cab and provide appropriate wiring from the sonalert to the Wabtec equipment.

14.7 ELECTROMECHANICAL DEVICES

14.7.1 Based on Wabtec's outline drawing for the penalty cutout switch, the Contractor shall design a mounting location for the assembly under the console of the A Car.

14.7.2 Safety Relays

14.7.2.1 There are three safety relays that will be used to provide interfaces between PTC safety outputs and the vehicle control system. One relay is for penalty brake (full service), one is for emergency brake, and one is to drive the horn.

14.7.2.2 The PTC shall drive the relay coils and the Contractor shall wire the contacts into the control system.

14.7.2.3 The relays shall feature non-overlapping, non-weld contacts, of sufficient number to be applied as double-break contacts with feedback contacts to the PTC. The design of the relays shall comply with the requirements of Section TP 19.20.1.9.

14.7.2.4 Design a mounting location for the relay panel assembly with three relays.

14.7.2.5 All wiring shall be provided, installed, and routed to the PTC equipment.

14.7.2.6 As delivered, relay contacts shall be jumpered to allow vehicle operation in advance of PTC installation.

14.7.2.7 The jumpers shall be obvious by virtue of color, location, or other means, so that they cannot be left in place when PTC equipment is installed.

14.8 OTHER PTC WIRING

14.8.1 The Contractor shall supply and install wiring in the vehicle as follows:

a. An Ethernet cable with M12 connectors from the A Car console train management computer to the B Car console remote CDU.
b. Antenna cables and conduits from each antenna location to the A Car console area to allow for interface with the future V-ETMS equipment. The ends shall be terminated (both under console and on the roof) at the antenna locations and sufficient cable shall be allowed under the console to permit termination of the cables once the radio and GPS equipment is installed.
c. All necessary low-voltage circuit breakers.
d. Wiring from the vehicle low-voltage power supply to the PTC circuit breakers and from the circuit breakers to the console area in the A Car.

14.9 PTC SPEED SENSOR

14.9.1 The Contractor shall supply and install a dedicated PTC speed sensor on the vehicle.

14.9.2 The speed sensor shall be mounted in an available location on a powered or trailer truck.

14.9.3 The wiring from the speed sensor shall be routed to the Wabtec equipment located under the A Car console.

14.10 INTERFACE CONTROL DOCUMENT

The Contractor shall supply an interface control document (ICD) as follows **[CDRL 14-2]**:

a. Include all information necessary for Wabtec to design the PTC system interface
b. Include mechanical information such as mounting dimensions, weight limits, and temperature/power restrictions
c. Include electrical information such as terminal connections, signal levels, network protocols, and current limits
d. Include other deliverables (e.g., drawings) so that the ICD is a complete and independent document

14.11 DELIVERABLES

Contract deliverables required by this section of the technical provisions are summarized below.

CDRL 14-1 PTC system equipment design review package (TP 14.2.4)
CDRL 14-2 ICD (TP 14.10)

END OF SECTION

15.0 CARBODY INTERIOR

15.1 CITED REFERENCES

49 CFR Part 37	Transportation Services for Individuals with Disabilities
49 CFR Part 38	Americans with Disabilities Act Accessibility Specifications for Transportation Vehicles
49 CFR Part 609	Transportation for Elderly and Handicapped Persons
49 CFR Part 238	Passenger Equipment Safety Standards (FRA)
49 CFR Part 238 Appendix B	Test Methods and Performance Criteria for the Flammability and Smoke Emission Characteristics of Materials Used in Passenger Cars and Locomotive Cabs
ANSI A117.1	American National Standard for Buildings and Facilities – Providing Accessibility and Usability for Physically Handicapped People
ANSI Z26.1	Safety Glazing Materials for Glazing Motor Vehicles Operating on Land Highways – Safety Code
APTA Standard SS-C&S-006-98	Standard for Attachment of Interior Fittings for Passenger Railroad Equipment
APTA Standard SS-C&S-016-99	Standard for Row-to-Row Seating in Commuter Rail Cars
APTA Standard SS-PS-002-098	Standard for Emergency Signage for Egress/Access for Passenger Rail Equipment
ASTM D2047	Standard Test Method for Static Coefficient of Friction of Polished Coated Floor Surfaces as Measured by the James Machine

15.2 GENERAL

15.2.1 The design of the interior details shall be approved by SANBAG throughout the design review process.

15.3 FLOOR COVERING

15.3.1 Floor Covering

15.3.1.1 Flooring material shall be slip-resistant as required by ADA under wet and dry conditions, and its colors shall be coordinated with the interior colors.

15.3.2 The material shall comply with Section TP 19.6.6, Floor Covering, and shall resist degradation from ultraviolet light, cleaning solutions, and detergents.

15.3.2.1 The coefficient of friction of the floor material, or any other surface that passengers or maintenance or operating personnel regularly stand or walk on, shall not be less than 0.60 when tested to ASTM D2047.

15.3.3 Adhesives

Flooring material shall be bonded to floor panels with an adhesive recommended by the manufacturer of the flooring panels and complying with the fire and smoke requirements of Section TP 19.23, Flammability, Smoke Emission, and Toxicity.

15.4 INTERIOR FITTINGS

15.4.1 General

15.4.1.1 All interior fittings and surfaces shall be designed, constructed, and installed to meet or exceed the requirements of 49 CFR Section 238.233.

15.4.1.2 Surfaces requiring paint should be minimized.

15.4.1.3 All materials shall be resistant to graffiti and shall be readily cleanable with standard cleaning materials and solutions.

15.4.2 Windscreens

15.4.2.1 Passenger entranceways shall feature windscreens extending from the sidewall toward the aisle for one full double-seat width. This is to protect the seats next to the doorways from excessive drafts when doors are open.

15.4.2.2 Glass barriers on windscreens, if used, shall be made of laminated safety glass in accordance with ANSI Z26.1, Table 1, Item 1.

15.4.2.3 The intended windscreen configuration, including logos or other graphics, shall be submitted for SANBAG's approval **[CDRL 15-1]**.

15.4.3 Interior Rendering

The Contractor shall submit a rendering (or approved equal) showing the proposed color scheme of the entire car (floor to ceiling), accompanied by a swatch of every type of material, mounted and identified on a display board **[CDRL 15-2]**. Any changes to the interior materials shall require re-submittal of this CDRL.

15.5 SEATS

15.5.1 General

15.5.1.1 All seats shall conform to APTA Standard SS-C&S-016-99.

15.5.1.2 The intended seat design, and inserts as defined below, shall be submitted for approval **[CDRL 15-3]**.

15.5.1.3 Jump seats shall be fitted with a mechanism to retract (flip) the cushion assembly and pan upward. When retracted, the cushion/pan assembly shall be perpendicular to the floor.

15.5.2 Construction

The Contractor shall submit test reports to demonstrate compliance with the tests specified in APTA Standard SS-C&S-016-99, Section TS 3. In addition, the FRA seating requirements in FRA 238.233a shall be met.

15.5.3 Interchangeability and Comfort

15.5.3.1 Seats and cushion of like design shall be interchangeable with like seats and cushions throughout the passenger compartment of the vehicle.

15.5.3.2 A sample seat of each type shall be provided for SANBAG's approval of acceptable levels of comfort **[CDRL 15-4]**.

15.5.4 Materials

15.5.4.1 Seat back pans shall be sufficiently rigid to resist deformation as the result of passenger abuse. They shall be attached to the seat shells in an approved manner and shall not rattle or drum.

15.5.5 Cushion Inserts

15.5.5.1 All seat-bottom cushion and backrest assemblies shall be readily removable for repairs, but shall not be removed by normal passenger use, or by any loadings specified herein.

15.5.5.2 When installed, cushion and backrest assemblies shall be secure in place insuring that they shall not cause any noise during vehicle operation whether occupied or unoccupied.

15.5.5.3 All seat covering material shall be transportation-grade cloth, subject to SANBAG's approval. Color will be chosen after Contract award. Covers (both bottom cushions and backrests) shall not require the use of tacks or staples for attachment nor shall they become disengaged under normal use (including patrons placing their feet between the cushion and backrest).

15.5.5.4 All components used in the cushion assemblies shall meet the flammability and smoke emission requirements of 49 CFR 238 Appendix B as well as of Section TP 19.23, Passenger Emergency Equipment, of these technical provisions.

15.6 LUGGAGE RACKS

15.6.1 Luggage racks shall be provided along the passenger compartment sidewalls above the seating areas. The rack shall be designed to support a load of 25 lbs. (11.4 kg) per linear foot.

15.6.2 The luggage rack design shall be reviewed and approved by SANBAG as part of the overall interior design scheme.

15.7 BICYCLE RACKS

15.7.1 Bicycle racks shall be provided in each vehicle.

15.7.2 The Contractor shall submit a proposal for the location and number of bicycle racks in each vehicle for review and approval by SANBAG **[CDRL 15-5]**.

15.8 ELDERLY AND HANDICAPPED ACCOMMODATION

15.8.1 General

15.8.1.1 The vehicles shall comply with 49 CFR Part 38, Subpart E. The Contractor shall also be guided by the latest issues of the following to the extent that these do not conflict with the above requirements, which shall govern:

- 49 CFR Part 37
- 49 CFR Part 609
- ANSI A117.1-1998 (or latest revision), American National Standard for Buildings and Facilities – Providing Accessibility and Usability for Physically Handicapped People.

15.8.1.2 The vehicle shall have provisions for two wheelchairs. An approved number of spring-operated retractable jump seats as described in Section TP 15.5, Cushion Inserts, shall be provided in each wheelchair area for use by ambulatory passengers when wheelchairs are not present.

15.9 INTERIOR HANDHOLDS AND STANCHIONS

15.9.1 Handholds and stanchions required for safety and convenience of passengers and crew shall be provided for the interior of each car.

15.9.2 All installations shall be free of rattles and squeaks.

15.9.3 The attachment strength of all handholds, stanchions, and other interior fittings shall meet or exceed the requirements of APTA Standard SS-C&S-006-98, latest edition.

15.9.4 The Contractor shall submit to SANBAG for review and approval detailed drawings of all stanchions and handholds showing the device, its location on the car, and its method of attachment **[CDRL 15-6]**.

15.10 SIGNAGE

15.10.1 All interior emergency signage shall comply with the requirements outlined in APTA Standard SS-PS-002-098.

15.10.2 The type and location of other signage shall be submitted for approval by SANBAG.

15.11 DELIVERABLES

Contract deliverables required by this section of the technical provisions are listed below.

CDRL 15-1 Intended windscreen configuration (TP 15.4.2.3)

CDRL 15-2 Interior Materials Display Board (TP 15.4.3)

CDRL 15-3 Conceptual and detailed drawings of intended seat and seat insert design (TP 15.5.1.2)

CDRL 15-4 Representative samples of seats (TP 15.5.3.2)

CDRL 15-5 Location and number of bicycle racks in each vehicle (TP 15.7.2)

CDRL 15-6 Drawings of all stanchions and handholds (TP 15.9.4)

END OF SECTION

16.0 TRAINLINE AND LOCAL SIGNAL ARCHITECTURE

16.1 CITED REFERENCES

IEEE 1475 Standard for the Functioning of and Interfaces among Propulsion, Friction Brake, and Train-borne Master Control on Rail Rapid Transit Vehicles

16.2 GENERAL

16.2.1 A detailed plan shall be submitted identifying and transmitting all control signals subject to the requirements of this section **[CDRL 16.01]**.

16.2.2 The control signals identification and transmission plan shall include a preliminary safety and hazard analysis.

16.2.3 The control signals identification and transmission plan shall use IEEE 1475 for guidance.

16.2.4 The network system shall be as much as possible service proven, optimized of the specific function, maintain an open design plan that uses network components and transceivers that are either non-proprietary or proven to be available from multiple manufacturing sources.

16.3 PERFORMANCE

16.3.1 Component faults shall neither inhibit nor severely degrade train control functions other than the failed component.

16.3.2 The audio trainlines shall allow for simultaneous operation of both analog and digital audio communication.

16.3.3 The passenger emergency intercom shall have priority over other audio announcements.

16.4 DELIVERABLES

Contract deliverables required by this section of the technical provisions are summarized below.

CDRL 16-01 Identification and transmission of all control signals (TP 16.2.1)

END OF SECTION

17.0 MONITORING AND DIAGNOSTICS

17.1 CITED REFERENCES

None.

17.2 GENERAL

17.2.1 Each unit shall be equipped with a monitoring and diagnostic system (MDS).

17.2.2 The MDS shall be a physically distributed, functionally integrated system that monitors signals and events within the vehicle and within subsystems on the vehicle and stores the collected subsystem, vehicle, and train data in non-volatile memory.

17.2.3 The maintenance philosophy on which the hardware and software depend shall be defined at the system level during the earliest program review meetings **[CDRL 17-1]**.

17.3 PERFORMANCE REQUIREMENTS

17.3.1 The MDS shall have sufficient non-volatile storage to retain all recorded data without overwriting for at least the interval between periodic inspections.

17.4 DELIVERABLES

Contract deliverables required by this section of the technical provisions are summarized below.

CDRL 17-1 MDS maintenance philosophy definition (17.2.3)

END OF SECTION

18.0 SOFTWARE SYSTEMS

18.1 CITED REFERENCES

IEEE 1016	Recommended Practice for Software Design Descriptions
IEEE 730	Software Quality Assurance Planning

18.2 GENERAL

18.2.1 Software Requirements

18.2.1.1 All software for this project, whether resident within an electronically controlled intelligent subsystem, provided as part of a test or interface equipment used for the purpose of post-download data analysis and processing, or incorporated within training technology, shall be subject to the requirements of this section, except as approved by SANBAG.

18.2.1.2 In addition to microprocessor-controlled systems, the requirements of this section shall also apply to programmable logic components such as field programmable gate arrays (FPGAs), complex programmable logic devices (CPLDs) and other similar devices.

18.2.2 Contractor Qualifications

18.2.2.1 The Contractor, as systems and software integrator, and Subcontractors who are providing software, shall have a mature and documented software development process.

18.2.2.2 To confirm its software development process capability, the Contractor shall be subject to a software process audit for itself and for each Subcontractor providing software. The software process audit shall assess the following areas:

a. Documentation generation and control
b. Clear and concise requirements definition
c. Traceable verification of requirements and implementation
d. Configuration control and versioning
e. Quality assurance (QA) oversight

Alternatively an ISO 9001 certificate can be provided.

18.2.2.3 For problem areas identified in the software process audit, an action plan to implement process improvements for the project shall be submitted by the Contractor in a window of time agreed to by SANBAG.

18.2.2.4 The audit action plan shall specify the specific procedures, reviews, reports, or other activities for the project that shall be implemented to compensate for the noted problem areas.

18.3 SOFTWARE CLASSIFICATION

18.3.1 Where the software is essentially a modification of an existing product to meet SANBAG's requirements, the design process and documentation shall be submitted for review and approval by SANBAG **[CDRL 18-1]**.

18.3.2 For newly developed software, the Contractor and/or supplier shall submit a software quality assurance plan for approval **[CDRL 18-2]** complying with IEEE 730, EN 50128 or equivalent, and containing, at a minimum, the following documentation requirements:

a. Software requirements specification
b. Software design description
c. Software verification and validation plan
d. Software verification and validation report
e. User documentation

18.3.3 Source code shall be written, where suitable, in a high-level language such as C. All source code shall be properly documented.

18.3.4 The software design description in (b) above shall comply with IEEE 1016, EN 50128 or equivalent.

18.3.5 The requirements of this section shall be presented to SANBAG at the preliminary design reviews. SANBAG shall be properly notified of meetings and reviews scheduled to determine progress with respect to the software requirements and the software design description by the Contractor.

18.4 ESCROW

18.4.1 Deleted.

18.4.2 The placing of software details, such as proprietary source code, documents, or tools in a third-party escrow account in accordance with Section GC 7.2 in lieu of submittal to SANBAG shall be permitted, provided that sufficient software information is provided (submitted and/or shown to an approved reviewer) to enable SANBAG to evaluate overall system performance.

18.4.3 Deleted.

18.4.4 Deleted.

18.5 DELIVERABLES

Contract deliverables required by this section of the technical provisions are summarized below.

CDRL 18-1	Existing software design process and documentation (TP 18.3.1)
CDRL 18-2	Software quality assurance plan (TP 18.3.2)

END OF SECTION

19.0 MATERIAL AND WORKMANSHIP

19.1 CITED REFERENCES

49 CFR Part 223	Safety Glazing Standards–Locomotives, Passenger Cars, and Cabooses
49 CFR Part 238	Passenger Equipment Safety Standards
AA	Aluminum Association Standards for Aluminum Mill Products
AAR	Specifications for the Construction of New Passenger Equipment Cars
AAR	Signal Manual, Vol. 2, Section 6
AAR 2518	incorporated in Standard S-400 (AAR Manual E)
AAR M-201	Steel Castings
AAR M-618	High Pressure Hoses
AAR RP-585	Wiring and Cable Specification
AAR RP-587, RP-588	Wire and Insulating Materials
AAR S-538	Wiring Practice and Rolling Stock Standard
ANSI B1.1	Unified Inch Screw Threads (UN and UNR Thread Form)
ANSI B18.1.2	Square and Hex Bolts and Screws Inch Series
ANSI C37	Circuit Breakers
ANSI J-STD-001B	Requirements for Soldered Electrical & Electronic Assemblies
ANSI Z26.1	Safety Code for Safety Glazing Materials for Glazing Motor Vehicles Operating on Land Highways
APA PS1-95	Construction and Industrial Plywood
APTA SS-C&S-015-99	Standard for Aluminum and Aluminum Alloys for Passenger Equipment Car Body Construction
ASME	Boiler and Pressure Vessel Code
ASME B31.1	Power Piping
ASNT, TC-1A	American Society of Non-Destructive Testing
ASTM A123	Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A242	Standard Specification for High-Strength Low-Alloy Structural Steel
ASTM A27	Steel Castings, Carbon, for General Application
ASTM A31	Steel Rivets and Bars for Rivets, Pressure Vessels
ASTM A488	Standard Practice for Steel Castings, Welding, and Qualifications of Procedures and Personnel
ASTM A502	Steel Structural Rivets
ASTM A514	Standard Specification for High-Yield-Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding
ASTM A588	Standard Specification for High-Strength Low-Alloy Structural Steel with 50 Ksi Minimum Yield Point to 4 Inch Thick
ASTM A606	Standard Specification for Steel, Sheet, and Strip, High-Strength, Low-Alloy, Hot-Rolled, and Cold-Rolled, with Improved Atmospheric Corrosion Resistance
ASTM A666	Standard Specification for Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar
ASTM B108	Aluminum-Alloy Permanent Mold Castings
ASTM B174	Standard Specification for Bunch-Stranded Copper Conductors for Electrical Conductors
ASTM B247	Aluminum and Aluminum-Alloy Die Forgings, Hand Forgings, and Rolled Ring Forgings
ASTM B26	Aluminum-Alloy Sand Castings
ASTM B33	Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes
ASTM B633	Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel

ASTM B85	Aluminum-Alloy Die Castings
ASTM C177	Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus (Supersedes ANSI Z98.1)
ASTM C1036	Standard Specification for Flat Glass
ASTM C1048	Standard Specification for Heat-Treated Flat Glass—Kind HS, Kind FT Coated and Uncoated Glass
ASTM C1166	Standard Test Method for Flame Propagation of Dense and Cellular Elastomeric Gaskets and Accessories
ASTM C1422	Standard Specification for Chemically Strengthened Flat Glass
ASTM C542	Specification for Lock-Strip Gaskets
ASTM D256	Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics
ASTM D2583	Standard Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor
ASTM D1055	Flexible Cellular Materials, Latex Foam
ASTM D1056	Flexible Cellular Materials – Sponge or Expanded Rubber
ASTM D1149	Standard Test Method for Rubber Deterioration-Surface Ozone Cracking in a Chamber
ASTM D2047	Standard Test Method for Static Coefficient of Friction of Polish-Coated Floor Surfaces as Measured by the James Machine
ASTM D2240	Standard Test Method for Rubber Property—Durometer Hardness
ASTM D2244	Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates
ASTM D2651	Standard Guide for Preparation of Metal Surfaces for Adhesive Bonding
ASTM D2724	Standard Test Methods for Bonded, Fused, and Laminated Apparel Fabrics
ASTM D3359	Standard Test Methods for Measuring Adhesion by Tape Test
ASTM D3574	Standard Test Methods for Flexible Cellular Materials—Slab, Bonded, and Molded Urethane Foams
ASTM D3675	Standard Test Methods for Surface Flammability of Flexible Cellular Materials Using a Radiant Heat Energy Source
ASTM D395	Standard Test Methods for Rubber Property-Compression Set
ASTM D412	Standard Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers-Tension
ASTM D471	Standard Test Method for Rubber Property-Effect of Liquids
ASTM D523	Standard Test Methods for Specular Gloss
ASTM D573	Standard Test Method for Rubber-Deterioration in an Air Oven
ASTM D618	Standard Practice for Conditioning Plastics for Testing
ASTM D624	Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers
ASTM D638	Standard Test Method for Tensile Properties of Plastics
ASTM D695	Standard Test Method for Compressive Properties of Rigid Plastics
ASTM D746	Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact
ASTM D785	Standard Test Method for Rockwell Hardness of Plastics and Electrical Insulating Materials
ASTM D790	Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
ASTM D792	Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
ASTM D4329	Standard Practice for Fluorescent UV Exposure of Plastics

ASTM E 1354	Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter
ASTM E 1537	Standard Test Method for Fire Testing of Upholstered Furniture
ASTM E 1590	Standard Test Method for Fire Testing of Mattresses
ASTM E 424	Standard Test Methods for Solar Energy Transmittance and Reflectance (Terrestrial) of Sheet Materials
ASTM E119	Standard Test Methods for Fire Tests of Building Construction and Materials
ASTM E162	Standard Test Methods for Surface Flammability of Materials Using a Radiant Heat Energy Source
ASTM E648	Standard Test Methods for Critical Radiant Flux of Floor-Covering Systems Using a Radiant Heat Energy Source
ASTM E662	Standard Test Methods for Specific Optical Density of Smoke Generated by Sold Materials
ASTM F593	Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs
ASTM F1344	Standard Specification for Rubber Floor Tile
ASTM G155	Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials
AWS A5.0	Filler Metal Procurement Guidelines
AWS C1.1	Welding Resistance – Recommended Practices
AWS D15.1	Railroad Welding Specification – Cars and Locomotives
AWS	Brazing Handbook
AWS	Welding Handbook
AWS-D1.1	Structural Welding Code – Steel
AWS-D1.2	Structural Welding Code – Aluminum
AWS-D1.3	Structural Welding Code – Sheet Steel
California Technical Bulletin 129	Flammability Test Procedure for Mattresses for use in Public Buildings
California Technical Bulletin 133	Flammability Test Procedure for Seating Furniture for Use in Public Occupancies
CFFA-1A	Abrasion Resistance
CFFA-2	Accelerated Light Aging
CFFA-3A	Adhesion of Coating to Fabric
CFFA-4	Blocking
CFFA-6A	Cold Crack Resistance
CFFA-7	Crocking Resistance
CFFA-15	Stretch and Set
CFFA-16C	Tearing Strength
CFFA-17	Tensile Strength and Elongation
CFFA-700	Dimensions of Coated Fabric
DIN 267	Fasteners – Technical Specifications
FAR 25.853	Air Worthiness Standards: Transport Category Airplanes, Fire Protection, Compartment Interiors
FED-STD-191	Textile Test Methods
IEC 249 (60249)	Base Materials for Printed Circuits
IEC 326-3 (60326-3)	Design and Use of Printed Circuit Boards
IEC 60077	Rules for Electric Traction Equipment
IEC 61133	Electric Traction Rolling Stock Test Methods for Electric and Thermal/Electric Rolling Stock on Completion of Construction and Before Entry into Service

IEEE 11	Rotating Electrical Machinery for Rail and Road Vehicles
IEEE 383	Type Test for Class 1E Electric Cables, Field Splices, and Connections
ISO 3506	Mechanical Properties of Corrosion-Resistant Stainless-Steel Fasteners
ISO 898	Mechanical Properties of Fasteners Made of Carbon Steel and Alloy Steel
ISO 4042	Threaded Components – Electroplated Coatings
MIL-C-7438	Core Material, Aluminum, for Sandwich Construction
MIL-DTL-5015H	Specification for Connectors, Electric, Circular Threaded, AN Type, General
MIL-HDBK-349	Manufacture and Inspection of Adhesive Bonded, Aluminum Honeycomb Sandwich Assemblies for Aircraft
MIL-HDBK-691B	Adhesive Bonding
MIL-P-8053	Plywood, Metal-Faced (inactive but used for reference)
MIL-PRF-6106	Relays, Electromagnetic, Including Established Reliability Types
MIL-STD-889	Dissimilar Metals
MIL-W-22759/6B	Wire, Electrical, Fluoropolymer-Insulated, Abrasion Resistant, Extruded TFE, Nickel-Coated, Copper Conductor, 600-Volt
MIL-W-81044	Wire, Electric, Crosslinked Polyalkene, Crosslinked Alkine-Imide Polymer, or Polyarylene Insulated, Copper or Copper Alloy
MIL-W-81381	Wire, Electric, Polyamide-Insulated, Copper or Copper Alloy
NEC	National Electrical Code (NFPA 70)
NEMA AB1	Molded Case Circuit Breakers
NEMA LD 3	High Pressure Decorative Laminates
NEMA LI1	Industrial Laminated Thermosetting Products
NEMA WC 70	(ICEA S-95-658) – Standard for Nonshielded Power Cables Rated 2000 Volts or Less for Use in the Distribution of Electrical Energy
NEMA WC 71	(ICEA S-96-659) – Standard for Nonshielded Power Cables Rated 2001-5000 Volts for Use in the Distribution of Electrical Energy
NFPA 130	Standard for Fixed Guideway Transit Systems
NFPA 70	National Electrical Code
SAE AMS W 6858	Welding, Resistance: Spot and Seam
SAE J403	Chemical Compositions of SAE Carbon Steels
SAE J429	Mechanical and Material Requirements for Externally Threaded Fasteners
SAE J673	Automotive Safety Glass
SAE J995	Mechanical and Material Requirements for Steel Nuts
SAE J1199	Mechanical and Material Requirements for Metric Externally Threaded Fasteners
SAE J1200	Blind Rivets-Break Mandrel Type
SAE-J1885	Accelerated Exposure of Automotive Interior Trim Components Using a Controlled Irradiance Water Cooled Xenon-Arc Apparatus

19.2 UMTA-DC-06-0152-83-1 A CORROSION CONTROL MANUAL FOR RAIL RAPID TRANSITGENERAL

19.2.1 Workmanship and quality shall conform to the best manufacturing practices in all respects. All work shall be performed by qualified personnel who are using correct tooling and procedures and are properly trained and skilled in the tasks they will be performing.

19.2.2 Surfaces exposed to passengers, crew, or maintainers shall be smooth and free of burrs, sharp edges or corners, and dangerous protrusions. The vehicle design shall avoid pinch points, tripping hazards, snagging points, water traps, and debris accumulation points.

19.2.3 Carbody structural parts that are permanently covered and concealed after assembly shall not be made of copper, copper-bearing aluminum alloys, brass, bronze, silver, or nickel.

19.2.4 Foreign matter, such as shavings, chips, etc., shall be completely removed from all parts of the vehicle, its components, assemblies, and subassemblies, whether hidden or exposed as practicable.

19.2.5 Materials for the construction of the vehicle shall be in accord with the stated specification or cited standard, unless the Contractor obtains SANBAG's approval for a substitution in writing. Alternate standards may be proposed, but the Contractor must supply a narrative in English comparing both standards, and citing justification why the substitution is equivalent.

19.2.6 All materials shall perform safely and satisfactorily within their operating environment and in accordance with their intended function.

19.2.7 Whenever a commercial material is not covered by a specification or standard, the Contractor shall identify the material by the commercial trademark, name, and address of the supplier. The Contractor shall submit a description, and the technical data specifications, of the material composition for approval **[CDRL 19-1]**. The Contractor shall maintain records that trace all materials to their manufacturers, and shall help verify compliance with quality standards specified or cited in these technical provisions.

19.2.8 The Contractor shall inform SANBAG of all single-source materials (when known) for approval. Approval shall be determined on a case-by-case basis. Specification equivalency and benefit data for any substitution to a cited standard shall be submitted to SANBAG for review and approval **[CDRL 19-2].**

19.2.9 The following materials shall not be used in the construction of the vehicle unless otherwise approved by SANBAG:

- **a.** Polyvinyl chloride (PVC)
- **b.** Asbestos
- **c.** Lead in brake shoes
- **d.** Urethane foam
- **e.** Chlorinated fluorocarbons that may cause environmental problems or handling hazards
- **f.** Materials that, in their normal installed state, emit products that are known to be toxic or irritants
- **g.** Beryllium

19.2.10 The Contractor shall keep on file an MSDS for all chemical materials (paints, solvents, adhesives, caulking, etc.) used in the manufacture of the vehicle, and provide MSDS information as requested by SANBAG for any additional material in question. A copy of each MSDS shall be submitted to SANBAG for review and approval **[CDRL 19-3].**

19.2.11 All Critical Materials used in the construction of the vehicle shall be subject to approval by SANBAG. The Contractor shall keep a running list of all materials used in the vehicle in matrix format (matrix shall contain: material name, specification or material identification (ID) number, application, approval status, correspondence number, etc.). The Contractor shall submit this matrix, along with material certifications and material property test reports, to SANBAG for review **[CDRL 19-4].**

19.2.12 The Contractor shall submit for approval by SANBAG joining and fastening data, specifications, drawings, or standard titles for all non-industry types and methods of fastening and joining used where available, and required for maintenance purposes **[CDRL 19-5].**

19.2.13 All name and rating plates shall be permanently attached using mechanical fasteners. Exceptions may be made for small components and circuit boards as practicable.

19.2.14 All materials shall be new and of recent manufacture. Material that is found to be Defective and subsequently repaired cannot be used unless specific approval is granted by SANBAG.

19.2.15 All materials used shall be inherently corrosion-resistant, or be suitably finished with a corrosion-resistant finish to minimize corrosion and degradation of appearance or function.

19.3 UNITS OF MEASURE

19.3.1 Each vehicle system shall be designed and manufactured to a single standard.

19.4 STORAGE OF MATERIAL

19.4.1 All stored material subject to corrosion shall be adequately protected by waterproof covers, coatings, or packaging to prevent damage.

19.4.2 Equipment covers, cable entrances, and openings shall be suitably closed to prevent ingress of water or dirt.

19.4.3 All dated material shall have the expiration date clearly marked. Expired material shall not be used.

19.4.4 Material or components that require maintenance during storage shall be properly maintained per the component(s) manufacturer's instructions. The Contractor shall document such maintenance, and provide these records as requested by SANBAG.

19.4.5 Rejected or damaged material shall be clearly marked, dispositioned, and stored separately from all other material.

19.5 METALS

19.5.1 Low-Alloy, High Tensile Strength, Structural Steel

19.5.1.1 Low-Alloy, High Tensile (LAHT) steel for the carbody shall comply with the applicable EN 10155, ASTM standard: ASTM A242 or ASTM A588 for structural shapes, plates, and bars.

19.5.1.2 LAHT hot-rolled and cold-rolled steel sheets and steel strips, with improved atmospheric corrosion resistance, shall comply with EN 10155, EN 10210, EN 10084, EN 10025, and ASTM A606.

19.5.2 Heat-Treated Alloy Steel

Heat-treated alloy steel suitable for welding and other structural purposes shall comply with EN 10137-2, ASTM A514, Grade F.

19.5.3 Stainless Steel

19.5.3.1 Austenitic, stainless steel sheets, strips, plates, and flat bars shall comply with EN 10088, ASTM A666, except that the carbon content shall not exceed 0.03%.

19.5.3.2 Stainless steel shall be EN 10088American Iron and Steel Institute (AISI) type 201, 301, 301L, 302, 304, 304L, 316, 316L or 347 in accordance with the intended function.

19.5.3.3 Stainless steel used in structural applications shall conform to paragraph (f) of Section 2 of Association of American Railroads (AAR) Specifications for the Construction of New Passenger Equipment Cars.

19.5.4 Steel Castings

19.5.4.1 Steel castings shall be selected for the composition, heat treatment, and design best suited for the intended service.

19.5.4.2 Weld repairs of castings shall be allowed, provided that repairs are performed in accordance with an approved written procedure, and by welders qualified to ASTM A488 or EN ISO 15614-1 together with EN11970 and SEW 110.

19.5.4.3 High strength castings shall be tested, inspected, and accepted in accordance with AAR M-201 or EN 287-1.

19.5.4.4 General-purpose steel castings shall comply with ASTM A27, either Grade 65-35 or Grade 70-36 or EN 10293 and EN 1559.

19.5.4.5 Low-alloy nickel castings shall comply with AAR M-201 or EN 10293 and EN 1559.

19.5.5 Rivet Steel

Rivet steel shall comply with ASTM A31 or ASTM A502, or ANSI B18.1.2. or DIN 660, DIN7337, ISO15973, ISO15974, ISO15977, ISO15978 Exposed rivets shall be concentric to the shank and free from rings, pits, burrs and deformities. All rivets removed and replaced shall have the holes reamed round to the size required such that the next larger rivet may be driven accurately. Rivets exposed to view shall be austenitic stainless steel or aluminum, as appropriate to the material being joined.

19.5.6 Aluminum

19.5.6.1 Aluminum alloy mill products shall be identified by designations prescribed by the Aluminum Association (AA) and shall comply with the requirements contained in the AA publication, "Aluminum Standards for Aluminum Mill Products" or appropriate EN Standard.

19.5.6.2 Aluminum alloy surfaces shall not make direct metal-to-metal contact with dissimilar metals (copper, brass, bronze, silver, nickel, lead tin, ferrous metal, etc. or alloys of these materials), unless proper precautions have been made to protect the joint from corrosion. Electrical connections where appropriate joint compounds shall be used can be made.

19.5.6.3 The forming of aluminum parts, their joining by bolting, riveting, or welding, and protection of contact surfaces shall comply with APTA Standard SS-C&S-015-99 or as required to meet AVT.

19.5.7 Aluminum Extrusions

Extrusions, sheets, and plate shall comply with APTA Standard SS-C&S-015-99 or EN 755-1+2, EN 754-1+2, EN AW 6005A T6 (AlMgSi0.7), EN AW 6082 T6 (AlMgSi1.0), or EN AW 6060 T6 (AlMgSi0.5).

19.5.8 Aluminum Castings and Forgings

19.5.8.1 Forgings shall comply with EN 1706, EN AW 6082, ASTM B247 or Aluminum Association Standards for Aluminum Mill Products, alloy, and temper 6061-T6.

19.5.8.2 Castings shall comply with EN 1706, or ASTM B26, ASTM B85, ASTM B108, or Aluminum Association Standards for Aluminum Mill Products alloy and temper 356-T6, 364-T5, or 356-T6, respectively, and shall be free from blowholes, cracks, shrinkage and other Defects.

19.6 NON-METALS

Material specifications (Technical Data & Specification Sheets) for all non-metal Critical Materials used in the vehicle shall be submitted to SANBAG for review and approval, (to be included in CDRL 19-4)**.** All non-metals shall comply with the requirements in Section TP 19.2.3, Flammability, Smoke Emission & Toxicity.

19.6.1 Elastomers

19.6.1.1 Elastomeric parts may include door and window seals, glazing strips, truck bumpers/snubbers, structural and compressible gaskets, and mounting pads.

19.6.1.2 All elastomeric parts shall be composed from suitable elastomers compounded and cured to perform satisfactorily under the intended application and the environmental conditions in which the vehicle may be operated.

19.6.1.3 Elastomeric parts shall be suitably sized for the intended application such that the fit is correct, (i.e., no gaps, bulges, stress tears). Gaskets or sealing extrusions shall not bulge, kink, or spread when installed. Seams in joined, extruded gaskets shall be oriented to minimize the possibility of leakage.

19.6.1.4 Elastomeric parts used for interior decorative trim shall be colored to harmonize with adjacent surfaces. All colors shall be as approved by SANBAG. Table 19-1 shall be used as a reference for the suggested parameters for the physical properties of suitable elastomers used on this Project.

Table 19-1

Physical Property	Test Method	Test Value
Hardness	ASTM D2240 DIN 53505, DIN 7868	45 to 75, Durometer A
Tensile strength	ASTM D412 DIN 53504	1500 psi
Ultimate elongation	ASTM D412 DIN 53504	300%, min
Ozone resistance	ASTM D1149, Type A, 7 Days, Ozone concentration 100ppm, 104°F DIN ISO 1431-1–A, 48 h, ozone concentration 50 ppm, 23°C, probe: DIN 53509-1,	No cracks under 7x magnification
Oil aging resistance	ASTM D471, Test oil/fuel shall be representative of application, 72 hours, 158°F DIN ISO 1817, DIN 5514-2, test equipment no. 4, 5 and 6 (55 °C, 48 h)	+30% maximum change in volume
Permanent-set resistance	ASTM D395, Method A or B DIN ISO 815	25% Maximum Set
Tear resistance	ASTM D624, Method B ISO 34-1-A	300 lbs./in
Brittleness temperature	ASTM D746 ISO 974	Brittleness temperature no greater than -40ºF
Resistance to heat aging	ASTM D573 / ISO 188, 72 hours, 158°F	-30% change in elongation -15% change in tensile strength -5 to +15 change in hardness

19.6.1.5 Metal parts to which elastomeric materials are cured shall be made of SAE J403 hot-rolled steel or equal, suitably cleaned for bonding. Elastomeric materials shall be tested to verify compliance with performance requirements as given below. The Contractor shall submit the testing certificates of the elastomeric material to SANBAG for review and approval stating compliance with the requirements of the standards **[CDRL 19-6].**

19.6.1.6 In addition to the tests indicated in Table 19-1, elastomers must pass the combustibility requirements as specified in Section TP 19.2.3, Flammability, Smoke Emission & Toxicity.

19.6.2 Neoprene Foam

19.6.2.1 Neoprene foam (flexible cellular rubber products) shall be high-resiliency foam latex. Base elastomer of latex shall be polymerized chloroprene (polychloroprene) and shall contain no reclaimed rubber. The structure of the foam shall consist of a network of closed cells of uniform character. The foam shall have a high resistance to flexing, tearing, and wetting. The Contractor shall provide to SANBAG for review and approval the physical and performance characteristics of all neoprene foam used in the vehicle **[CDRL 19-7]**.

19.6.3 Fiberglass-Reinforced Plastic

19.6.3.1 Fiberglass-reinforced plastic (FRP) shall be polymeric-reinforced laminated material, composed of a gel-coated surface, fiberglass reinforcement, and a polyester, acrylic, phenolic, or approved equal resin.

19.6.3.2 FRP shall be able to withstand, without any physical degradation or deformation, the stresses encountered in the environment where it is to be used. Fiberglass components shall be molded, stored, and mounted, in their final, designed, shape, and shall not be mounted in a deformed/stressed condition.

19.6.3.3 FRP shall be resistant to acids, mild alkalis, and cleaning solutions normally used in rail transit service.

19.6.3.4 FRP products shall meet the requirements listed in Section 19.2.3, Flammability, Smoke Emission & Toxicity.

19.6.3.5 Fiberglass reinforcement shall be mat, fabric, woven roving, continuous roving, chopped spun roving, or swirl mat, as required to meet physical and process requirements. Glass content by weight shall be thirty percent (30%) minimum. Gelcoats shall be resistant to scuffing, fire, weather, perspiration, and cleaning agents, and shall be pigmented to match approved colors. Gelcoat must contain ultraviolet (UV) inhibitors/stabilizers, or be formulated to minimize any discernible yellowing or color degradation.

19.6.3.6 Gelcoat additives, fillers, monomers, catalysts, activators, inhibitors, pigments, or flame- proofing materials shall be added to resin mixes to obtain finished products with required characteristics. Mineral filler shall not exceed twenty-eight percent (28%) of finished weight for preformed matched die molding process.

19.6.3.7 FRP shall be manufactured by one of the following methods:

a. Method 1: Open molding, hand lay-up, or spray lay-up (Chopper Gun)
b. Method 2: Matched die molding, requirements traceability matrix (RTM), vacuum bag, or preform.

19.6.3.8 Production techniques shall ensure that the fiberglass reinforcement is distributed throughout the final product in such a manner as to preclude resin-rich or resin-starved sections.

19.6.3.9 Open-molded parts shall be gelcoated.

19.6.3.10 Surfaces shall be uniform, smooth, and free of porosity and crazing.

19.6.3.11 The Contractor shall submit for approval certificates verifying that reinforced plastic materials comply with the minimum requirements specified in Table 19-2 as practicable for the application **[CDRL 19-8]**. Pre-test conditioning of test specimens shall conform to ASTM D618.

Table 19-2

Mechanical Property	Test Method	Method #1	Method #2
Tensile Strength	ASTM D638 or ISO 527-1/2	13,000 psi	18,000 psi
Compressive Strength	ASTM D695 or	22,000 psi	32,000 psi

	ISO 604		
Flexural Strength	ASTM D790 or ISO 178	21,000 psi	28,000 psi
Impact	ASTM D256 or ISO 180	10 ft-lbs./in of notch	13 ft-lbs./ in of notch
Hardness	ASTM D2583 or ISO 2039-1/2	45 Barcol	45 Barcol
Heat	None	175 °F continuous	–
Thickness	None	0.125 in., minimum	0.125 in., minimum
Gelcoat Thickness	None	0.014" or 14 mils, ± 2 mils	N/A

19.6.4 Thermoplastic

19.6.4.1 Thermoforming plastic material (commonly available in the form of a PVC-acrylic material) may be used, subject to SANBAG's approval, in the low-smoke toxicity versions commonly available for transit applications.

19.6.4.2 Thermoplastic materials shall comply with Section 19.23, Flammability, Smoke Emission & Toxicity , and with the requirements listed in Table 19-3 used as a reference as practicable.

Table 19-3

Physical Property	**Test Method**	**Performance Requirement Value**
Specific Gravity	ASTM D792 or ISO 11833	1.20 to 1.36
Hardness, Rockwell	ASTM D785 or ISO 2039-2	90 to 100, R-Scale
Tensile Strength	ASTM D638 or ISO 527-1/2	5,500 psi (38 MN/m^2) minimum at 73 °F (23 °C)
Flexural Modulus	ASTM D790 or ISO 178	320,000 psi (2,206 MN/m^2) minimum elasticity at 73 °F (23 °C)
Flexural Strength	ASTM D790 or ISO 178	10,000 psi (68,947.6 kPa) minimum @ 73 °F (23 °C)
Impact Strength (@ 73 °F notched Izod	ASTM D256 or ISO 180	6.6 lbf per inch of notch minimum.
Heat Shrinkage	None	15% maximum, 10 minutes @ 380 °F (193 °C)
Thickness	None	3/32 inch (2.38 mm) minimum

19.6.5 Glass

Test reports to verify glazing material compliance per the criteria specified in this section shall be provided **[CDRL 19-9].**

19.6.5.1 Laminated Safety Glass

Laminated safety glass shall be used exclusively and shall conform to the following general, manufacturing, and finish requirements:

a. Float glass quality shall conform to ASTM C 1036, Type 1, Class 1, quality Q3.
b. If tempered glass is used in the laminate, it shall be fully tempered in accordance with ASTM C 1422, surface compression level 3, case depth level B.
c. Edges shall be seamed and ground smooth per SAE J673, Edge no. 4, and sealed with aluminum tape, Sika or equivalent.

d. Any overlap of one sheet of glass with respect to the other at an edge shall not exceed 0.031 inch (0.8 mm).
e. The thickness tolerance of the individual sheets as supplied shall be held within 0.020 inch (0.5 mm).
f. The dimensional tolerance for the cut size dimensions of rectangular shapes, including squareness will be according to ASTM C 1036 Table 1.
g. Masking, if used, shall be applied between the laminated layers of the glass unless otherwise approved by SANBAG.
h. Tinted assemblies shall use a tinted polyvinyl butyral (PVB) layer with clear glass laminate. The color and tint level of all glass shall be subject to SANBAG's approval.
i. Manufacturer's stamp shall be positioned in lower right-hand corner as viewed from inside the vehicle.

19.6.5.2 Window glazing shall be bonded with an approved type of plasticized PVB resin in the form of a membrane 0.045 inch (1.1 mm) ±10 % thick, which shall not be degraded by UV or visible light or temperatures that can be obtained by solar heating.

19.6.5.3 Laminated safety glass shall also conform to the requirements of the applicable classification, as follows:

Group I glass shall:

- Be clear laminated safety glass used for forward-facing glazing (i.e., windshields).
- Meet the requirements of 49 CFR, Part 223, FRA Type I rating, having a minimum thickness of 9/16 inch (14 mm).
- Be certified to comply with the requirements of ANSI Z26.1, Table 1, item 1.

Group II glass shall:

- Be clear laminated safety glass or polycarbonate used for Operator side windows.
- Be certified to comply with the requirements of ANSI Z26.1, Table 1, item 2.
- Meet the requirements of 49 CFR, Part 223, FRA Type II rating, having minimum thickness of 3/8 inch (10 mm).

Group III glass shall:

- Be tinted laminated safety glass or polycarbonate used for passenger side, and door windows.
- Be certified to comply with the requirements of ANSI Z26.1, Table 1, item 3.
- Have a minimum thickness of 1/4 inch (6.4 mm).
- Have a tinting sufficient for the sunlight conditions found in the San Bernardino area.

19.6.5.4 Tempered Safety Glass

Tempered safety glass that may be used for internal glazing and partitions shall be manufactured to ASTM C1048, Kind FT, Condition A, Type 1 clear, Class 1 clear, Quality q3 (or Class 3, tinted, light reducing), or DIN EN 13329.

19.6.6 Floor Covering

19.6.6.1 The floor covering shall be rubber sheet or approved equal. The floor covering material shall contain twenty percent (20%) (nominal, by weight of compound) butadiene styrene rubber; shall be non-staining, non-discoloring, and non-oil extended; and contain additives to preclude damage or discoloring to UV light.

19.6.6.2 Only high-quality hard clay shall be used as filler. No limestone shall be used in the compound.

19.6.6.3 The rubber flooring shall be fully homogeneous throughout.

19.6.6.4 At 68°F (20° C), the rubber flooring shall bend 180 degrees around a 1/2-inch- (13 mm)-diameter mandrel without breaking, cracking, crazing or showing any change in color.

19.6.6.5 The rubber flooring material shall comply with Table 1 in ASTM F1344, with tile size adjusted for maximum sheet coverage, Class 1, B, or as approved by SANBAG, and also comply with Section TP 19.23, Flammability, Smoke Emission & Toxicity.

19.6.6.6 The coefficient of friction of the floor rubber shall not be less than 0.60 when tested to ASTM D 2047 or DIN 51130.

19.6.6.7 The Contractor shall submit color/material samples for approval by SANBAG **[CDRL 19-10].**

19.6.6.8 Prior to the installation of the floor covering, any depressions, voids, or cracks in the sub-floor shall be filled and the sub-floor shall be leveled and smoothed with a leveling compound approved by SANBAG.

19.6.6.9 The floor covering shall be permanently secured to the sub-floor with an approved adhesive and as recommended by the flooring manufacturer. The bottom side of the flooring shall be sanded and then securely bonded to the sub-floor panels. The floor covering and adhesive shall be resistant to cleaning solutions and solvents normally encountered in rail transit service.

19.6.6.10 There shall be no tears or cracks allowed in the installed floor lining, and non-penetrating Defects such as blisters, lumps, craters, and deformations shall be no greater than 0.030 inch (0.76 mm) in height difference from the nominal, surrounding rubber thickness, and shall occur no more than the following:

- Defect diameter ≥ 1 inch – Not permitted,
- 1 in. > Defect diameter > 1/4 inch – 1 each every 6 feet allowed, but must be repaired,
- Defect diameter ≤ 1/4 inch – 3 per 12 inch x 12 inch square area allowed, with no others closer than 3 feet.

19.6.7 Marking Films & Graphics

19.6.7.1 All graphic materials shall be transportation grade materials. Signage graphics shall have an opaque background with clear, vandal-resistant overlayment such as polyvinyl fluoride or polycarbonate. Printed graphics shall be either reverse printed on the back of the clear overlayment, or printed on opaque background and covered by the clear overlayment.

19.6.7.2 SANBAG shall approve all materials, graphic construction, and fixing method.

19.6.7.3 Application techniques shall be in accordance with manufacturer's recommendations

19.6.7.4 Physical Properties of Graphic Material

- Lettering or striping film shall be sufficiently opaque so that, when applied, the film shall completely hide any contrasting background and shall be readily legible.
- There shall be an initial 60-degree gloss value of 40 when tested in accordance with ASTM D523.
- Films shall retain adhesive properties after 1 week of continuous exposure to a temperature of 66°C (150°F).
- Films shall be able to conform to moderate contours of the vehicle's interior and exterior surfaces at locations where applied as practicable.
- Overall thickness of processed film shall be where practicable between 0.004 inch and 0.008 inch (0.10 mm and 0.20 mm, respectively); multiple layer graphics shall be where practicable up to 0.020 inch (0.50 mm) in total thickness (excluding mounting adhesive thickness).

- Films shall withstand immersion in either distilled water or SAE No. 20 motor oil for twenty-four hours at temperatures of from 70°F to 90°F (21°C to 32°C) without any appreciable degradation in adhesion, color, or general appearance.
- Marking films shall withstand effects of detergents and brushes used in washing procedures for removal of graffiti.
- It is preferred that films use a removable grade adhesive that upon removal does not require use of solvents or secondary operations to remove adhesive or graphic residue.
- Square or rectangular graphics shall have rounded corners of suitable radius to prevent the lifting or curling of corners.

19.6.7.5 Graphic material used for vehicle striping shall be 3M 690 Plus (Flexible Reflective Sheeting) or SANBAG's approved equivalent.

19.7 STRUCTURAL PANELS

19.7.1 General

19.7.1.1 Sandwich panels include, but are not limited to, plymetal, honeycomb, or lumber-core panels, with metal or other approved facing material.

19.7.1.2 Melamine, high-pressure laminates used in the construction of the vehicle shall be two-ply laminated and shall consist of a hard plastic film facing permanently bonded to base sheet as practicable

19.7.1.3 Contact adhesives shall not be used to bond the melamine to the base.

19.7.1.4 The final laminate assembly shall comply with NEMA LD-3, General Purpose Type, or EN 438, and comply with Section TP 19.23, Flammability, Smoke Emission & Toxicity.

19.7.2 Honeycomb

19.7.2.1 When finished, continuous edge reinforcement shall be incorporated if needed to facilitate transfer of stresses and to seal edges against moisture penetration and other damage. Where mechanical fasteners are used, threaded inserts shall be bonded into the panel.

19.7.2.2 The term "honeycomb panels," as used in these technical provisions, refers to honeycomb material bonded to melamine or to metal.

19.7.2.3 Honeycomb-core panels shall comply with applicable requirements of MIL-C-7438G, and MIL-HDBK-349, unless otherwise specified.

19.7.2.4 Bonding between the base material and the cover shall be sufficient to develop the full strength of the honeycomb material. The Contractor shall demonstrate by test and analysis that the honeycomb panel design selected for a particular application is adequate for the intended purpose.

19.7.3 Plywood and Plymetal

19.7.3.1 All plywood shall comply with National Institute of Standards and Technology (NIST), APA PS1-95, Exterior Grade B-B, High Density Overlay, or EN 636. Floor panels shall be a minimum of 5/8 inch (16 mm) in thickness.

19.7.3.2 Plymetal panels for floor construction shall be faced on both sides and at all edges with stainless steel (wrapped). The stainless steel cladding shall not be susceptible to any telegraphing of the plywood grain or other surface imperfections. All plymetal panels shall have the metal seams properly bonded together.

19.7.3.3 All exposed edges of the panels, openings, or cutouts within the panels shall be waterproofed and sealed with an approved sealant as appropriate and as soon as possible after fabrication, and prior to installation.

19.7.3.4 Each plywood panel shall be formed from one piece. Jointed panels shall not be allowed.

19.7.3.5 Plymetal panels shall also meet, where appropriate, the test criteria listed in Table 19-4.

19.7.4 Panel Flatness

19.7.4.1 The overall flatness shall not exceed a maximum deviation of 0.015 inch (0.38 mm) per linear foot, with a maximum of 0.125 inch (3.18 mm) deviation of any point on the panel measured from a reference plane taken from any three corners.

19.7.4.2 The overall deviation of the panel thickness shall not exceed 0.031 inch (0.78 mm).

19.8 FASTENING / JOINING

19.8.1 No protruding screws, rivets, mounting bolts, or similar items shall be permitted on the exterior of the vehicle, except where approved by SANBAG. The use of exposed fasteners on the vehicle interior shall be minimized. Interior fasteners shall be countersunk where possible, or low- profile heads used where countersinking is not possible. Interior fasteners shall not protrude enough to become a tripping or snagging hazard. In general the DIN 25201 shall be followed for all bolted joints.

19.8.2 Fastening to Structural Members

19.8.2.1 Fastening to structural members shall be done only on the low stress portion of the member and shall not be located within 3/4 inch (17 mm) from the open edge of the structural member.

19.8.2.2 The Contractor shall ensure that any fastening or joining to structural members does not result in moisture accumulation within any structural member. To this end, fastenings to hollow, closed section structural members shall not be accomplished using drilled holes in the structural member.

19.8.3 Threaded Fasteners

19.8.3.1 The number of different sizes and styles of fasteners used shall be minimized. A single standard, U.S. (ANSI/SAE/IFI) or ISO, shall be adopted for the fasteners used. Fasteners shall be properly marked per the system adopted. All threaded fasteners shall comply with ANSI B1.1 Class 2 requirements, unless otherwise specified or approved by SANBAG. All structural threaded fasteners shall have rolled threads.

19.8.3.2 Self-tapping or thread-forming screws may be used with SANBAG's approval only, on a case-by-case basis.

19.8.3.3 Use of threaded inserts or special or non-standard fasteners shall require SANBAG's approval.

19.8.3.4 At least 1-1/2 threads shall be visible beyond all nuts. Bolts smaller than 0.25 inch (6 mm) shall not project more than 1-1/2 thread plus 0.25 inch (6 mm). Bolts 0.25 inch (6 mm) or larger shall not project by more than 8 threads.

19.8.3.5 Fasteners exposed to public view shall be treated as follows:

- On the vehicle interior, all exposed fasteners shall be stainless steel with flat or oval heads, properly countersunk.
- On the vehicle exterior, all exposed fasteners shall be stainless steel, unless otherwise specified.
- Exposed screws shall be of an approved tamper-proof type.

19.8.3.6 Fasteners not exposed to passengers on the vehicle interior shall be of stainless steel or zinc-plated steel.

19.8.3.7 Fasteners and fastener components used on the vehicle underfloor or roof areas shall be stainless steel except in cases where high-strength fasteners such as SAE grade 8 are required. The Contractor shall provide a list of all relevant threaded fasteners, fastener classification, material, finish, and location used, for SANBAG's approval **[CDRL 19-11]**.

19.8.4 Fastener Materials

19.8.4.1 Fastener component materials (screws, nuts, washers, etc.) shall be properly selected for the application and shall not be mixed within an assembly unless approved by SANBAG. All fasteners shall be stainless steel, or steel finished with a protective coating such as passivation, dichromate, or zinc plating, depending on the specific application.

19.8.4.2 Threaded aluminum fasteners shall not be used except in tapped holes in solid aluminum structures, subject to approval by SANBAG.

19.8.4.3 Stainless steel nuts and bolts shall be used for stainless-to-stainless joints. Anti-seize compounds shall be used on all stainless steel fasteners threaded into stainless steel, or using stainless steel nuts.

19.8.5 U.S. Standard

19.8.5.1 Threaded fasteners shall conform to current SAE J429 standards for externally threaded fasteners and SAE J995 standards for internally threaded fasteners. Steel fasteners 0.25-inch-diameter (6 mm) and above shall be SAE grade 5 minimum.

19.8.5.2 Stainless steel fasteners shall be manufactured from austenitic stainless steel alloys, according to ASTM F 593, with a nominal tensile strength of 100 kilopounds per square inch (ksi). All fasteners shall be clean and free of manufacturing scale.

19.8.5.3 Non-structural screws, such as Phillips or slotted head screws with a diameter smaller than 0.25 inch (6 mm) may be SAE grade 2 minimum.

19.8.6 Locking Requirements

19.8.6.1 All threaded fasteners shall be self-locking or provided with locking devices. Locking devices shall be lockwire, lock washers, torque patch, or prevailing torque type locknuts as appropriate for the application or service. Lockwire, if used, shall be stainless steel as specified in Section TP 19.0, Material and Workmanship.

19.8.6.2 Prevailing torque locknuts shall be of the nylon collar insert type. Previously installed and removed locknuts shall not be re-used. High-temperature applications may use metallic distorted thread locknuts upon SANBAG's approval.

19.8.6.3 Bolts for use with locknuts shall not be drilled for cotter pins or in heat-related applications.

19.8.6.4 All locknuts shall comply with the IFI or ISO requirements regarding locking ability.

19.8.6.5 When oversized or slotted holes are provided for installation tolerance allowance, flat washers, of suitable size to cover oversized holes, or slots shall be used in all locations adjacent to the hole. In this case, at least 1 hole shall be of close tolerance to ensure accurate positioning of component. If slotted holes are provided as a means of adjusting a piece of equipment, a secure method of fixing the adjustment shall be provided, such as adjustment screws, ribbed or toothed adjustment washers, drilled holes and pins, etc.

19.8.7 Plating & Treatment of Fasteners

19.8.7.1 All steel fasteners shall be zinc-plated with the highest protective service condition available per thread configuration. Stainless steel fasteners shall be passivated. If stripping and re-plating of fasteners is required to meet the aforementioned criteria, documentation must be made available to verify that all applicable post-plating treatments and standards have been met. SANBAG may require batch testing of stripped and re-plated fasteners to ensure there is no hydrogen embrittlement.

19.8.7.2 After manufacturing, steel fasteners shall be electroplated, zinc with a yellow chromate conversion per ASTM B633, Type II - Yellow (refer to Table 19-5 for thickness).

19.8.7.3 After manufacturing, steel fasteners shall be electroplated, zinc with a yellow chromate conversion per ISO 4042 (refer to Table 19-5 for plating thickness).

Table 19-5

Plating Thickness for Steel Fasteners, Zinc, Yellow Chromate Conversion			
Bolt Size (diameter)	**Metric DIN 267**	**U.S. ASTM B633**	**Thickness (in./μm)**
Up to #8 (M3)	A1L	–	0.00012/3
>#8 (M3) to 5/16 in. (M8)	A2C or A2L	SC1	0.00020/5
>5/16 in. (M8) to 7/8 in. (M22)	A3C	SC2	0.00031/8
>7/8 in. (M22) to 1-1/8 in. (M33)	A4C	SC3	0.00051/13
>1-1/8 in. (M33) and greater	A5C	–	0.00059/15

19.8.8 Hydrogen Embrittlement

Fasteners or fastener components with hardness greater than or equal to 320 HV (32 HRC) are susceptible to hydrogen embrittlement when these parts are pickled and/or electroplated. This may cause these fasteners to fail at relatively low loads even if stress relief annealing (baking) is performed after plating. Examples of hardened fasteners are steel bolts – U.S. Grade 8, hardened steel washers, spring washers, etc. These types of fasteners shall be mechanically plated to avoid hydrogen embrittlement.

19.8.9 Torque Marking/Indexing

19.8.9.1 The Contractor shall ensure the proper application of all threaded fasteners.

19.8.9.2 Torque marks or stripes extending from the secured hardware to the surrounding surface shall be applied to all safety-related hardware, including truck, door, and brake equipment bolts.

19.8.9.3 Tightening indication may be required on other non-safety-related hardware upon SANBAG's request as practicable.

19.8.10 Bolts and Nuts

19.8.10.1 All threaded fasteners falling into this category used in this project shall require a submittal of Certifications of Compliance (C of C) with each shipment of hardware to the end user. The C of C shall be traceable to a manufacturer.

19.8.10.2 High-strength fasteners such as SAE grade 8 hardware shall be used for mounting the traction motors to the trucks, and for all truck-mounted appurtenances, unless specifically allowed otherwise by SANBAG.

19.8.11 Electrical and High Temperature Connections

Electrical and High Temperature Connections shall be suitably fastened in accordance with OEM specification for high temperatures without degradation of the strength of the hardware or its corrosion resistance.

19.8.12 Riveting

19.8.12.1 Rivet holes shall be accurately sized, located, and aligned for the intended rivet. Rivet holes that have been repaired, or the rivet removed, shall be reamed to the next larger rivet size, and the next larger rivet installed. Rivets exposed to passengers on the outside of the vehicle shall be stainless steel.

19.8.12.2 Hand-driven steel rivets shall be driven hot and shall completely fill the holes.

19.8.12.3 Two-part rivets consisting of a pin and collar (such as Huck-Bolt types) shall be installed such that the pin breaks flush with the end of the collar.

19.8.12.4 Blind rivets may be used subject to SANBAG's approval. Blind rivet materials may be stainless steel, or plated carbon steel with plated steel or stainless steel mandrels compliant with SAE J1200, or aluminum. The mandrel shall break flush or slightly below the surface of the rivet head, but shall remain locked in place as a structural part of the rivet assembly. All rivets shall be installed according to the rivet manufacturer's instructions, using equipment approved by the rivet manufacturer.

19.8.12.5 Rivet nuts shall be of the positive locking variety, with either exterior serrations or hex cross-sections to preclude spinning once installed. The rivet nut hole shall be made per the rivet nut manufacturer's recommendations.

19.8.12.6 Aluminum alloy rivets shall comply with Aluminum Association Standards for Aluminum Mill Products alloys and tempers 6061-T6 or 6053-T61, EN ISO 14588, EN ISO 15973, EN ISO 15974 or similar.

19.8.13 Welding

19.8.13.1 All welding practice in the United States not specifically covered in this section shall be in accordance with the applicable requirements and recommendations of the EN 15085, EN ISO 3834, American Welding Society (AWS), as contained in the latest revisions of the "Structural Welding Code" (AWS D1.1), "Aluminum Welding Code" (AWS D1.2), "Structural Welding Code - Sheet Steel" (AWS D1.3), "Recommended Practices for Resistance Welding" (AWS C1.1), "Railroad Welding Specification" (AWS D15.1), and the AWS "Welding Handbook" (AWS WHB).

19.8.13.2 Where non-AWS welding or non EN 15085 welding is used, the supplier shall demonstrate equivalence. The Contractor shall demonstrate compliance with AWS or EN 15085 welding requirements and standards **[CDRL 19-12]**.

19.8.13.3 The Contractor shall be responsible for the quality of all welding and brazing, including the welding and brazing of its Suppliers and Subcontractors.

19.8.13.4 Prior to welding, all surfaces shall be thoroughly cleaned to remove corrosion, rust, scale, slag, grease, oil, water, paint, and other foreign materials in accordance with applicable parts of AWS D1.1, Section 8.5 on Workmanship and Technique or EN 15085.

19.8.13.5 Parts to be joined by welding shall be supported and held in position by tables, jigs, or fixtures to prevent warping. Weld joint design and welding method shall be selected to include provisions for shrinkage and warping caused by the welding process. Welding shall be applied in a manner to minimize distortion. Acceptable distortion levels shall be submitted for SANBAG's approval.

19.8.13.6 All weld quality shall be in accord with acceptable weld criteria as defined in EN ISO 10042, EN ISO 5817, or the AWS Welding Codes. The Contractor shall submit welding procedure specifications (WPSs) and welder certifications for approval by SANBAG **[CDRL 19-13].**

19.8.13.7 Welder Qualification

19.8.13.7.1 Welders shall be tested and certified to verify their proficiency for producing sound welds, for each weld type performed by the welder as defined by EN ISO 9606 or the AWS welding code.

19.8.13.7.2 Welder qualification tests shall be performed in accordance with the applicable requirements of EN ISO 9606; EN 287 or AWS standards, or other approved equivalent standards. Welder qualification tests for pressure vessel welding shall be in accord with applicable requirements of EN ISO 9606; EN 286-3 or Section IX of the ASME Boiler and Pressure Vessel Code, or other approved specifications. The Contractor and all Suppliers and Subcontractors shall retain records of welder qualifications and shall make these records available to SANBAG upon request.

19.8.13.7.3 SANBAG shall have the right to require the making of test welds by any welder, whether under the direct control of the Contractor or a Supplier or Subcontractor, to ascertain his/her competence and to determine the suitability of the welding procedure used.

19.8.13.8 Welding Procedures

19.8.13.8.1 All welding practices not specifically covered in other sections shall comply with AWS D1.1, AWS D1.2, EN 15085, EN 1011, or AWS D1.3 and the AWS Welding Codes as appropriate.

19.8.13.8.2 Requirements for dynamically loaded structures shall be applied.

19.8.13.8.3 Resistance welding shall be in accordance with SAE AMS W 6858, EN ISO 18595, or EN ISO 14373. Resistance welding operations shall be undertaken using only equipment fitted with meters or readouts and adjustments for time, current, and pressure.

19.8.13.8.4 The method used in depositing weld metal shall be one that reduces warping and residual stresses. To achieve this, tack welding, offset welding, skip welding, and other devices and sequences well known to the craft shall be used where appropriate.

19.8.13.8.5 Machine welds of any thickness may be made with one or more passes as per the Procedure Qualifications Record (PQR) for the weld joint.

19.8.13.8.6 The Contractor shall submit a PQR for all weld joints to be used, pre-qualified per AWS codes and all WPS for the project, or equivalent specification and qualification according to the EN ISO 15614.

19.8.13.8.7 Procedures used for the welding of metal combinations not specifically covered by the AWS standards (i.e., stainless steel to steel) or EN standards shall be approved by SANBAG. Stainless steel to steel welds shall use austenitic stainless steel filler metal.

19.8.13.9 Welding Electrodes

19.8.13.9.1 The choice of welding rod or wire filler metal shall be made with consideration of the make, type, size, composition, and suitability to the application, and shall be in accordance with "Specification for Filler Metal," AWS A5.0 or the EN ISO 18273 and EN ISO 14341.

19.8.13.9.2 Welding electrodes shall be stored in a dry, closed environment to prevent contamination in accordance with AWS recommended practices for filler material storage. Welding electrodes shall be clearly marked.

19.8.13.10 Weld Repairs

19.8.13.10.1 Weld repairs shall be performed in accordance with approved procedures, which comply with AWS D1.1 or the AWS Code applicable to the welded material, or the EN 15085.

19.8.13.10.2 When a production weld has been determined to be substandard, all production since the previous acceptable production quality control test shall be segregated, and disposition shall be recommended to SANBAG for approval. All parts with substandard welds shall be rejected or repaired by weld removal, re-weld, and inspection.

19.8.13.11 Welding Inspection and Examination

19.8.13.11.1 The Contractor shall inspect the welds according to their classification and operating grade, to verify compliance with these provisions and specifications. For the classification an industry standard as the EN 15085 in conjunction with the EN 12663-1 shall be applied.

19.8.13.11.2 Welding inspection procedures and welding inspector qualification tests shall be performed in accordance with the applicable requirements of the AWS standards for weld inspection or, for welds according to the EN 15085, according to the classification of the specific weld in accordance with the EN 15085.

19.8.13.11.3 The Contractor shall use and demonstrate the use of personnel qualified to perform weld inspection. An AWS or EN ISO 14731 Certified Welding Inspector (CWI) shall be used for inspection or oversight of welding inspection.

19.8.13.11.4 Non-destructive examination and testing of welds and welder qualification tests shall be performed in accordance with the applicable requirements of the AWS Welding Handbook, EN 13018, EN ISO 17637, or the EN ISO 9712.

19.8.13.11.5 Personnel performing NDT shall have documented qualifications in accordance with American Society of Nondestructive Testing (ASNT), TC-1A or EN ISO 9712.

19.8.13.11.6 In addition to visual inspection requirements specified by the AWS welding codes, EN ISO 3452, or EN ISO 9934, nondestructive surface inspection (dye penetrant or magnetic particle methods, as appropriate) shall be used to inspect all first-production welds.

19.8.13.11.7 The Contractor shall specify additional visual and other nondestructive inspection requirements for subsequent welds. If the Contractor elects to inspect less than one hundred percent (100%), then the Contractor shall submit a random sampling inspection plan for approval by SANBAG. In no case shall the length of weld nondestructively inspected be less than one percent (1%) of the total weld length.

19.8.13.11.8 All welds designed to carry primary stresses in members such as side sills, end frames, bolsters and other important truck and frame members shall be inspected by the Contractor for Defective welding.

19.8.13.11.9 Critical areas of all such welds shall be magnetic particle or dye penetrant or ultrasonic tested, and radiographic tests shall be used on a random sample basis as defined in the EN ISO 16826.

19.8.13.11.10 The following Defects in excess of limits indicated or established in the approved procedures shall be cause for rejection of the Work affected: cracks, regardless of length, magnitude or location; overlaps; lack of penetration; incomplete fusion; inclusions except if they do not materially affect the strength of the welded joint and do not indicate improper technique or an unsatisfactory procedure; undercuts; poor surface appearance; or improper size of weld.

19.8.13.11.11 On the first structure or component, all types of full-penetration welds shall be nondestructively, volumetrically inspected (ultrasonic or radiographic methods). Historical inspection data, or sample welds, according to the AWS welding codes or the EN 15085, are accepted in lieu of actual testing on the first car body supplied to SANBAG. The Contractor shall specify a random sampling plan for volumetric inspection of subsequent full-penetration welds for approval by SANBAG.

19.8.13.11.12 With the approval of SANBAG, destructive sectioning and metallurgical examination may be substituted for some or all of the required volumetric inspection requirements.

19.8.13.12 Heat Treatment

19.8.13.12.1 Where required by specifications or drawings, welded assemblies shall be stress-relieved by heat-treating in accordance with AWS D1.1. Chapter 4, Part A.

19.8.13.12.2 Heat treatment procedures shall be documented and submitted for review for first piece/part processing.

19.8.13.12.3 All heat treatment documentation (results) shall be retained by the Contractor or Subcontractor.

19.8.14 Brazing

19.8.14.1 The Contractor, if brazing is applied, shall maintain a brazing program similar to the welding program specified in the welding portion of this specification.

19.8.14.2 All brazing, qualification of brazers, and repair of brazing Defects shall be in accordance with the requirements and recommendations specified in the AWS Brazing Handbook or the DIN 8593-7.

19.8.14.3 The Contractor, if brazing is applied, shall maintain QC procedures necessary to ensure high-quality brazing. The Contractor shall submit brazing specifications, procedures, and certifications for approval by SANBAG **[CDRL 19-14].**

19.8.15 Soldering

Soldering of electronic equipment shall comply with the requirements of ANSI J-STD-001B or ROHS. The Contractor shall submit soldering specifications, procedures, or certifications for approval by SANBAG for customer specific electronics **[CDRL 19-15].**

19.9 PIPING, TUBING & PRESSURE VESSELS

19.9.1 Air or hydraulic hose applications shall not be permitted in locations where adequate visual inspections cannot be made. Hose installations shall be located/arranged in such a manner as to prevent accidental cross-connections to other hoses located in the same general area.

19.9.2 Hose installations shall be such that kinking, rubbing, straining and unnecessary swinging are precluded. Routing that requires other piping, or cables, as the sole means of support shall not be accepted.

19.9.3 The Contractor shall perform a leak test on the final air or hydraulic piping system, with all components installed, on each vehicle in accordance with IEC 61133. The Contractor shall submit a copy of the test procedure for approval. A copy of the test report for each vehicle, including retest reports if appropriate, shall be included with each Vehicle History Book.

19.9.4 Loss of main reservoir air pressure as a result of cumulative leakage in the entire pneumatic system, not including that required for system functioning, per vehicle, shall not exceed 10 psig in 15 minutes, following a 5-minute settlement period from the point at which the system was fully charged and the air compressor was shut off.

19.9.5 The Contractor shall submit piping, tubing, and pressure vessel specifications and data for approval by SANBAG **[CDRL 19-16].**

19.9.6 Piping and Tubing

19.9.6.1 Piping and tubing shall be adequately supported at least every 24 inches (610 mm) throughout its length as practicable and at connections, and must not interfere with the removal of or access to other components. A minimum clearance of 0.125 inch (3 mm) shall be maintained on all piping and tubing used in the vehicle. Attachment shall be by securely fastening with elastomeric or polymeric lined, steel clamps, or an approved equivalent, between the pipe and clamp, to prevent chafing and vibration.

19.9.6.2 All piping, with the exception of brake piping, shall be seamless stainless steel or precision steel as determined by the application. Brake piping shall be supplied in accordance with Section TP 12.10, Brake Piping.

19.9.6.3 Stainless steel fittings must be used with stainless steel piping and tubing. Forged steel fittings, zinc plated to ASTM B633, Type II, Yellow, SC3 / SC4, or similar may be substituted upon SANBAG's approval.

19.9.6.4 All piping, tubing, valves, fittings, installation, and testing methods shall comply with ASME B31.1, DIN EN 10297-2, DIN EN 10305-1, or DIN ISO 1127.

19.9.6.5 Joints that serve the sole purpose of connecting straight runs of pipe shall not be used. Unavoidable joints in piping shall be made in a manner approved by SANBAG. All inaccessible runs of tubing or piping shall be without joints.

19.9.6.6 Piping segments shall be deburred and blown out after cutting, and thoroughly cleaned and capped after fabrication. SANBAG reserves the right to verify that piping cleanliness is to SANBAG's satisfaction at any time during the production process.

19.9.6.7 After full installation on the vehicle, and before connection or installation of system components, the piping system, with the exception of brake piping, shall be completely flushed with a suitable liquid solution, using appropriate pressure and velocity to fully dissolve all contaminants from manufacture and installation or cleaning methods approved by SANBAG. The Contractor shall submit for approval by SANBAG proposed flushing and cleaning procedures for the piping and piping system **[CDRL 19-17]**.

19.9.6.8 Following installation, piping systems shall be pressure-tested in accordance with ASME B31.1 or other approved method. All leaks that appear during pressure testing shall be repaired to SANBAG's approval and re-tested until acceptable under the approved test criteria.

19.9.6.9 All hoses used shall comply with AAR M-618, DIN 20 066, or DIN EN 854. All hose fittings shall be of an approved reusable type. Iron pipe fittings used with steel piping shall be AAR-approved, with additional corrosion resistance as approved by SANBAG.

19.9.6.10 All piping shall be installed in accordance with AAR 2518 as incorporated in Standard S-400 (AAR Manual E) or in accordance with DIN EN 10297-2, DIN EN 10305-1 and DIN ISO 1127, as well as incorporated in such a manner as to provide drainage to prevent freezing.

19.9.7 Air Filters

19.9.7.1 The filtering capability, flow rate capacity, and overall size of filters shall be appropriate for the application so that the filter replacement interval can be greater than 1 year. The filter element shall be a common production type, commonly available through various sources.

19.9.7.2 Access to the filter element for replacement purposes shall be possible without requiring the opening of any pipe fittings. Filters shall not be located in inaccessible locations for routine maintenance access.

19.9.8 Pressure Vessels

19.9.8.1 Unfired pressure vessels shall comply with Section VIII and IX of the ASME Boiler and Pressure Vessel Code or the EN 286.

19.9.8.2 A test report shall accompany each pressure vessel received by the Contractor, and a copy of the test report shall be included in the appropriate Vehicle History Book.

19.9.8.3 Each pressure vessel shall be stamped by the testing facility, whether it is the manufacturer or a third party, as verification of unit testing.

19.9.8.4 Drain cocks shall be provided at the low points of all reservoirs.

19.10 BEARINGS & LUBRICATION

19.10.1 All bearings and lubricants shall be readily available in the United States. U.S. Standard grease fittings or plugs shall be provided for all bearings not internally splash- or bath-lubricated.

19.10.2 All rotary shafts shall be supported by cylindrical or tapered roller bearings where practicable. Ball bearings may be used, subject to approval by SANBAG. Rotary/motor shafts shall be suitably protected against corrosion to allow unencumbered removal of bearings.

19.10.3 Bearings subject to atmospheric or liquid contamination shall be sealed by labyrinth, lip, or face seals. Bearings installed in a vertical application shall have suitable protection to prevent moisture or contaminants from accumulating on, or entering, bearings.

19.10.4 Bearings that are not splash- or bath-lubricated shall be provided with standard grease fittings and drain plugs or pressure-release devices for re-lubrication. Ball bearings of 1-inch (25-mm) shaft size and smaller may be factory lubricated-for-life, subject to approval by SANBAG.

19.10.5 Bearings shall be installed and removed without major disassembly of related components. Thrust style bearings shall be used whenever there is an axial load on the rotating shaft carried across rolling elements.

19.10.6 Sleeve bearings shall be used for shafts with rotary motion of less than one full revolution. Sleeve bearings shall be adequately lubricated. Sleeve bearings supporting ferrous shafts shall be composed of bronze, brass, or aluminum alloys as approved. Sleeve bearings may be used to support rotary shafts if space limitations preclude the use of anti-friction bearings.

19.10.7 Self-lubricated bushings (sintered metal) shall be used in accordance with the manufacturer's recommendations, but shall not be used for shafts with speeds greater than 500 rpm.

19.10.8 The Contractor shall submit bearing specifications and data for approval by SANBAG **[CDRL 19-18]**.

19.10.9 All lubricants shall be products approved by the Supplier of the parts on which the lubricant is to be used. All lubricants shall, as a minimum, conform to applicable ANSI and ASTM specifications. Multi-purpose lubricants shall be used where possible. The Contractor shall submit for approval by SANBAG data on lubricants recommended for bearings and bushings **[CDRL 19-19].**

19.11 CORROSION CONTROL

19.11.1 All materials used shall be either inherently corrosion-resistant, or suitably treated, or coated to resist corrosion. Equipment located in areas highly susceptible to corrosion shall be made from inherently corrosion-resistant materials.

19.11.2 Areas exposed to corrosive fluids or cleaning solutions shall be protected with coatings resistant to those fluids. The Contractor shall be responsible for verifying that all such areas are protected through communications with SANBAG.

19.11.3 Except as otherwise indicated, all aluminum exposed to view in finished work in the interior of the vehicle shall have a protective anodized coating.

19.11.4 The recommendations contained in "A Corrosion Control Manual for Rail Rapid Transit," UMTA-DC-06-0152-83-1, shall be used, except as otherwise directed by SANBAG.

19.11.5 The Contractor shall prepare a Corrosion Control Plan, which shall locate all materials that require treatment to prevent corrosion resulting from atmospheric exposure, and areas of dissimilar metal or other material joining that could result in galvanic action and material deterioration. This plan shall document the methods used to preclude failure resulting from corrosion for any of the above conditions. The Contractor shall update this document as materials and treatments change. The Corrosion Control Plan shall be submitted to SANBAG for review and comment **[CDRL 19-20].**

19.11.6 Dissimilar Metal Treatment

19.11.6.1 Direct contact between electrically dissimilar metals is prohibited except as approved by SANBAG for electrical connections between copper and aluminum where appropriate joint compounds are used as specified herein. Isolating and moisture-proofing materials, appropriate to the materials being joined, shall be used at all times.

19.11.6.2 All metals used in the fabrication process shall be surface-treated with corrosion-resistant materials as applicable prior to assembly, with consideration being given to the severity of exposure to which the surface shall be subjected.

19.11.6.3 The joining of incompatible metals and materials shall be minimized as much as possible. When such metals must be joined, provision shall be made in accordance with MIL-STD-889 to prevent chemical reactions between the metals.

19.11.6.4 Surfaces of aluminum alloy parts secured to ferrous parts shall be protected with 1-part polysulfide or silicone sealant used as joint compound, or with joint material that is non-hygroscopic and is free from chlorides and heavy metal ions.

19.11.6.5 Fibrous joint material shall be impregnated with bitumen or other water-repellant substance, which shall completely cover interfacing surfaces.

19.11.6.6 All ferrous metal surfaces, other than stainless steel, shall be protected by painting or zinc plating as defined in this specification, unless otherwise specified. Steel surfaces not requiring protection shall be galvanized by the methods and requirements described in ASTM A123. Minor damage to galvanized coatings shall be repaired with an approved zinc-rich paint.

19.11.6.7 The Contractor shall submit for approval by SANBAG a description of the procedures and processes employed to prevent corrosion and to prevent corrosion arising from the use of dissimilar metals **[CDRL 19-21]**.

19.12 CURED MATERIALS

19.12.1 All materials that are applied prior to curing shall be applied according to the manufacturer's full recommendations, including surface preparation, mixing criteria, application temperature, shelf life limits, pot life limits, curing temperature, curing exposure (before handling, or loading), etc.

19.12.2 All uncured material shall be stored and applied according to the manufacturer's full recommendations. All materials shall be used within the specified shelf life limits; material that has exceeded the shelf life shall not be used.

19.12.3 Preparation prior to bonding or painting the surface shall be prepared according to ASTM D2651 or DIN 6701.

19.12.4 Paint & Primer

19.12.4.1 All paint must be fully repairable within the parameters of restrictive air quality zones and the local, governing air quality management authority. The Contractor shall submit to SANBAG for approval data on all paints, primers, and application processes or procedures to be used for SANBAG's vehicle **[CDRL 19-22]**. The undercoating material shall be applied according to the manufacturer's instructions.

19.12.4.2 All dents, roughness, or other surface imperfections shall be corrected prior to the application of the final coat.

19.12.4.3 Primer, finish paint, and related components shall be supplied as a complete system, manufactured by a single manufacturer. Paint has to be treated according to the manufacturer's specification.

19.12.4.4 Preparation for paint application shall follow the paint manufacturer's recommendations. At a minimum, prior to paint application, surfaces shall be cleaned to remove all traces of contamination and properly treated to promote paint adhesion.

19.12.4.5 Paint shall be applied evenly, and the finished surface shall be free of dirt, runs, "orange peel," or other imperfections as practicable. Paint inspection and acceptance criteria are subject to SANBAG's approval. Paint quality control samples may be proposed to establish visual acceptance criteria, subject to SANBAG's approval.

19.12.4.6 Cosmetic coatings of paint shall have specified gloss levels for the appearance desired. The gloss levels shown in Table 19-6 are defined according to common terminology, with the following criteria based on the ASTM D 523 – 60° axis angle with equivalents shown for 80° and 20°.

Table 19-6

Gloss Level Definition	Glossmeter Setting and Gloss Value		
	20 degree	**60 degree**	**85 degree**
- High Gloss	85-90%	90-95%	95-100%
- Semi Gloss	0-10%	20-30%	50-60%
- Flat Gloss	0%	0-10%	10-20%

19.12.4.7 At least two coats of finish paint shall be applied, with appropriate surface preparation between coats.

19.12.4.8 Touch-up paint shall be identical in all respects to the original paint. Color chips for color match may be provided by the Contractor for SANBAG's approval, to establish acceptable color match tolerances. It is the Contractor's responsibility to ensure that the color match is acceptable. It may be required that the color match be made according to ASTM D 2244. In no case shall color mismatch detract from the overall appearance of the Equipment.

19.12.4.9 Prior to assembly, all low-alloy steel areas shall be painted with 1 coat of an approved etching primer followed by 1 coat of an approved sealer to prevent rusting.

19.12.4.10 All coatings used are to be EPA-compliant and compliant with SANBAG's area requirements.

19.12.4.11 Painted surfaces shall develop full adhesion to the substrate to which they are applied. Testing for adhesion between the paint and the substrate surface will be done on a random basis and shall conform to ASTM D 3359, 3a Classification, using Permacell® #99 adhesion test tape or according to DIN EN ISO 2409.

19.12.5 Carbody Exterior

19.12.5.1 The carbody exterior shall be painted with an high quality urethane paint system consisting of primers, two color coats, and clear topcoat as approved by SANBAG. Exterior surfaces, except the underframe and underside of the flooring, shall receive a minimum of 2 coats of primer, a coat of surfacer, a minimum of 2 coats of color, and 1 coat of clear.

19.12.5.2 All body filling material shall be selected to effectively discourage flame propagation and cracking.

19.12.6 Roof

19.12.6.1 Roof walkway areas, either on the car structure or equipment containers, shall have an anti-skid material, coating, or surface application to provide a safe walking surface when wet. Areas not capable of supporting weight of maintenance personnel shall be clearly marked with "no step."

19.12.7 Underfloor

Exposed underfloor steel surfaces, after installation of welded-on bracketry, shall receive a minimum of 2 coats of primer and 2 coats of an approved paint. In areas where intermittent welding is used, the seam shall be completely sealed after paint application.

19.12.8 Equipment Enclosures

19.12.8.1 The exterior of all Equipment enclosures shall receive a minimum of 2 coats of primer, and a minimum of 2 coats of an approved paint.

19.12.8.2 The interior of all Equipment enclosures shall be coated with a primer and an approved white or light-colored coating. Electrical Equipment enclosures shall use an approved non-conductive white coating. Powder coating is for enclosures also be an accepted method.

19.12.9 Exposed Piping, Conduits, and Wireways

19.12.9.1 The Contractor shall ensure that wireways, conduits, and piping that can be corroded shall receive a minimum of 2 coats of primer and 2 coats of an approved paint.

19.12.9.2 This priming and painting can be accomplished either before or after installation of the item on the carbody.

19.12.10 Undercoating

19.12.10.1 Specifications for undercoating material, if required, shall be submitted for SANBAG's approval, and shall remain functional throughout the service life of the vehicle.

19.12.10.2 The undercoating material shall be applied according to the manufacturer's instructions. Undercoating thickness shall conform to the manufacturer's recommended practices.

19.12.10.3 The composition of the materials selected for the protective treatment system shall be such that treated members may be readily cut or removed using conventional cutting methods, such as burning or sawing, without creating any fumes that are hazardous to employees.

19.12.10.4 Undercoating shall be applied following priming and painting and prior to installation of conduit, piping, raceways and wireways.

19.12.10.5 Undercoating shall not be applied to unprimed or unpainted surfaces, or to conduit and piping, or bracketry.

19.12.11 Painting Restrictions

Any component that would be damaged or suffer impaired performance from painting shall not be painted. These items include, but are not limited to, the following:

- Wire, cable, flexible conduits and fittings, electrical grounding points
- Wearing surfaces, threads used for adjustments, lubrication points
- Elastomeric parts, hoses, bumpers, etc.
- Heat transfer surfaces, resistors, electrical insulators, etc.
- Moving parts, linkages, gas springs, etc.
- Wheels

19.12.12 Powder Coating

19.12.12.1 Powder coating, if used, shall be epoxy-based for interior surfaces and polyester-based for exterior surfaces. Finished film thickness shall be 3.5 mil (0.089 mm) ± 1.0 mil (0.025 mm). The surface preparation and pre-treatment shall be according to the powder manufacturer's recommendations.

19.12.12.2 Powder coating finish gloss level for cosmetic surfaces shall be according to Powder Coating Institute, Gloss Level Standard(s) – 7 to 10.

19.13 ADHESIVES

19.13.1 Adhesives to be used for installation of floor covering, panels, insulation and vibration isolation materials shall have a satisfactory history of performance in a rail transit environment. A list of all adhesives to be used, including location, technical data and specification sheets, and flammability properties shall be submitted for approval by SANBAG **[CDRL 19-23]**. Adhesives used in small quantities may not require flammability data, subject to SANBAG's approval.

19.13.2 Joining of components by adhesives shall be completed within the maximum working times per the manufacturer’s instructions.

19.13.3 Adhesives that use atmospheric or humidity cure shall be installed such that the air circulation to fully cure the adhesive is possible.

19.13.4 Adhesive selection and bonded joint design shall consider MIL-HDBK-691B or DIN 6701.

19.14 SEALANTS AND CAULKING

19.14.1 The use of caulking and sealing compounds shall be minimized.

19.14.2 Caulking and sealing compounds shall be applied in accordance with the manufacturer's instructions and recommendations, shall be non-staining, and shall be supplied in colors closely matching those of adjacent materials and surfaces. Caulking used in exterior applications shall be UV-resistant. If butyl-type is used, it shall be extruded polyisobutylene sealer compound of one hundred percent (100%) solids.

19.14.3 Caulking primers shall be quick-drying, colorless, non-staining sealers of a type and consistency recommended by manufacturers of caulking materials for the particular surface involved.

19.14.4 Packing (backstop) shall be non-staining, resilient material, such as fiberglass roving, neoprene, butyl, closed-cell foams, or other compressible materials compatible with the caulking compound used. Joints, spaces, and junctures to be packed and caulked or sealed shall be completely cleaned of dirt, dust, oil, and other foreign materials that would adversely affect caulking quality. Suitable primer shall be used to achieve full adhesive bond.

19.14.5 Surfaces shall be thoroughly dry before caulking compounds are applied. Caulking compound application shall be compatible with prior or subsequent paint application. When so stipulated by the sealant manufacturer, paint and other protective coatings shall be removed from surfaces to be caulked prior to priming and application of sealants.

19.14.6 Compounds shall be applied with pneumatic guns. Where the use of a caulking gun is impracticable, suitable hand tools shall be used.

19.14.7 Unless otherwise indicated, the entire perimeter of each opening shall be caulked.

19.14.8 The finish of caulking joints on flush surfaces and in internal corners shall be neatly pointed; excess material shall be removed and, where exposed, the caulking shall be free of wrinkles and uniformly smooth.

19.14.9 Application of polysulfide or silicone compounds shall be in accordance with the manufacturer's instructions and recommendations.

19.14.10 Compounds shall not be used when they become too gelled to be discharged in a continuous flow or if they exceed their stated shelf life, and they shall not be modified by addition of liquids, solids, or powders. Compounds shall be installed within the manufacturer's defined temperature range.

19.14.11 Installation and working of compounds shall be completed within the maximum working times per manufacturer’s instructions.

19.14.12 Adjoining surfaces, finishes, and fixtures shall be carefully protected throughout caulking operations. Stains, marks, or damage as a result of caulking and sealing work shall be removed.

19.15 INSULATION

19.15.1 Where required, insulating materials shall be fire-retardant, non-hygroscopic, resistant to fungus, and provided with a vapor barrier as required to prevent the entry of moisture, oil, gases and dust.

19.15.2 The materials shall not absorb fluids and gases and shall possess the required properties to meet the noise and vibration requirements of this specification.

19.15.3 The method of insulation retention in the carshell, for all insulating materials, shall be subject to SANBAG's approval.

19.15.4 The Contractor shall submit for approval data on thermal and acoustic insulation materials and application processes **[CDRL 19-24].**

19.15.5 Acoustic Insulation

Sound damping material used in the fabrication of the vehicle shall be resistant to diluted acids, greases, gasolines, fuel oils, aliphatic oils, and vermin; and must be resistant to fungus; and must not support combustion. The material shall not be affected by sunlight or ozone, and shall not become brittle with age. Application shall be in accordance with the Supplier's recommendations.

19.15.6 Thermal Insulation

19.15.6.1 Thermal insulation materials shall be transportation grade of the rigid, non-rigid, or spray-on type. Insulation shall be installed with a vapor barrier to preclude moisture accumulation where required.

19.15.6.2 The type of thermal insulation to be used shall not be susceptible to mold or rot and shall not absorb water. Metals that are attached to the insulation shall be corrosion-resistant, and not settle under vehicle vibration. The vehicle thermal insulation shall not have an odor or be capable of absorbing odors, and shall not sustain vermin. Urethane foam insulation is expressly prohibited.

19.15.6.3 Deleted.

19.16 FABRICS AND UPHOLSTERY

Upholstery fabrics for vehicle seats shall be approved transportation-grade fabrics with backing. Fabric shall be able to be cleaned by at least three widely available commercial industrial cleaning agents that are known to be chemically compatible.

19.16.1 Vinyl Fabric

19.16.1.1 Vinyl upholstery fabrics for vehicle seats shall be transportation-grade fabric with woven backing and shall be approved by SANBAG.

19.16.1.2 Seat upholstery physical properties shall meet the test criteria listed in Table 19-7.

Table 19-7

Physical Property	Requirement	Test Method
Total Weight	33.0 oz./yd @ 54 in. wide (linear yard)	CFFA-700D
Thickness	45 mils	CFFA-700C
Tensile Strength	65 lbs. (long direction) 60 lbs. (cross direction)	CFFA-17
Tearing Strength (Trapezoid)	14 lbs. (long direction) 12 lbs. (cross direction)	CFFA-16C
Coating Fabric Bond	3 lbs./in.	CFFA-3A
Stretch	5% (long direction) 25% (cross direction)	CFFA-15
Abrasion Resistance	a) No wear through skin @ 500 double rubs with 240-grit silicon-carbon cloth and b) No wear through skin @ 250,000 double rubs with #8 cotton duck	CFFA-1AWyzenbeek
Crocking	Good-Minimum	CFFA-7, dry
Blocking	Scale Rating No.3 Maximum	CFFA-4
Cold Resistance	-20°F, No cracking	CFFA-6A, 5# roller
Accelerated Weathering Resistance Test	No fading, discoloration, or stiffness after 225.6 kJ	CFFA-2, A1, (SAE-J1885) B1, (ASTM G155) C1, (ASTM D4329)

19.17 ELECTRICAL

19.17.1 Wiring General Requirements

19.17.1.1 Wire sizes, insulation requirements, materials, shielding methods, and identification of wire and cable used for primary, auxiliary, control, and communications applications shall be based on the current carrying capacity, voltage drop, mechanical strength, temperature, and flexibility requirements of AAR, ASTM, EN, ICEA, 49 CFR Part 238 Appendix B, or MIL specifications. Wire, cable, and bus bars shall be copper.

19.17.1.2 All wire and cable insulation shall meet the flame and smoke test requirements of Section TP 19.23, Flammability, Smoke Emission & Toxicity, and shall be substantially free of halogens. The wire and cable selected shall be rated by the manufacturer to last the life of the vehicle.

19.17.1.3 The Contractor shall mark clearly each wire, by wire type, and mark each wire end (as a minimum) with a function code matching the schematics.

19.17.1.4 SANBAG shall approve all electrical wire and cable used in the vehicle. The Contractor shall submit samples and specifications of each size and type of wire and cable proposed for use in the vehicle for SANBAG's approval **[CDRL 19-25]**.

19.17.1.5 Braided copper wire, or wire rope, shall be used in all ground strap applications. Flexible stranded copper wire is acceptable in other applications.

19.17.1.6 All conductors of multi-conductor cables shall be terminated.

19.17.2 Conductors

19.17.2.1 Maximum current capacities shall conform to EN 50343.

19.17.2.2 Except as otherwise specified, conductors shall be of soft, annealed, tinned copper stranded in accordance with ASTM B33, EN 50264, or EN 50306.

19.17.2.3 Stranding and conductor construction for all wires and cables No. 18 AWG and larger shall comply with NEMA WC 70, NEMA WC 71, and AAR RP-585, or EN 50264 respectively EN 50306, as is appropriate for the application. Stranding shall be per ASTM B174; Class I or equivalent - 10 to 7 AWG, and Class K or equivalent - 18 to 12 AWG.

19.17.2.4 Stranding and conductor construction for wires and cables No. 20 and No. 22 AWG shall be of 19-strand construction as appropriate for the usage requirements.

19.17.3 Wire & Cable Insulation

19.17.3.1 Each conductor shall be separately covered with insulation. Flat cables are prohibited, except for specific data/communications or EMC applications where other arrangements are impractical.

19.17.3.2 Wire and cable insulation used for carbody wiring shall be flexible, cross-linked polyolefin, or equivalent. Wire and cable shall comply with the electrical and physical requirements of NEMA WC 70, NEMA WC 71, and AAR RP-585, or EN 50264 respectively EN 50306.

19.17.3.3 Wires within enclosed equipment or suitably protected locations shall comply with MIL-W-81044, EN 50343, or as otherwise approved.

19.17.3.4 For general-purpose wire and cable shall conform to the EN 50264 respectively EN 50306, in general the insulation shall be of heat- and moisture-proof material suitable for a continuous temperature rating of 167°F (75°C) minimum in dry and wet locations. For high-temperature applications, such as connecting to heaters and resistors, the insulation shall be suitable for a maximum conductor temperature of 230°F (110°C).

19.17.3.5 Asbestos, urethane, and PVC-based insulations or jacket materials shall not be used.

19.17.3.6 Outer jacket material of multi-conductor cable shall be the same as that used to insulate individual conductors, unless physical considerations indicate a different material with superior characteristics.

19.17.3.7 Multi-conductor cables shall provide at least ten percent (10%) spare wires and at least one spare of each wire type and size where practicable.

19.17.3.8 Shielding shall be used over multi-conductor cable for safety-critical circuits as required by the EN 50343. Shielding material shall be woven wire providing not less than sixty percent (60%) coverage and shall be soft, annealed, tinned copper of an area equal to or greater than the largest conductor, or according to EN 50264 respectively EN 50306.

19.17.3.9 Non-conducting separators and fillers may be applied between conductor and insulation on conductor sizes greater than No. 5 AWG.

19.17.3.10 Leakage between primary wiring and vehicle body shall be measured in accordance with IEEE Standard 11 or EN 50124-1. The leakage shall be at least 10 MOhms when measured with a 1,000-V megOhmeter.

19.17.3.11 Hi-Pot shall be accomplished on all primary power wiring at 2,500 VAC for 1 minute per IEEE Standard 11, or EN 50124-1.

19.17.3.12 General carbody wiring insulation shall be flame-retardant, halogen-free, extra-flexible, cross-linked polyolefin material, and free of halogens, phosphorus, sulphur, and nitrogen (combined to less than 1% by weights).

19.17.4 High-Temperature Wire and Cable

Insulation for all wires in high-temperature applications, including but not limited to those connecting with heaters, resistors, or lights, shall conform to the following:

a. For wire sizes No. 16 AWG and larger, the insulation shall be silicone rubber in accordance with AAR RP-585, RP-587,RP-588, EN 50264, or EN 50306, 110°°C irradiated cross-linked polyolefin, or abrasion-resistant extruded polytetrafluoroethylene (PTFE) Teflon meeting MIL-W-22759/6B, or equivalent.

b. For wire sizes No. 18 AWG and smaller, the insulation may be abrasion-resistant extruded tetraflourethylene (TFE) Teflon meeting MIL-W-22759/6B, or equivalent according to EN 50306. When used for interconnecting pieces of apparatus, this type of wire shall be bundled and shall have a protective covering where needed.

19.17.5 Communications Wire & Cable

19.17.5.1 The communications system manufacturer shall approve all carbody wire and cable applicable to the communications equipment.

19.17.5.2 All communications wire and cable shall be installed in raceways, conduits, or as otherwise approved by SANBAG.

19.17.5.3 The jacket shall be waterproof and abrasion-resistant and shall provide insulation resistance greater than 100 MOhm/km between shield and water, or as defined by the EN 50306 respectively EN 50264.

19.17.6 Conduit & Wire Channel

19.17.6.1 All conduits and wireways shall be free of burrs, sharp edges, and square corners. Conduit welded into the carbody shall not have any burn-through of weld, or any other penetration into the interior of the conduit. The ends of the conduits and wireways shall be suitably rounded to prevent edge contact with the wire. Conduit radius shall be sufficiently large enough to allow easy pulling of the wire.

19.17.6.2 Wires and cables installed in flexing applications shall be housed in abrasion-resistant, flexible conduit or sheathing designed for the application and installed such that there is no pinching, stretching, or kinking under all ranges of motion.

19.17.6.3 The Contractor shall ensure that wireways, conduits, and piping that is susceptible to corrosion shall be suitably protected from corrosion, such as zinc plating per ASTM B633 Type II yellow, SC4; or receive a minimum of 2 coats of primer and 2 coats of a paint approved by SANBAG. This priming and painting can be accomplished either before or after installation of the item on the carbody.

19.17.7 Application & Installation

19.17.7.1 All wiring shall be performed and directed by experienced personnel using appropriate tools for stripping insulation, cutting, soldering, and attaching mechanical crimp-type terminals with correct dies.

19.17.7.2 All car wiring connected to a given piece of electrical apparatus shall be insulated for the highest voltage supplied to that apparatus. Wires operating with potential differences of 50 V or more shall not be cabled or routed together. Signaling, LVDC, AC, and HVDC wiring shall be separated, or as defined by EN 50343.

19.17.7.3 Wiring for any communications system equipment shall be done in a manner approved by SANBAG to conform to the requirements established by the Supplier of that equipment.

19.17.7.4 All circuits shall be adequately protected and insulated from ground. All circuits and branches must be separable by a switch or terminal board to isolate their grounds when troubleshooting is required.

19.17.7.5 Wiring shall be fabricated into standard harnesses, installed in prefabricated groupings, and at standardized locations in the vehicles.

19.17.7.6 Car wiring shall comply with EN 50343, or with AAR S-538 Manual of Standards, Section F, Wiring Practice, and Rolling Stock Standard, or EN 50343, except where otherwise specified.

19.17.7.7 Circuit protection shall comply with EN 50343.

19.17.7.8 Electrical circuits and associated cabling shall be designed with clearance and creepage distance between voltage potentials and carbody ground in accordance with the environmental conditions to which the circuits and cabling will be subjected, and in accordance with 49 CFR Part 238 Appendix B or equivalent IEC or EN standards.

19.17.7.9 Electrical apparatus shall be housed in sealed enclosures to remain clean and dry. Cooling air shall be filtered to remove all conductive and non-conductive dust as practicable.

19.17.7.10 The layout of wiring shall be designed in advance of its installation and in cooperation with those furnishing the related Equipment.

19.17.8 Undercar and Roof Wiring Installation

19.17.8.1 All wiring shall be run in insulated metal raceways and wire ducts with securely fastened but easily removable metal covers.

19.17.8.2 Wire and cable shall be securely anchored in the ducts in a manner approved by SANBAG to prevent chafing from relative motion.

19.17.8.3 Minimum wire size for under car wiring shall be 16 AWG for power or signal and 20 AWG for multi-strand. Within Equipment enclosures, minimum wire size shall be 22 AWG.

19.17.8.4 When physical strength is required, No. 6 AWG or larger wires may be used and supported in place without any type of enclosure by using molded rubber cable support blocks. This method is also acceptable in protected areas that may be subject to damage or vandalism.

19.17.8.5 The wire ducts and conduits shall be of waterproof construction. Watertight strain-relief bushings with insulated throat liners shall be provided at duct entrance and exit points. Bushings shall be sized such that the wire and lug may be removed through the bushing.

19.17.8.6 Wires or cables shall maintain a safe distance from the battery compartment.

19.17.8.7 Floor wiring shall be run in conduits or ducts and may be run through partitions, but only if suitable bushings are provided at such points of passage.

19.17.8.8 Sufficient slack and wire length shall be provided to prevent breaking or pulling out of bushings or terminals, and to allow for a serviceability loop long enough for 3 re-terminations.

19.17.8.9 Drip loops shall be provided where appropriate.

19.17.9 Power Cables

19.17.9.1 HVDC power cables (with the exception of cables passing through or above the floor) that are No. 6 or larger shall be cleated in place.

19.17.9.2 The cleats, as specified in Section TP 19.17.13, Cleating, shall be positioned at intervals no greater than 1.5 feet (257 mm), and adequate clearance shall be maintained between cables and any structural members, components, or items of equipment as practicable.

19.17.9.3 Where mechanical protection is required, short lengths of conduit complying with Section TP 19.17.12, Conduit and Raceway Requirements, may be employed, subject to approval by SANBAG.

19.17.10 Cable Connectors

19.17.10.1 All cable connectors shall be of watertight design, unless enclosed in interior watertight cabinets and approved by SANBAG, with removable/replaceable crimp contacts of the correct size for the wire being terminated.

19.17.10.2 Cable connectors shall be equipped with sealing gaskets. Extension bodies shall be used if necessary to ensure that there is sufficient room to terminate the cable wires within the connector body.

19.17.10.3 The cable jacket shall extend within the body, shall be held by a clamp, and shall have a gasket seal at the entrance.

19.17.10.4 Unused connector pin positions shall be sealed with either connector contacts or plastic sealing plugs designed for that purpose.

19.17.10.5 Adjacent connectors shall either use different inserts or different insert orientations to prevent erroneous connections.

19.17.10.6 Connectors installed in exterior locations shall comply with MIL-DTL-5015 or EN 50467. All other connectors shall comply with an equivalent standard, as approved by SANBAG.

19.17.11 Terminals

19.17.11.1 Terminations and connections throughout the vehicle shall be with insulated ring tongue connectors of the compression (crimp) type or other type of terminal/connector as approved by SANBAG.

19.17.11.2 Quick-disconnect (fast-on) terminals with locking features may be used, subject to approval, provided that the type of fast-on has demonstrated a satisfactory service in a similar fashion. Materials such as phosphor bronze shall be shown to be suitable for repeated use.

19.17.11.3 Terminals shall not use PVC insulation.

19.17.11.4 Terminals shall be attached to the wiring with the crimping tools and dies recommended by the connector manufacturer.

19.17.11.5 The terminal used shall be of the type that securely grips and holds the insulation of No. 10 AWG wire or smaller. The crimp terminal shall be rated to match the wire conductor diameter and the insulation diameter.

19.17.11.6 Conductors that will be subjected to motion shall use the proper strain relief mechanism recommended by the manufacturer.

19.17.11.7 Spare terminals shall be provided for each terminal assembly in an amount equal to at least ten percent (10%) of all terminals, with at least one spare terminal provided for each terminal size as practicable. Spare conductors in a multi-core cable need not be terminated at spare terminal strip locations.

19.17.12 Conduit and Raceway Requirements

19.17.12.1 All car wiring shall be housed in metal raceways or other types as approved by SANBAG. Open metal raceways and their elbows, couplings, nipples, bushings, locknuts, universal joints, expansion joints, and other conduit fittings shall be so designed that the sections can be mechanically and electrically coupled, while the wires are protected from abrasion.

19.17.12.2 High voltage wiring, (i.e., wiring in excess of 120 V (nominal)) shall not be run in the same cable ducts, conduits, or raceways as low-voltage wiring.

19.17.12.3 All conduits shall be arranged to prevent moisture traps and shall drain toward control boxes, and shall be supported to the carbody at least every 24 inch (610 mm).

19.17.12.4 Wires in conduits, ducts, and raceways shall be free of kinks, insulation abrasions, and insulation skinning.

19.17.12.5 If a conduit is designed to come through the flooring of the vehicle and into equipment boxes located at the passenger compartment level, the conduit must extend 1 inch (25.4 mm) above floor level to prevent water or cleaning chemicals from draining onto the below-floor cables.

19.17.13 Cleating

19.17.13.1 Split block cleats of molded neoprene rubber or a manner approved by SANBAG equivalent shall cleat all cable and wiring not installed in conduits. A nonflammable insulating material with a durometer reading of 50 to 60 Shore A hardness shall be used for cleating.

19.17.13.2 The holes in the cleat shall be sized for the individual wires and cables. Hole edges shall be radiused to prevent square edge contact with cable insulation.

19.17.13.3 Each cleat shall have a stiffener on the side away from the mounting bracket that will act to spread the bolt clamping force over the entire length of the cleat.

19.17.13.4 Bolts shall have lock nuts of a design approved by SANBAG.

19.17.13.5 Cable and wiring, other than HVDC, using cleating shall be supported to the carbody at least every 24 inch (610 mm).

19.17.14 Equipment Enclosures and Junction Boxes & Fittings

19.17.14.1 Boxes, covers, and fittings of ferrous metal shall be galvanized inside and outside after fabrication. The box covers shall be held in place with latches or blunt-end screws. Self-tapping screws shall not be used for box covers.

19.17.14.2 Screws and other hardware shall be made of stainless steel or appropriately protected against corrosion.

19.17.14.3 All undercar and roof-mounted junction boxes shall be waterproofed and vented, and shall protect enclosed equipment and connected conduits from water seepage as practicable.

19.17.14.4 The interiors of all equipment enclosures and junction boxes shall be protected for corrosion and electrically insulated as required.

19.17.15 Wire Identification and Terminal Markings

19.17.15.1 Wire terminal designations shall be assigned to all electrical conductors, whether individual wires or cables, within the entire car.

19.17.15.2 All wires and cable shall be marked at a minimum at the end of the wire.

19.17.15.3 Wires shall be identified according to circuit function, wire number, wire segment and gauge in accordance with schematics. A document defining and explaining the identification, nomenclature and labeling concept shall be provided. **[CDRL 19-26]**.

19.17.16 Splicing and Taping

Splicing and taping shall not be allowed unless expressly approved by SANBAG on a case-by-case basis.

19.18 CIRCUIT PROTECTION

19.18.1 Handles shall indicate ON, OFF, and TRIPPED positions. Circuit breakers shall be molded-case type, single- or multi-pole, with frame size suitable for continuous current and interrupting duty.

19.18.2 Each pole shall be equipped with a trip mechanism consisting of an inverse time element for overload protection, and an instantaneous magnetic element for short-circuit protection.

19.18.3 Each pole shall be equipped with adequate means of arc extinction to prevent flashover.

19.18.4 Multi-pole breakers shall operate contacts simultaneously.

19.18.5 Breaker current rating shall be clearly visible after installation and shall comply with UL 489, NEMA AB1, ANSI C37.13, C37.14, or C37.16.

19.18.6 Continuous current rating shall be selected in accordance with EN 50343 for load and type of service indicated.

19.18.7 Electrically controlled breakers shall be equipped for operation from the LVPS.

19.18.8 Circuit breakers shall be properly coordinated with protective devices.

19.18.9 Other than high-speed circuit breakers (HSCBs) used for HVDC circuits, circuit breakers shall not be used for protection on HVDC circuits.

19.18.10 Fuses shall not be used except for indicator type fuses within electronic assemblies, high voltage circuit protection, and special applications with approval of SANBAG.

19.19 GROUNDING

19.19.1 Grounding connections shall be made through aluminum, copper or bronze pads, tinned, and silver soldered by other appropriate means to the carbody.

19.19.2 The aluminum, copper pads shall be tinned or silver electroplated after attachment. Stainless steel ground pads may also be used, subject to SANBAG's approval and conformance to the bonding requirements as specified in Section TP 19.0, Material and Workmanship.

19.19.3 Low voltage and high voltage circuits shall not be grounded to the same grounding pad, if such grounding is permitted by this technical specification.

19.19.4 All ground pads shall be visible and accessible for inspection and troubleshooting as practicable. The ground connections shall be attached by an approved bolt, washer, and nut designed for the purpose.

19.19.5 Resiliently mounted equipment shall be grounded with flexible strap-type grounding leads bolted between a carbody grounding pad and the equipment's grounding pad. Strap flexibility and length shall be sufficient to prevent failure from fatigue. Fixed equipment may be grounded by flexible straps or properly terminated wire of the same type used for car wiring.

19.19.6 The ground strap termination method shall form a gas-tight, uniformly distributed connection with the conductive surface. Current density shall not exceed bonding requirements discussed below.

19.19.7 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 50 V. 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.

19.19.8 All ground pads shall be readily visible and accessible for inspection and troubleshooting as practicable.

19.19.9 All equipment enclosures and shock-mounted equipment shall be grounded with tinned, braided copper, flexible strap grounding leads bolted to a carbody grounding pad.

19.19.10 Ground cables and shunts shall be extra-flexible, tinned, and non-insulated stranded copper cable meeting the additional requirements of Section TP 19.11.2, and shall be terminated by approved crimped ring terminals on both ends.

19.19.11 Ground cables and shunts shall be sized to withstand, without failure, the maximum failure current that could be anticipated should the return wiring totally fail.

19.19.12 In no case shall the size of a ground cable or shunt be less than No. 14 AWG.

19.19.13 The Contractor shall ensure that all metal parts inside and outside the vehicle that could be touched by passengers or operating personnel, including equipment boxes, panels, and test receptacles in the passenger or Operator areas, shall never exceed carbody potential.

19.20 ELECTRICAL COMPONENTS

Electrical components, which are singly replaceable, shall be connected to car wiring through individual, removable connections, or "pigtails" with connectors. Replaceable components shall not be connected to car wiring using soldered connections. Electrical components installed on the vehicle without protective enclosures, including, but not limited to inductors, transformers, resistors, and capacitors, shall be designed, selected, and installed to make them impervious to the effects of SANBAG's railroad environment and operations. This shall include, as a minimum, the effects of extreme weather, water, snow and ice, extreme temperature swings, and possible impact by debris. Exceptions to this requirement may be granted on a case-by-case basis, upon approval by SANBAG.

19.20.1 Relays and Contactors

19.20.1.1 Contactors and relays shall meet or exceed IEC 60077.

19.20.1.2 Low-current relays (less than 10 Amps per pole) shall have silver-alloy or industry approved equivalent contacts.

19.20.1.3 Very low current relays (1 Amp and less) shall have gold-plated, silver-alloy contacts.

19.20.1.4 Relays and contactors that have not been proven in rail service shall comply with MIL-PRF-6106.

19.20.1.5 Relays should be capable of at least 1 million electrical operations at rated contact capacity with the exception of those operating on the order of 1,000 times per day being capable of at least 10 million electrical operations at rated capacity.

19.20.1.6 Plug-in relays shall be secured in their sockets by mechanical restraints.

19.20.1.7 Relay and contactor coils shall be suppressed to mitigate transient voltage spikes, with the suppressing network mounted as close to the coil as possible.

19.20.1.8 Relays and contactors, except low-power miniature relays mounted on printed-circuit boards, shall incorporate means of visually determining whether contacts are picked up or dropped out.

19.20.1.9 Relays used in safety-critical circuits with single point failures shall comply with the AAR Signal Manual, Volume 2, Section 6, unless otherwise approved.

19.20.1.10 Contactors used to interrupt HVDC circuits shall be equipped with blowout coils or other means of arc suppression in accordance with Section TP 9.0, Auxiliary Electrical Equipment.

19.20.2 Pushbutton Switches and Indicators

19.20.2.1 Switches shall be heavy-duty, with electrical characteristics, ratings, and accessories as required for circuit application.

19.20.2.2 Pushbutton (including illuminated) switches shall have silver-plated or silver-alloy terminals or industry approved equivalent.

19.20.2.3 Indicators and pushbutton switches shall have insulation resistance of at least 1 MOhm to case at 500 VDC, or according to EN IEC 60947-1, 60947-5-1, or DIN IEC 60512-2-4. Re-lamping of indicators shall be from front.

19.20.2.4 Contacts shall have maximum resistance of 0.10 ohm at 3 VDC and 10 milliamp load. Minimum open contact resistance shall be 50 MOhm, or according to EN IEC 60947-1, 60947-5-1, DIN IEC 60512-2-4.

19.20.2.5 Contact shall be rated for inductive loads. The contacts shall normally operate at not more than twenty percent (20%) of the manufacturer's inductive rating for 25,000 cycles of operation at 25°C, or as defined in the EN IEC 60947-1, 60947-5-1, or DIN IEC 60512-2-4. The electrical-contact material shall be silver or silver with a gold flash or gold plate, and be normally a break-before-make type.

19.20.2.6 Indicators shall be LED type where possible.

19.20.3 Inductors

Power inductors shall have vacuum-impregnated windings and be rated to withstand at least twice the maximum peak-to-peak voltage expected in normal operation or industry approved equivalent.

19.20.4 Transformers

Transformers shall have vacuum-impregnated windings and have a minimum inter-winding breakdown voltage of 1,500 VDC or industry approved equivalent. Exceptions to this requirement may be granted on a case-by-case basis, upon approval by SANBAG.

19.20.5 Resistors

Resistors other than power/braking resistors shall be derated fifty percent (50%) minimum. Service proven solutions will be accepted.

19.20.6 Capacitors

Capacitors shall be rated for transients of at least twice the maximum peak voltage expected in normal operation and be applied at continuous voltages not greater than eighty percent (80%) of rated working voltages. Exceptions to this requirement may be granted on a case-by-case basis, upon approval by SANBAG. Service proven solutions will be accepted.

19.20.7 Motor Starters

19.20.7.1 Starters shall be rated for continuous duty at service indicated, shall be equipped with magnetic holding coils, and shall be capable of resetting automatically upon loss of supply voltage.

19.20.7.2 Starters shall be equipped with sufficient auxiliary contacts to comply with requirements for annunciator circuits, as indicated.

19.20.7.3 Thermal overload protection shall be provided.

19.20.7.4 Three-phase starters shall be three-pole.

19.21 ELECTRONIC COMPONENTS

19.21.1 Electronic components shall be free of storage and handling damage. Where possible, components shall be clearly and permanently labeled with values or type identification.

19.21.2 Semiconductor devices shall be available from 2 or more qualified manufacturers. Exceptions to this requirement may be granted on a case-by-case basis, upon approval by SANBAG. Service proven solutions will be accepted.

19.21.3 Components as applied in their circuits shall be derated by at least twenty-five percent (25%) from manufacturer's ratings. Service proven solutions will be accepted.

19.21.4 For power semiconductors, derating of current shall be such that the manufacturer's maximum junction temperature is not exceeded with twenty-five percent (25%) increase in semiconductor current above that required for performance. Service proven solutions will be accepted.

19.21.5 Printed Circuit Boards

19.21.5.1 Printed circuit boards (PCBs) shall be of glass epoxy construction, complying with NEMA LI1, grade FR-4, or equivalent standard such as IEC 249. Service proven solutions will be accepted.

19.21.5.2 PCBs shall be uniformly coated.

19.21.5.3 Conductor materials shall be determined on the basis of current carrying capacity and in accordance with IEC 326-3. Service proven solutions will be accepted.

19.21.5.4 Edge connectors and boards shall be keyed to prevent insertion of any board in the wrong position, and mounted for ease of board removal and replacement.

19.21.5.5 To the greatest extent practicable, component labeling shall be provided on PCBs.

19.21.6 Semiconductor/Integrated Circuits Requirements

19.21.6.1 The Contractor shall be responsible for ensuring that all electrical and electronic circuitry, including those of Suppliers and Subcontractors, at a minimum meet the criteria for the use of semiconductors and/or integrated circuits listed in this section, unless otherwise approved by SANBAG.

19.21.6.2 Suppression devices shall be provided to protect the devices and limit the circuit voltage.

19.21.6.3 Non-JEDEC registered devices that carry more than 100 amps may be used with prior approval by SANBAG, based on submission of complete procurement specifications defining each such device and evidence of availability from 2 or more manufacturers.

19.21.6.4 All semiconductor/integrated circuits shall be rated to properly perform in the range of –40 to +185 °F (–40 to +85 °C). Service proven solutions will be accepted.

19.21.6.5 Transistors and other solid-state power devices operated from nominal battery supply shall have minimum breakdown ratings of 4 times the maximum circuit voltage. Suppression devices shall be provided to protect the devices and limit the circuit voltage. Service proven solutions will be accepted.

19.21.6.6 All integrated circuits shall be screened for Defects including an industry typical burn-in phase.

19.22 MICROPROCESSOR-BASED SYSTEM REQUIREMENTS

19.22.1 Microprocessor-based components, assemblies, and power supplies shall be provided with voltage/current regulation and protection to ensure proper operation. Service proven solutions will be accepted.

19.22.2 All interfacing wiring shall be protected against interference from other on-car or wayside electrical radiation.

19.22.3 The microprocessor shall be of a family shown to be suitable for the rugged environmental conditions encountered in rail applications, and shall be supported by software development language and diagnostic programs that are acceptable to SANBAG.

19.22.4 The microprocessor assembly shall be housed in an enclosure that shields the microprocessor assembly and the surrounding circuits from EMI radiation and interference.

19.22.5 The microprocessor shall have external buffers provided, and shall be protected from external voltage and current transients and EMI. Service proven solutions will be accepted.

19.23 FLAMMABILITY, SMOKE EMISSION AND TOXICITY

19.23.1 Materials used in the vehicle shall comply with the flammability, smoke emission, toxic gas, and fire retardation requirements specified in Table 19-8.

19.23.2 Materials used in the vehicles shall be zero halogen in addition to meeting the low-smoke requirements specified below. Deviations from this requirement shall be subject to approval by SANBAG.

19.23.3 At a minimum, all materials used in the construction of the vehicle shall meet the requirements of the 49 CFR Appendix B to Part 238-Test Methods and Performance Criteria for the Flammability and Smoke Emission Characteristics of Materials Used in Passenger Cars and Locomotive Cabs (Edition 10-1-12).

19.23.4 Should a conflict exist between the federal requirements and requirements listed elsewhere in these technical provisions, the more restrictive shall govern.

19.23.5 The Contractor shall furnish a list of materials as specified by 49 CFR Appendix B. The Contractor shall submit laboratory test results for each test, including a technical data sheet, for approval by SANBAG **[CDRL 19-28]**.

19.23.6 Test report documentation shall identify the tested material by the same description that appears on the technical data sheet and other related references. This documentation must be directly traceable to the applicable Contractor drawings without ambiguity.

19.23.7 Copies of prior test results showing that proposed materials have complied with the specified standards and tests may be submitted for approval. Assurance may be required that the material presently being considered for use is the same composition as that previously tested.

Table 19-8 Flammability and Smoke Emission

Function of Material (see comments)	Test Procedure	Performance Criteria
All vehicle materials and components except as otherwise noted. (Wall Panels, Ceiling Panels, Partition Panels, Windscreens, Fiberglass, Plastics, Diaphragms, Non-sealing Elastomers, etc.) (1, 2, 9, 12)	ASTM E 162 ASTM E 662	$I_s \leq 35$ $D_s (1.5) \leq 100$, $D_s (4.0) \leq 200$
HVAC Ducting (1, 2)	ASTM E 162 ASTM E 662	$I_s \leq 35$ $D_s (4.0) \leq 100$
Lighting Diffusers / Plastic Glazing (2, 14)	ASTM E 162 ASTM E 662	$I_s \leq 100$ $D_s (1.5) \leq 100$, $D_s (4.0) \leq 200$
Thermal and Acoustical Insulation (1, 2)	ASTM E 162 ASTM E 662	$I_s \leq 25$ $D_s (4.0) \leq 100$
Flexible Cellular Foams used in armrests and seat padding (1, 2, 4, 6)	ASTM D 3675 ASTM E 662	$I_s \leq 25$ $D_s (1.5) \leq 100$, $D_s (4.0) \leq 175$
Elastomers – Other gaskets or seals (1, 2, 10, 11)	ASTM C 1166 ASTM E 662	4.0 inches (100 mm), maximum flame propagation (15) $D_s (1.5) \leq 100$, $D_s (4.0) \leq 200$
Structural – Floor, Roof (15, 16, 17)	ASTM E 119	Pass (15 minutes minimum endurance at AW3 loading)
Floor Covering (12, 13)	ASTM E 648 ASTM E 662	CRF ≥ 5 kW/m^2 $D_s (1.5) \leq 100$, $D_s (4.0) \leq 200$
Seat Cushion, Mattresses (1, 2, 3, 4, 5, 6, 7, 8)	ASTM D 3675 ASTM E 662	$I_s \leq 25$ $D_s (1.5) \leq 100$, $D_s (4.0) \leq 175$

Function of Material (see comments)	Test Procedure	Performance Criteria
Seat Frame, Seat Shroud (1, 2)	ASTM E 162 ASTM E 662	$I_s \leq 35$ D_s (1.5) ≤ 100, D_s (4.0) ≤ 200
Upholstery (1, 2, 3, 6, 7, 8)	FAR 25.853 (Appendix F, vertical, textiles) ASTM E 662	Flame Time ≤ 10 seconds Burn Length ≤ 150 mm, (6"). D_s (4.0) ≤ 200

Notes:

Numbered notes are based on 49 CFR Appendix B to Part 238. These comments have been either quoted, combined from both, or adapted/edited to passenger transit applications.

1) Materials tested for surface flammability shall not exhibit any flaming, running, or dripping unless an appropriate fire hazard analysis is conducted and approved by SANBAG.

2) The ASTM E 662-97 maximum test limits for smoke emission (specific optical density) shall be measured in both the flaming or non-flaming mode; values shall be provided for both cases.

3) Testing of a complete seat assembly (including cushions, fabric layers, upholstery) according to ASTM E 1537 using the pass/fail criteria of California Technical Bulletin 133, and testing of a complete mattress assembly (including foam and ticking) according to ASTM E 1590 using the pass/fail criteria of California Technical Bulletin 129, shall be permitted in lieu of the test methods prescribed herein, provided the assembly component units remain unchanged or new (replacement) assembly components possess equivalent fire performance properties to the original components tested. Testing shall be at 50 kW/m^2 applied heat flux with a retainer frame. A fire hazard analysis must also be conducted that considers the operating environment within which the seat or mattress assembly will be used in relation to the risk of vandalism, puncture, cutting, or other acts that may expose the individual components of the assemblies to an ignition source. The requirements of Notes 5, 6, 7, and 8 shall be met.

4) Testing is performed without upholstery.

5) The surface flammability and smoke emission characteristics shall be demonstrated to be permanent after dynamic testing according to ASTM D 3574, Test I 2 (Dynamic Fatigue Test by the Roller Shear at Constant Force) or Test I 3 (Dynamic Fatigue Test by Constant Force Pounding) both using Procedure B, except that the test samples shall be a minimum of 6 inches (154 mm) by 18 inches (457 mm) by the thickness of the material in its end use configuration, or multiples thereof. If Test I 3 is used, the size of the indentor described in paragraph 96.2 shall be modified to accommodate the specified test specimen.

6) The surface flammability and smoke emission characteristics shall be demonstrated to be permanent by washing, if appropriate, according to FED-STD-191a Textile Test Method 5830.

7) The surface flammability and smoke emission characteristics shall be demonstrated to be permanent by dry-cleaning, if appropriate, according to ASTM D 2724-87.

8) Materials that cannot be washed or dry-cleaned shall be so labeled and shall meet the applicable performance criteria after being cleaned as recommended by the manufacturer.

9) As a minimum, all combustible materials used anywhere in the vehicle (see Note 10) are required to be tested including interior cab components as well as exterior components. Combustible signage shall not be required to meet flame spread or smoke emission requirements if (a) the actual thickness of the signage is no greater than 0.060 inch (1.5 mm); (b) the aggregate area of combustible signage does not exceed ten percent (10%) of the wall area of the car, including windows; and (c) no single sign is larger

than 0.47 m^2 (5.0 ft^2). Items that cannot be made compliant because of other more critical engineering requirements may not be required to meet the flammability or smoke emission performance criteria specified, but still must be tested to establish the relative risk and evaluated, and waived, by SANBAG.

10) Materials used to fabricate miscellaneous, discontinuous small parts (such as knobs, rollers, fasteners, clips, grommets, and small electrical parts) that will not contribute materially to fire growth in end use configuration are exempt from flammability and smoke emission performance requirements, provided that the surface area of any individual small part is less than 16 in^2 (100 cm^2) in end use configuration and an appropriate fire hazard analysis is conducted that addresses the location and quantity of the materials used, and the vulnerability of the materials to ignition and contribution to flame spread.

11) If the surface area of any individual small part is less than 16 in^2 (100 cm^2) in end use configuration, materials used to fabricate such a part may be tested in accordance with ASTM E 1354 as an alternative to both (a) the ASTM E 162 flammability test procedure, or the appropriate flammability test procedure otherwise specified in the table, and (b) the ASTM E 662 smoke generation test procedure. Testing shall be at 50 kW/m applied heat flux with a retainer frame. Materials tested in accordance with ASTM E 1354 shall meet the following performance criteria: average heat release rate over a 180 second period less than or equal to 100 kW/m^2, and average specific extinction area (in ft^2) less than or equal to 500 m^2/kg over the same 180-sec period.

12) Carpeting used as a wall or ceiling covering shall be tested according to ASTM E 162 and ASTM E 662 and meet the respective criteria of I s less than or equal to 35 and D s (1.5) less than or equal to 100 and D s (4.0) less than or equal to 200. Notes 1 and 2 apply.

13) Floor covering shall be tested with padding in accordance with ASTM E 648, if the padding is used in the actual installation.

14) For double window glazing, only the interior glazing is required to meet the requirements specified herein. (The exterior glazing is not required to meet these requirements.)

15) Penetrations (ducts, access openings, etc.) shall be designed so as not to act as passageways for fire and smoke, and representative penetrations shall be included as part of test assemblies.

16) A structural flooring assembly separating the interior of a vehicle from its undercarriage shall meet the performance criteria during a nominal test period as determined by SANBAG. The nominal test period must be twice the maximum expected time period under normal circumstances for a vehicle to stop completely and safely from its maximum operating speed, plus the time necessary to evacuate all the vehicle's occupants to a safe area. The nominal test period must not be less than 15 minutes. Only one specimen need be tested. A proportional reduction may be made in the dimensions of the specimen provided it serves to truly test the ability of the structural flooring assembly to perform as a barrier against under-vehicle fires. The fire resistance period required shall be consistent with the safe evacuation of a full load of passengers from the vehicle under worst-case conditions.

17) Portions of the vehicle body that separate major ignition sources, energy sources, or sources of fuel-load from vehicle interiors, shall have sufficient fire endurance as determined by a fire hazard analysis acceptable to SANBAG that addresses the location and quantity of the materials used, as well as vulnerability of the materials to ignition, flame spread, and smoke generation. These portions include Equipment carrying portions of a vehicle's roof, and the interior structure separating the levels of a bi-level car, but do not include a flooring assembly subject to Note 16.

19.24 DELIVERABLES

Contract deliverables required by this section of the technical provisions are summarized below:

CDRL 19-1	Commercial Material; Specifications and Description of Material Composition (TP 19.2.7)
CDRL 19-2	Specification Equivalency/Benefit Data for any Substitution to a Cited Standard (TP 19.2.8)
CDRL 19-3	Material Safety Data Sheets for All Chemical Materials Used in Vehicle Construction (TP 19.2.10)
CDRL 19-4	Material Matrix Including Copies of Technical Data & Specification Sheets, Test Reports, and Material Certifications (TP 19.2.11)
CDRL 19-5	Joining and Fastening Data, Standards, and Specifications (TP 19.2.12)
CDRL 19-6	Elastomer Properties and Specifications (TP 19.6.1.5)
CDRL 19-7	Neoprene Foam Physical and Performance Characteristics (TP 19.6.2.1)
CDRL 19-8	Certificates for Reinforced Plastic Materials (TP 19.6.3.11)
CDRL 19-9	Test Reports to Verify Glazing Material Compliance (TP 19.6.5)
CDRL 19-10	Floor Covering Samples (TP 19.6.6.7)
CDRL 19-11	Fastener Material and Usage (TP 19.8.3.7)
CDRL 19-12	Demonstration of AWS Welding Compliance (TP 19.8.13.2)
CDRL 19-13	Welding Specifications, Procedures, and Certifications of Personnel Performing These Operations (TP 19.8.13.6)
CDRL 19-14	Brazing Specifications, Procedures, and Certifications of Personnel Performing These Operations (TP 19.8.14.3)
CDRL 19-15	Soldering Specifications, Procedures, and Certifications of Personnel Performing These Operations (TP 19.8.15)
CDRL 19-16	Piping, Tubing, and Pressure Vessel Data (TP 19.9.5)
CDRL 19-17	Piping Flushing and Cleaning Procedures (TP 19.9.6.7)
CDRL 19-18	Bearing Data for All Recommended Bearings and Bushings (TP 19.10.8)
CDRL 19-19	Lubricant Data for All Recommended Bearings and Bushings (TP 19.10.9)
CDRL 19-20	Corrosion-Resistance Procedures/Processes (TP 19.11.5)
CDRL 19-21	Dissimilar Metal Corrosion Protection Plan (TP 19.11.6.7)
CDRL 19-22	Data on Paints, Primers, and Application Processes/Procedures (TP 19.12.4.1)
CDRL 19-23	List and Properties of Adhesives (TP 19.13.1)
CDRL 19-24	Thermal and Acoustical Insulation Data and Application Process (TP 19.15.4)
CDRL 19-25	Samples, and Specifications, of Each Size and Type of Wire and Cable (TP 19.17.1.4)
CDRL 19-26	Wire Numbering Plan (TP 19.17.15.3)
CDRL 19-27	Deleted
CDRL 19-28	Combustible Material Matrix and Supporting Test Results for All Combustible Materials (TP 19.23.5)

END OF SECTION

20.0 MANAGEMENT PLAN AND SYSTEM ASSURANCE

20.1 CITED REFERENCES

ANSI/ASQC Z1.9	Sampling Procedures and Tables for Inspection by Variables for Percent Nonconforming
CFR 49, Parts 27, 37 and 38	Transportation for Individuals with Disabilities
CFR 49, Parts 200 to 399	Chapter II - Federal Railroad Administration
DOT-FTA-MA-90-5006-02-01	Handbook for Transit Safety and Security Certification
ISO 9001	Quality Systems – Model for Quality Assurance in Design, Development, Production, Installation and Servicing
MIL-STD-105	Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-882	System Safety Program Requirements
NFPA 130	Standard for Fixed Guideway Transit Systems
MIL-STD-45662	Calibration Systems Requirements

20.2 SYSTEM ASSURANCE STANDARDS

The Contractor is required to provide a vehicle that is safe, reliable, and readily maintainable. The detailed requirements as identified within this section provide processes and metrics designed to provide evaluation of the vehicle.

20.3 SYSTEM ASSURANCE PROGRAM PLAN

20.3.1 The Contractor shall develop and implement a Systems Assurance Program Plan **[CDRL 20-1]** that describes the organization and process by which the Contractor will integrate and control systems assurance activities. The system assurance program shall be maintained through the duration of the Contract and all warranty periods.

20.3.2 The elements of the Contractor's systems assurance program shall be imposed on all entities within the Contractor's organization. The Contractor shall assure conformance with the system assurance program requirements of all such entities. The Contractor shall make available for SANBAG's review and inspection, all procedures, plans, manuals, and any other documentation to be used to ensure conformance. All Subcontractors shall be verified having an acceptable system assurance program in place.

20.3.3 The Systems Assurance Program Plan shall include plans for system safety, reliability, and quality assurance. These may be submitted to SANBAG by the Contractor as individual documents or compiled into a comprehensive plan. In any case, the elements of the Systems Assurance Program Plan shall be fully integrated and consistent with one another. If separate plans are submitted for safety, reliability, maintainability and quality, they shall all be considered to be CDRLs.

20.4 SAFETY AND REGULATORY REQUIREMENTS

20.4.1 SANBAG's vehicles 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 insure that all systems' safety aspects are considered for each individual system and for systems as integrated to complete the vehicle design.

20.4.2 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 these Technical Provisions, are determined to have a significant impact on passenger safety shall conform to all 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 carbody.

b. Applications which do not meet the criteria described in the previous paragraph will require conformance to all operational, performance, service, and maintenance requirements.

20.4.3 All equipment shall comply with applicable codes, standards, and regulations cited in TP 20.4.4 and elsewhere in this Technical Specification. Where conflicts exist between standards, the more restrictive, as determined by SANBAG, shall apply.

20.4.4 All equipment shall comply with applicable local, state, and federal safety rules and regulations. These include, but are not limited to, the following:

a. 49 CFR Parts 200 to 399: "Chapter II - Federal Railroad Administration." (U. S. Dept. of Transportation).
b. 49 CFR Parts 27, 37 and 38: "Transportation for Individuals with Disabilities." (U. S. Dept. of Transportation).
c. Handbook for Transit Safety and Security Certification DOT-FTA-MA-90-5006-02-01
d. Military Standard, MIL-STD-882 (1984): "System Safety Program Requirements." (U. S. Dept. of Defense).
e. .

20.4.5 Deviations from, and substitutions of, specified standards shall be made only if approved by SANBAG in advance. 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.

20.4.6 Fire and Life Safety

20.4.6.1 The entire vehicle and its components, subsystems, and systems shall comply with the requirements of 49 CFR 238 and 49 CFR 239. Measures shall be adopted to minimize injury due to fire, smoke, explosion, or panic due to fire. Measures shall be adopted to protect equipment from damage by fire or explosion. The Contractor shall submit to SANBAG for approval a Fire and Life Safety Report **[CDRL 20-2]**, documenting all design and test efforts taken to comply with the requirements of this section, 49 CFR 238 and 49 CFR 239.

20.4.6.2 The vehicle shall be designed to prevent penetration of an underfloor or roof fire to the vehicle interior. Fire stops shall be provided at floor and roof penetrations. Equipment shall, whenever practicable, be located outside of the passenger compartment. Enclosures for control and other critical equipment shall provide protection against environmental contamination and mechanical damage.

20.4.7 The Contractor shall submit to SANBAG proof that the vehicles, as designed, manufactured, tested and delivered, meet or exceed the applicable safety standards. Acceptable proof may include test procedures and related test reports, design calculation, strength and stress analyses **[CDRL 20-3]**.

20.5 HAZARD MITIGATION

The Contractor shall develop and maintain a comprehensive matrix of all hazards identified throughout the design, manufacturing and testing phase that might result in death, injury or property loss **[CDRL 20-4]**. The matrix shall describe each identified hazard and its ultimate resolution and shall identify its current status. Hazard resolution entries must be such that they can be traced back to specific drawings, procedures, analyses or reports. The Contractor shall submit updates of the matrix as part of the monthly progress report to SANBAG.

20.6 RELIABILITY PROGRAM

20.6.1 The Contractor shall develop and implement a program to ensure that the vehicle and its major systems meet or exceed the reliability requirements specified in this section. The Contractor shall be responsible for providing all measures required to meet the specified reliability requirements, including design, manufacture, installation, retrofit of the entire fleet, and all changes.

20.6.2 Failure Classification

20.6.2.1 Failures that require subsequent maintenance action shall be classified into 1 of the following 4 categories:

a. Type 1 - Failures that can be reset or bypassed from the Operator's cab and result in no loss of performance or other penalty. A maximum fault isolation and correction time of two minutes is allowed.
b. Type 2 - Failures that require the Operator to leave the cab to reset, bypass, or otherwise correct the failure, or that result in a performance reduction (such as a door cutout, loss of more than twenty-five percent (25%) of propulsion, loss of more than twenty-five percent (25%) of required braking power, loss of more than twenty-five percent (25%) of HVAC capacity). A maximum fault isolation and correction time of four minutes is allowed. Unscheduled removal from revenue service or prevention of scheduled entry into service due to a vehicle failure shall also be included in this category.
c. Type 3 - Failures that require a longer fault isolation and correction time than four minutes.
d. Type 4 - Failures that are not detected during vehicle operation, failures that occur while the vehicle is not operating, and all other failures that are not classified as Type 1, 2, or 3.

The above failures exclude any failures due to third party influence or external factors.

20.6.2.2 Type 1 and Type 2 failures that cannot be isolated and corrected within two or four minutes respectively, using the fault annunciators and facilities provided, shall be classified as Type 3 failures.

20.6.3 Reliability Demonstration

20.6.3.1 The Contractor shall conduct a reliability demonstration test to prove that the reliability requirements of TP 20.6.4 have been achieved. The formal test shall commence at the start of revenue service of the first vehicles and shall continue for a period of two years, or until the final reliability figures are achieved to the satisfaction of SANBAG. To assist in this process, the Contractor shall implement a failure review board comprising relevant personnel from the Contractor and SANBAG's organizations.

20.6.3.2 The reliability figure reported for each failure type shall be the sum total of all mileage traveled by all vehicles during a given time period, divided by the total number of each type of failure that occurred during the same time period.

20.6.3.3 The Contractor shall record the Mean Distance Between Failure (MDBF) for major systems while the vehicles are operated in revenue service on SANBAG's property. The Contractor shall document the achieved reliability in a Reliability Report **[CDRL 20-5]** and shall submit the report to demonstrate compliance with the requirements. Analyses shall be provided demonstrating resolution of all Type 1, 2, or 3 failures.

20.6.3.4 The Reliability Report shall be updated monthly until fleet Defects are corrected to the satisfaction of SANBAG.

20.6.4 Reliability Requirements

20.6.4.1 The following specifies the reliability requirements (MDBF) for the revenue fleet of SANBAG's DMUs:

Table 20.1 Reliability Requirements

Fleet Reliability	Type 1 Failure (miles/km)	Type 2 Failure (miles/km)	Type 3 Failure (miles/km)
After one month in service	2,000/3220	8,000/12,880	16,000/25,760
After 12 months in service	4,000/6,440	16,000/25,760	32,000/51,520
At end of reliability demonstration period	12,000/19,320	24,000/38,640	48,000/77,280

20.6.4.2 For the purposes of the above calculation, a chargeable failure is defined as any failure that requires repair or replacement of any vehicle subsystem or component which is not an approved consumable item, or which is an approved consumable but has not achieved its design service life. Exclusions to this definition are failures caused by:

a. Occurrence of a failure in another system or subsystem.
b. A failure by SANBAG to perform recommended preventive or service maintenance actions.
c. Collisions, vandalism, incorrect operation or abuse of equipment, or any other failure due third party actions or external factors.
d. Operating or weather conditions of unusual aspect or severity beyond those specified in TP 1.0. The term "unusual aspect or severity" shall be understood to mean a condition that does not on average occur on SANBAG right of way more often than once in 10 years. The time, place, or type of service operated by the vehicle at the time of a failure shall not be of any consequence.
e. Multiple occurrences of “no fault found” on the same vehicle. In such a case, only a single failure shall be recorded, where it can be demonstrated by the Contractor that the fault is due to a common cause.

20.6.5 Reliability Design Criteria

The Contractor shall include the following in as much is practicable in the vehicle’s design criteria to ensure maximum reliability:

a. The specific design criteria for reliability of each critical component, equipment or subsystem specified are consistent with the system element requirements.
b. Standardization and high-reliability parts are being used in critical design areas.
c. Standard and proven circuits are utilized where possible and required adjustments have been minimized.
d. Solid-state devices are used wherever possible and heat-transfer devices or designs are efficient.
e. Mechanical support structures are adequate.
f. Where possible, equipment has been designed to eliminate the need for shock mounts and the installation of vibration isolators.
g. Reliability trade-offs have been considered and employed to improve the design.
h. Redundancy has been provided where needed to meet reliability goals.

20.7 MAINTAINABILITY REQUIREMENT

20.7.1 Modular Design

a. The Contractor shall employ modular design principles to the greatest extent practicable. Components shall be packaged together, in replaceable subassemblies, according to their logical function. Dimensions and components shall be standardized to achieve flexibility in use.
b. Components or subassemblies requiring occasional removal shall preferably be plug-in units. Plug-in units shall be adequately identified, secured, and keyed to prevent misapplication.
c. Modular equipment shall include, as a minimum:
    - HVAC unit
    - Diesel engines (propulsion and auxiliary)
    - Auxiliary generator, inverter, and LVPS
    - Propulsion generator and inverter (if diesel-electric propulsion is provided)
    - Propulsion control logic unit

- Brake control unit
- Truck (complete)
- Door actuating system
- Communication and passenger information system units.

20.7.1.1 Line Replaceable Units (LRUs) and Lowest-Level Replaceable Units (LLRUs)

The Contractor shall submit a list of LRUs and LLRUs that identifies those units that can be replaced on the vehicle (LRU) and those that must be replaced in the back shop (LLRUs) **[CDRL 20-6]**.

20.7.1.2 Adjustments

The need for adjustments shall be avoided. If any adjustment points are approved by SANBAG, then they shall be readily accessible, adequately identified, and self-locking to prevent inadvertent adjustment or drift. The Contractor shall provide a list of adjustment points and initial settings in the Vehicle History Book.

20.7.1.3 Accessibility

Ready access shall be provided to all systems and components to be serviced as part of periodic preventive maintenance. Such access shall not require the removal or physical movement of components unrelated to the specific maintenance and/or repair tasks involved. The relative accessibility of components, measured in time needed to gain access, shall be inversely proportional to the frequency of maintenance and repair of the components.

20.7.1.4 Interchangeability

Assemblies or components that are functionally interchangeable shall be physically interchangeable. Assemblies or components that are not functionally interchangeable shall not be physically interchangeable.

20.7.2 Maintainability Design Criteria

The Contractor shall include the following in the vehicle's design criteria to ensure maximum maintainability:

a. Systematic fault isolation procedures shall be developed for inclusion in maintenance manuals.
b. Built-in test points shall be provided and marked.
c. Failure indicators shall be provided and identified. Color-keyed indicators shall be used wherever possible.
d. All test points, fault indicators, modules, wire junctions, pipes, tubes, and wires shall be identified by name plates, color coding, number coding, or other means.
e. Components shall be placed in equipment cabinets, enclosures, or confined places so that the most accessible positions are given to those items requiring the most frequent maintenance or adjustment.
f. Door panels and openings shall be of sufficient quantity and size, and placed in such a way, as to provide ready access from normal work areas.
g. Standard, commercially available industrial components and hardware shall be used wherever possible.
h. Captive fasteners shall be used on covers and access panels.
i. Access to structural components shall be provided to the greatest extent practicable to enable inspection for cracks and corrosion.
j. Major components shall be designed for ease of removal.
k. Means shall be provided to verify the operability of redundant or parallel hardware components and associated switching devices during maintenance, troubleshooting, and testing.

20.8 QUALITY ASSURANCE PLAN

20.8.1 Quality Assurance Program Plan

20.8.1.1 The Contractor shall submit for approval a Quality Assurance (QA) Program Plan **[CDRL 20-7]**. The QA plans shall include a company policy statement, which defines the authority and role of QA within the Contractor or Subcontractor's organization, particularly with regard to schedules and cost. The plan shall be formatted in accordance with ISO 9001, which shall be used as the guiding document for all QA activities. Subcontractor QA plans shall be approved by the Contractor and submitted to SANBAG. Subcontractors are not required to develop a project specific QA plan, but to provide their standard corporate QA plan.

20.8.1.2 The Contractor and Subcontractors shall maintain a Quality Assurance Program with established quality control functions in accordance with the approved Quality Assurance Program Plan. The Contractor shall audit Subcontractors and Suppliers per the Contractor's QA plan to ensure that they adhere to all elements of the Contractor's Quality Assurance Program Plan and Contract requirements. The QA programs will be subject to regular audits by SANBAG to ensure implementation throughout all phases of the Contract.

20.8.1.3 The Quality Assurance Program shall include an Inspection and Test Plan that provides a narrative description of the manufacturing, inspection, and testing-processes and a schedule showing major manufacturing and inspection milestones. The Inspection and Test Plan shall also include a rectifying feedback system that provides information to the Contractor's or Subcontractor's engineering and production groups. The Plan shall be updated as milestone dates or other significant items change. SANBAG's quality representative will use the Inspection and Test Plan to identify the Contractor's inspection, witness, test, and hold points.

20.8.1.4 The Quality Assurance Program shall include a system of Configuration Control and Software Management and Verification. The Contractor shall establish and implement measures to ensure that engineering procedures are well defined and designs are controlled, prepared, verified, issued, and revised in accordance with the requirements of the Quality Assurance Program. The Contractor's QA staff shall verify that each component, assembly and vehicle is manufactured and tested in accordance with the approved drawings, procedures, software, and documentation.

20.8.1.5 The Quality Assurance Program shall include a system and procedure to ensure that all measuring and test equipment is calibrated, adjusted, and maintained at prescribed intervals against certified equipment, to adhere to national or international standards.

20.8.1.6 Written procedures shall be implemented to:

a. Ensure that purchased material conforms to the requirements of purchase specifications
b. Ensure that items are handled, stored, and shipped to prevent damage and loss
c. Prevent the use of items that do not conform to specifications
d. Control those manufacturing and production processes shown on the approved manufacturing and inspection plans.

20.8.2 Quality Assurance Program Criteria

20.8.2.1 The QA function shall be placed within the Contractor's organization in such a way that schedule and cost considerations shall have no effect on the quality of products delivered under the terms of this Contract. Any conflicts that may arise as a result of this Technical Provision shall be brought to SANBAG's attention by the Contractor's Quality Assurance representative and shall be resolved to SANBAG's satisfaction before affected items are shipped.

20.8.2.2 Management responsibility for the QA function shall be set forth in the Contractor's policy statement and organization chart and shall be independent of the production function.

20.8.3 Management Review Board and Control of Non-Conforming Material

20.8.3.1 The Contractor shall establish and implement measures to ensure that items that do not conform to specified requirements are controlled to prevent inadvertent installation or use. The control measures shall contain procedures for identification, documentation, segregation, and disposition of non-conforming materials, and for notifying the affected organizations (e.g., Subcontractors or engineering). Non-conforming material shall be tagged or otherwise marked and segregated in a designated holding area, pending disposition.

20.8.3.2 The Contractor shall establish a written Material Review Board procedure. The procedure shall define, but is not limited to, departmental responsibility, authority to determine disposition, definitions of dispositions (e.g., Rework, Repair, Use-As-Is), root-cause analysis, corrective action, preventative action, and forms. The Contractor shall submit a Material Review Board procedure for SANBAG's approval as part of the Quality Assurance Program Plan.

20.8.3.3 All non-conformances to the Quality Assurance Program Plan, drawings, specifications, procedures, or Contract requirements, as applicable, shall be documented and concerned entities shall be notified. Non-conformances shall be submitted to SANBAG and their disposition shall be to the satisfaction of SANBAG.

20.8.3.4 All Repair and Use-As-Is disposition must be approved by the Contractor's Engineering group.

20.8.3.5 All reworked material shall be inspected by the Contractor QA staff and shall either be rejected or certified as conforming. At no time shall nonconforming material be installed for rework or replacement at a later time. Approval from SANBAG shall be required before nonconforming material is redirected into the production flow.

20.8.3.6 For nonconforming materials, reports shall provide a description of part problems and dispositions.

20.8.4 Quality Assurance Audits

The Contractor and Subcontractors shall provide access for SANBAG to audit QA and quality control activities and determine compliance with the approved Quality Assurance Program Plan. During the initial audit of the Contractor's QA functions, SANBAG will audit the QA programs of Subcontractors.

20.9 INSPECTIONS

20.9.1 General

20.9.1.1 The Contractor shall assure inspection and verification of compliance at Contractor and Subcontractor facilities per the Contractor's QA plan. Further inspections shall take place at the Contractor's and SANBAG's facilities to identify any components, systems, or vehicles damaged during shipment.

20.9.1.2 SANBAG may make inspections of items, completed or in-progress, in conjunction with or in addition to the Contractor's inspection. This provision shall in no way eliminate or lessen the Contractor's obligation to conduct thorough inspections.

20.9.1.3 Exceptions taken to the quality of vehicle Contractor's workmanship, by either the Contractor's or SANBAG's inspection representatives, shall be posted in a manner convenient to review on the affected component or vehicle. The rejection or approval status of each exception shall be readily identifiable throughout the vehicle's manufacturing cycle and shall be kept current by the Contractor's inspection force on a routine, daily basis. All rejected work shall be corrected, re-inspected, and approved by the Contractor's and SANBAG's quality control representatives, as required, before the next phase of production begins.

20.9.2 Scheduling Inspections

20.9.2.1 The Contractor shall give 10 calendar days' notice prior to any shipment of major items from Subcontractors to enable SANBAG to conduct source inspections of the items. The Contractor shall not schedule more than 2 vendor inspections on the same date without prior approval by SANBAG.

20.9.2.2 Within 5 days after receipt of such notice, SANBAG will advise the Contractor as to whether SANBAG's representative will inspect the shipment.

20.9.2.3 Inspections shall not be scheduled for Saturdays, Sundays, or holidays observed by SANBAG, except that specific tests or inspections may be permitted by prior approval from SANBAG. Failure by the Contractor to recognize this restriction will be reason to reject the equipment involved. Inspections must then be rescheduled at SANBAG's convenience for normal daytime shifts

20.9.3 Contractor Provisions for SANBAG's Inspections

20.9.3.1 The Contractor shall provide adequate office facilities and equipment for use by SANBAG inspectors, comparable to Contractor's employees. The office space shall be equipped with desks, outside and interplant telephones, an additional telephone line for a PC modem, file cabinets, and chairs. Security measures and area protection equivalent to that used by the Contractor for the Contractor's facilities shall be provided for SANBAG's facilities and equipment at the Contractor's site.

20.9.3.2 Copies of all drawings, diagrams, schedules, changes, deviations, and data shall be furnished for use by SANBAG's inspectors. Data shall be adequate to enable SANBAG to verify design, construction, assembly, installation, workmanship, clearance, tolerance, and functioning of the vehicles.

20.9.4 Inspections by SANBAG

20.9.4.1 SANBAG reserves the right, to perform inspections and tests at the place of the manufacture, the shipping point, or the destination, to verify conformance to the applicable requirements, subject to the provisions outlined in GC 4.1 and GC 4.2.

20.9.4.2 SANBAG reserves the right to inspect and test all materials and each part or detail of the components, assemblies, or vehicle. Upon request from SANBAG, the Contractor shall provide information and permit access to all parts of the work. The Contractor acknowledges and agrees that any additional inspection or testing of the materials, part or detail of the components, assemblies, or vehicle as deemed necessary or advisable by SANBAG may be done by SANBAG.

20.9.4.3 SANBAG may, at any time, reject any material, component, assembly or vehicle for failure to comply with the applicable requirements, whether or not previous reviews, inspections, tests or approvals were conducted by SANBAG.

20.9.4.4 In the event that the Inspection and Test Plan shows a specific inspection or approval to be conducted by SANBAG's representative, or if SANBAG requests the right to conduct a specific inspection or approval, the Contractor shall not proceed with any work that would preclude SANBAG from making such inspection or approval until SANBAG has made the inspection or approval or has provided a written waiver of its right to inspect or approve.

20.9.4.5 SANBAG shall at all times have access to the work whether it is in preparation or in progress. The Contractor shall provide proper technical support, drawings, specifications, tools, and proper facilities for such access for inspection and testing.

20.9.5 Contractor Inspections

20.9.5.1 To affect the control of the quality of the work by means of inspection, the Contractor shall establish procedures for source inspection, receiving inspection, in-process inspection, and final inspection.

20.9.5.2 The Contractor shall maintain a system to track inspections of all components, materials, assemblies, and vehicles. The system shall identify the status of any such item to indicate acceptance, rejection, disposition, or pending inspection. The system shall be capable of identifying the present inspection status of any vehicle.

20.9.5.3 Inspection stations or hold points shall be at the best locations to inspect or test components, assemblies, or vehicles before they are concealed by subsequent fabrication or assembly operations. These shall, as a minimum, include, major carbody sub assemblies, structural carbody assembly, pre-paint inspection, paint inspection, water test, underframe equipment installation, roof equipment installation, interior equipment installation, cable and wiring installation, interior panel installation, pre-test inspection, test, after-test inspection and final inspection.

20.9.5.4 Sampling procedures to determine acceptable quality levels (AQL) and average outgoing quality levels (AOQL) shall be performed.

20.9.5.5 The Contractor shall specify one hundred percent (100%) inspection, or sampling inspection, for discrete items of work. If sampling plans are proposed, the Contractor shall submit complete details of the plans to SANBAG as part of the Quality Assurance Program Plan.

20.9.6 Statistical Quality Control

20.9.6.1 Statistical quality control (SQC) methods may be used on a case-by-case basis to accept parts and materials and to evaluate processes. Such methods shall be performed under MIL-STD-105 guidelines, and results shall be documented.

20.9.6.2 The Contractor shall submit to SANBAG for approval a list of parts and material to be inspected by SQC **[CDRL 20-8]**.

20.9.7 First Article Inspections

20.9.7.1 The Contractor shall develop a First Article Inspection (FAI) Procedure to ensure compliance and control of FAIs with respect to the Quality Assurance Program Plan. The Procedure should include a system to monitor the status of each FAI and a feedback system to address noted exceptions or issues. The Procedure is to be submitted to SANBAG for review and approval.

20.9.7.2 An FAI shall be performed jointly by SANBAG and the Contractor on all major components and equipment, including the first complete vehicle. The Contractor shall develop an FAI list that identifies the major components, assemblies and sub systems and their respective manufacturer or Supplier. The FAI list shall be approved by the Contractor's Quality and Engineering groups and submitted to SANBAG for review and approval.

20.9.7.3 The FAI shall establish the baseline configuration of the as-built configuration and the as-designed configuration. Any changes after FAI approval that affect form, fit, function, interchangeability, maintainability, reliability, or safety must be submitted to and approved by SANBAG before the change can take effect.

20.9.7.4 Equipment or assemblies as agreed per 20.9.7.1 shall be shipped from the point of manufacture or proceed in the Contractor's production line only after an FAI has been offered and has either been passed or waived by SANBAG. The Contractor shall provide in writing a minimum of 15 working days' notice to SANBAG before performing any FAI, whether it is internal or external.

20.9.7.5 At least 10 working days prior to each FAI, the Contractor shall submit a data package that includes the latest drawings, test procedures, specifications, and quality documentation required for adequate checkout of the equipment under inspection; and a controlled list of drawings **[CDRL 20-9]**. The list of drawings shall be identified by revision and shall be complete to the LLRU.

20.9.7.6 The Contractor shall perform pre-FAIs as needed to ensure that a Subcontractor is fully prepared for a formal FAI. The Contractor shall not schedule more than 2 FAIs on the same day without prior approval from SANBAG.

20.9.7.7 The FAI will evaluate component and system maintainability where possible. The FAI shall establish the quality of workmanship for the balance of like components. The quality of workmanship shall be established jointly by SANBAG and the Contractor.

20.9.7.8 The FAI shall not be conducted until the design review drawings of the article have been approved by SANBAG. If conditionally approved drawings are used, SANBAG's conditions for approval shall be satisfied at the FAI and represented by the inspection article.

20.9.8 The following requirements shall also apply to each FAI:

a. A complete set of approved (or conditionally approved) drawings with SANBAG's comments shall be available for the item to be inspected.
b. A copy of the vendor's purchase order, with commercial items excluded, shall be available.
c. Completed inspection forms for in-process and final work shall be available.
d. A complete list of any deviations to the approved configuration shall be available.
e. Completed test documents shall be available.
f. The inspection article shall be displayed on a stand or table.
g. Tools and labor to take mechanical or electrical measurements shall be provided.
h. Tools and labor for disassembly and removal of covers shall be provided.
i. Testing in accordance with approved test procedures testing shall be performed.

20.9.9 Hold Point Inspection

20.9.9.1 As part of its inspection and test procedures, the Contractor shall establish hold points, as for approval in the manufacturing and testing process, to provide the most critical form of inspection and test for completed operations or installations, or for items that will be covered during succeeding assembly operations.

20.9.9.2 Nonconforming products shall not be released from a hold point area until all discrepancies have been corrected. The Contractor shall use inspection forms to record the list of discrepancies noted. The inspection forms shall be posted at or near the point of inspection for each vehicle and included with the Vehicle History Book when all discrepancies have been eliminated. SANBAG shall have the option to witness inspections and tests.

20.9.9.3 In the event that the Quality Assurance Plan shows that a specific inspection or approval is to be conducted by SANBAG, or if SANBAG requests the right to conduct a specific inspection or approval, the Contractor shall not proceed with any work that would preclude SANBAG from making such inspection or approval until SANBAG has made the inspection or approval or has provided a written waiver of its right to inspect or approve.

20.9.10 Source Inspection

20.9.10.1 The Contractor shall provide for inspection of Subcontractor components and materials at Subcontractor plants.

20.9.10.2 Once a component has been approved at FAI, the Subcontractor may begin shipment to the Contractor's facility. Source inspections shall be scheduled prior to each shipment in accordance with TP 20.9.2.

20.9.11 Receiving Inspection

20.9.11.1 The Contractor shall provide for the inspection of all incoming materials. The Contractor shall establish a receiving inspection procedure that shall specify the type of inspection employed for each item, either, sampling, statistical, or one hundred percent (100%).

20.9.11.2 The Contractor shall retain all material certifications and test reports used as a basis for accepting materials.

20.9.11.3 The materials that have been inspected, tested, and approved shall be identified as acceptable to the point of use in the manufacturing or assembly process.

20.9.12 In-process Inspections

20.9.12.1 The Contractor shall perform in-process inspections to monitor the effectiveness of manufacturing and assembly control processes.

20.9.12.2 The Contractor shall perform in-process inspections in accordance with procedures and checklists approved by its QA group.

20.9.12.3 The Contractor shall maintain and enforce a system for identifying the progressive inspection status of materials, components, assemblies, sub-assemblies, and vehicle so that the inspection status is known and can be readily identified throughout manufacturing and testing.

20.9.13 Final Inspections

20.9.13.1 The Contractor shall schedule 1 day for SANBAG's inspection of each vehicle before each shipment. Before SANBAG's inspection, the Contractor shall perform final inspection in conformance with written procedures. Workmanship items covered by prior inspection reports shall be corrected before final inspection begins.

20.9.13.2 The Contractor shall provide a qualified supervisor to accompany SANBAG during final inspection to ensure that proper corrective action is taken. The Contractor shall provide labor and appropriate tools to remove or open and reapply covers and doors. All systems shall be operational during final inspection.

20.9.13.3 The Contractor shall provide to SANBAG for review, prior to inspection, all documentation of inspection, test results, deviations, configuration control, list of open engineering changes, and Vehicle History Book documentation.

20.9.13.4 If, in the judgment of SANBAG's inspector, the vehicle is complete, passes all inspection criteria, and complies with other agreed-upon conditions for shipment, SANBAG inspector shall issue the Contractor a "Certificate of In-Plant Inspection and Release for Shipment". The Contractor shall not ship any vehicle without first having received such a certificate.

20.9.14 Retrofit Inspection

20.9.14.1 The Contractor shall provide a written procedure for tracking and inspecting retrofits or changes made to vehicles on SANBAG's property. When the Contractor makes a retrofit or change, it shall be applied to the entire fleet.

20.9.14.2 The Contractor's Quality Control representative shall verify and document completion status of changes. Completed changes and retrofits shall be one hundred percent (100%) inspected by the Contractor's Quality Control representative. Records of completed changes and retrofits and associated inspections shall be made available to SANBAG.

20.9.15 Inspection by SANBAG

20.9.15.1 All inspections by SANBAG's representative shall be conducted in accordance with the provisions outlined in GC 4.1 and GC 4.2.

20.9.15.2 Deleted

20.9.15.3 At each primary work location to which SANBAG assigns a representative, the Contractor shall provide SANBAG and its consultants with access to a reasonably approved by SANBAG office space.

20.9.16 Authority of SANBAG's Inspector

SANBAG's inspectors shall have authority to inspect any and all work done and materials furnished. Such inspection may extend to all or any part of the work and to the preparation, fabrication, or manufacture of the materials to be used. The inspector will not be authorized to alter or waive the provisions of the Contract. The inspector will not be authorized to issue instructions contrary to the Technical Specification or to act as foreman for the Contractor; however, he or she shall have the authority to reject work or materials until a question at issue can be referred to and decided by SANBAG's Project Manager.

20.9.17 Notice of Inspections and Tests; Removal of Work

20.9.17.1 At all times before Final Acceptance of the Work, the Contractor shall remove or uncover such portions of the finished construction work as directed by SANBAG for the purpose of inspection and/or testing by SANBAG. After examination by SANBAG, the Contractor shall restore the work to the standard required by these Technical Provisions. If the work exposed or examined is not in conformance with the requirements of these Technical Provisions, then the cost of uncovering, removing and restoring the work and of recovery of any delay to any critical path occasioned thereby shall be at the Contractor's expense. If work exposed or examined under this section is in conformance with the requirements of these Technical Provisions, then any delay in any critical path from uncovering, removing, and restoring work shall be considered a delay caused by SANBAG, and the Contractor shall be entitled to a Change Order for the cost of such efforts and recovery of any delay to any critical path occasioned thereby.

20.9.17.2 Deleted

20.9.18 Verification Tests

Subject to mutual agreement between the Contractor and SANBAG, the Contractor shall perform such tests as SANBAG may require verification that corrective actions—including redesign, repairs, and replacements—comply with the requirements of the Contract. All costs associated with such corrective actions and testing, including the removal, replacement, and reinstitution of equipment and materials necessary to gain access, shall be borne by the Contractor.

20.9.19 Plant Inspection

20.9.19.1 SANBAG may undertake the inspection of materials at the source. Manufacturing plants may be inspected periodically for compliance with specified manufacturing methods. Material samples may be obtained for laboratory testing for compliance with materials quality requirements. This may be the basis for acceptance of manufactured lots as to quality.

20.9.19.2 In the event that a plant inspection is undertaken, the following conditions shall be met:

a. SANBAG shall have the cooperation and assistance of the Contractor and the producer with whom it contracted for the provision of materials and equipment.
b. SANBAG shall have full entry at all times to such parts of the plant as may concern the manufacture or production of the materials being furnished. SANBAG shall have the unrestricted ability to photograph the manufacture or production of SANBAG's equipment.
c. If required by SANBAG, the Contractor shall arrange for approved office space for the use of the inspector; such space is to be located conveniently in or near the plant.
d. Adequate safety measures shall be provided and maintained.

20.9.19.3 SANBAG reserves the right to retest materials that have been tested and accepted at the source of supply after the same have been delivered, and to reject materials that, when re-tested, do not meet the requirements of these Technical Provisions. The cost of re-testing in case of rejection shall be borne by the Contractor. If work examined under this section is in conformance with the requirements of these Technical Provisions, then any delay in any critical path from this additional work shall be considered a delay caused by SANBAG, and the Contractor shall be entitled to a Change Order for the cost of such efforts and recovery of any delay to any critical path occasioned thereby.

20.10 MANUFACTURING PLAN

20.10.1 The Quality Assurance Program Plan shall include a Manufacturing Plan. The Manufacturing Plan shall include a workflow block diagram showing each significant operation and the related control and hold points for inspections, examinations, and tests identified in the Quality Assurance Plan.

20.10.2 The Manufacturing Plan shall address the following:

a. Hold points, as defined in TP 20.9.9.
b. Controls to ensure that special processes, including but not limited to welding, heat treating, and nondestructive testing, are accomplished using personnel and procedures qualified in accordance with industry codes and standards or the requirements of these Technical Provisions. Certification credentials of Suppliers, manufacturers, or personnel shall be provided when requested by SANBAG.
c. The use of program effectiveness reviews and documented procedures to require evidence of corrective actions taken to preclude the recurrence of adverse quality conditions.
d. Control of all work instructions, procedures, and their revisions to ensure that manufacturing and processes are performed in accordance with this Technical Specification requirements.

20.11 CALIBRATION

20.11.1 The Contractor shall establish and implement approved control measures to ensure that tools, gauges, instruments, and other measuring and test equipment used on this Contract are calibrated in accordance with the Quality Assurance Program. The Contractor shall use MIL-STD-45662 or equivalent standard as a guide to establish the procedure and control measures. Calibration standards shall be traceable to the National Bureau of Standards or the equivalent. Each device requiring certification of calibration shall bear a marking indicating current certification status and date.

20.11.2 When production fixtures, tooling masters, templates, patterns, and other devices are used as media of inspection, they shall be proved for accuracy at formally established intervals and adjusted, replaced, or repaired as required to maintain quality. The Contractor's Quality Assurance group shall ensure that accuracy and corresponding documentation are verified and maintained.

20.11.3 Evidence of compliance shall be readily available for SANBAG's inspection.

20.12 MANUFACTURING QUALITY RECORDS

20.12.1 The Contractor's Quality Assurance group shall ensure that all quality records and procedures are prepared and maintained in accordance with the Quality Assurance Program. Quality records shall include, but are not limited to:

a. Material Certification
b. Test Records
c. Results of Examination
d. Inspections
e. FAIs
f. Engineering Changes

g. Process Controls
h. Certification of Processes or Procedures
i. Certification of Personnel
j. Repair and Use-As-Is MRB Dispositions
k. Repair Procedures
l. Configuration.

20.12.2 Records shall be maintained complete and in an orderly and easily accessible manner. The records shall be stored to prevent damage or loss.

20.13 MANAGEMENT PLAN

This section defines the minimum management program that the Contractor shall maintain to provide an effective process for planning, scheduling, and controlling the Work, and for reporting on its progress.

The Contractor shall cooperate with SANBAG and its representatives and consultants in their review of the design and inspection of the construction of the Work, and other matters relating to the Work.

20.14 CONTRACT MANAGEMENT

20.14.1 The Contractor shall designate a full-time Program Manager and shall delegate to this Manager overall responsibility and authority for effectively managing the Work of the Contract. The Contractor shall ensure that organizational structures, lines of authority, and resource levels promote effective contract management.

20.14.2 The Contractor shall submit, for SANBAG's approval, a Program Management Plan **[CDRL 20-10]** that explicitly defines the Contractor's program organization, project controls, and planning and scheduling methodologies. The plan shall include:

a. An organization chart that clearly identifies the lines of authority of all departmental managers and of the following key staff for this contract:
   Program Manager
   Project Engineer
   System Integrator
   QA Manager
   Lead Engineers responsible for vehicle system design, including carshell, trucks, propulsion, brakes, communications systems, EMC, interior, exterior, and auxiliary power design
   Personnel responsible for operation/maintenance manual preparation.
b. Resumes for each of the key staff members identified above.
c. A description of the duties and responsibilities of each key staff member.
d. A resource plan for the Work from NTP through the end of the basic warranty period, showing the levels of staffing to be provided at each phase for each discipline and functional area.
e. A description of the methodology to be used to track and control program progress against the program schedule.
f. A Master Program Schedule as described in TP 20.17.

20.15 RESOURCING

20.15.1 The Contractor shall commit to the program the types and levels of resources identified in the Program Management Plan.

20.15.2 Key staff shall be clearly identified by the Contractor to SANBAG.

20.15.3 Deleted

20.15.4 The following functional positions shall be filled on a full-time basis from NTP through acceptance of the first vehicle. Assigned personnel, once approved by SANBAG, shall not be replaced unless prior approval is obtained from SANBAG.

a. Program Manager – with complete responsibility for delivering all aspects of the Work. This person will represent the Contractor and be able to make binding decisions on all aspects of the Work.
b. Project Engineer – with complete responsibility for all engineering decisions related to all parts of the Work throughout the design, production, and testing phases.
c. System Integrator – with responsibility for managing all interfaces both internal and external to the vehicle. This person will be responsible for the areas defined in TP 20.20.

20.15.5 The following minimum requirements shall be met for each of the key staff listed in Table 20-2.

Table 20-2: Experience Levels for Key Staff

Position	Experience on Rail Vehicle Projects of Similar Magnitude/Complexity (in Same Position)	Other Requirements
Program Manager	10 years	Fluent in English
Project Engineer	5 years	Engineering degree, Fluent in English
System Integrator	5 years	Engineering degree, Fluent in English
Lead engineers (per TP 20.14.2.a)	2 years	Engineering degree Fluent in English

20.16 COMMUNICATIONS

20.16.1 Maximum use shall be made of electronic communications to minimize delays (as specified in TP 20.23.1).

20.16.2 Formal communications shall be between the Contractor's Program Manager and SANBAG.

20.16.3 SANBAG reserves the right to require the Contractor to arrange and conduct special meetings or discussions with Subcontractors, with the mandatory attendance of the Contractor.

20.17 MASTER SCHEDULE

20.17.1 The Contractor shall submit for approval a Master Schedule prepared using the latest version of Primavera for Windows **[CDRL 20-11]**. The approved Master Schedule shall serve as the baseline schedule for the Work and shall be updated monthly.

20.17.1.1 For the period from NTP through acceptance of the first vehicle, the Master Schedule shall be supported by a precedence network diagram. The Master Schedule shall identify all milestones and critical interfaces and shall clearly show the critical path or paths.

20.17.1.2 For the remainder of the Work, the Contractor may provide a schedule in bar chart format.

20.17.2 The Contractor shall provide supplementary written information, sufficient to describe the methods to be used and the resource constraints applied.

20.17.3 Work shall be scheduled such that any specified intermediate milestone dates and completion dates are met, as specified in these Contract documents.

20.17.4 The Contractor shall revise and resubmit the precedence network diagram and Master Schedule when any of the following conditions occur:

- A change or delay significantly affects any specified intermediate milestone date, completion date, or the sequence of activities.
- The Contractor elects to change any sequence of activities affecting the critical path, or to change the previously approved work plan significantly.
- It is SANBAG's opinion that the status of the Work is such that the detailed network diagram and supporting analysis are no longer representative for planning and evaluation of the Work.

20.18 POST-AWARD CONFERENCE

A post-award conference shall take place no later than 20 days after NTP, at SANBAG's or the Contractor's facilities, as directed by SANBAG, to accomplish the following:

a. Introduce SANBAG's key personnel to the Contractor
b. Confirm the Contractor's management team and key staff and the scope of supply of Subcontractors
c. Establish formal channels of, and procedures for, communication (e.g., letter and meeting numbering)
d. Establish an understanding of the Contractor's project control methodology and plans for initial activities before the start of formal progress reporting
e. Confirm that the Contractor is familiar with SANBAG's intended operations and maintenance environment
f. Identify the early information needs and decisions required by the Contractor from SANBAG.

20.19 PROGRESS REVIEWS AND REPORTS

20.19.1 Progress review meetings shall be held monthly at SANBAG's headquarters or at the Contractor's facility. Additional meetings shall be held at the Contractor's or its Subcontractors' facilities as deemed necessary by SANBAG.

20.19.2 The first monthly progress review meeting will be held not more than 30 days after the post award conference (ref. TP 20.18)

20.19.3 Within five working days after the conclusion of each meeting, the Contractor shall prepare the minutes of each progress review meeting and distribute them to each participant and SANBAG for approval.

20.19.4 The Contractor shall submit to SANBAG Monthly Progress Reports that assess actual progress against planned progress **[CDRL 20-12]**. The report shall include the following information:

a. An updated Master Schedule showing progress as of the reporting date, together with an updated precedence network diagram, if required (ref. TP 20.17.4).
b. A schedule report listing all activities, elapsed and remaining durations of activities, early start and early finish dates, late start and late finish dates, predecessor and successor activities, and float.
c. A narrative report that, as a minimum, describes:
    i. Work accomplished during the reporting period
    ii. Percent of design, manufacturing, delivery, testing, and system support elements completed during the reporting period, and percent of overall work completed
    iii. Delays incurred during the reporting period, their causes and effects, and the corrective actions proposed or taken to mitigate those delays
    iv. Changes in activity duration, and reasons for those changes
    v. Changes in activity logic, and reasons for those changes.
d. Updated drawing list (ref. TP 20.22.2.1).
e. Updated vehicle weight estimate (ref. TP 20.25.3).
f. Updated Hazard Mitigation Traceability Matrix (ref. TP 20.5).

20.19.5 The Contractor shall submit to SANBAG Monthly Progress Reports at least 5 working days prior to each scheduled monthly progress review meeting.

20.19.6 The Contractor shall submit to SANBAG special reports and/or shall hold special topical reviews, as requested by SANBAG, to address special concerns or problem areas.

20.20 SYSTEM INTEGRATION

20.20.1 The Contractor shall actively employ system integration principles throughout the design, production, and testing phases of the contract, to control and coordinate interfaces among the vehicle's systems and between the vehicle and operational and maintenance requirements.

20.20.2 The System Integrator shall be a knowledgeable engineer with an understanding of the interaction of vehicle systems and parameters, and with experience in coordinating interface requirements.

20.20.3 The System Integrator shall participate in all scheduled design reviews.

20.20.4 The System Integrator shall coordinate and control system parameters and requirements.

20.21 INDUSTRIAL DESIGN

20.21.1 Industrial design principles shall be employed throughout the design and manufacturing processes. These principles shall include, as a minimum, aesthetics, human factor interfaces, passenger comfort, material choices, color schemes, and graphics.

20.21.2 Industrial design principles shall be applied to all interior and exterior equipment, paneling, covers, and attachments.

20.22 CONFIGURATION CONTROL

20.22.1 The Contractor shall submit to SANBAG for approval a Configuration Management Plan that describes the method to be used to track and control all submittals and drawings and their subsequent revisions **[CDRL 20-13]**.

20.22.2 The Contractor shall submit to SANBAG a drawing tree and list of drawings **[CDRL 20-14]**. Based on the guidelines given below, the Contractor shall indicate on this list which drawings are intended for submittal and SANBAG's approval. The list shall provide space for tracking the submittal status of each drawing.

20.22.2.1 Updates of the drawing list shall be provided with each Monthly Progress Report.

20.22.2.2 As part of the drawing tree submittal, the Contractor shall include a description of the primary drawing numbering system, including the significance of the characters.

20.22.3 For the purposes of change control, the design baseline for each system shall be established when design approval is granted at Design Review (DR). Changes after the approval that affect the design characteristics agreed to, or presented at the DR, shall be submitted for SANBAG's approval.

20.22.4 The production baseline shall be established at First Article Inspection (FAI). Changes after FAI shall be documented in the form of engineering change proposals, and shall be submitted for approval.

20.22.5 The Contractor shall maintain accurate and current configuration documentation, which shall be made available to SANBAG upon request. This documentation shall have the capability of identifying the following:

a. The composition of any part, component, subassembly, or assembly, at any level, in terms of subordinate and next-part numbers
b. Engineering changes and records of superseded configuration requirements
c. Configuration of spare parts, and any retrofit or replacement requirements.

20.22.6 Component Serialization

The Contractor shall submit a list of items to be serialized **[CDRL 20-15]**. The Contractor shall provide a completed list of serialized items for each vehicle within the Vehicle History Book (ref. TP 20.26).

20.22.7 Contractor As-Built Drawings

The Contractor shall provide SANBAG with a complete set of as-built drawings electronically, as mutually agreed upon **[CDRL 20-16]**. The files shall be compatible with the "AutoCAD®" (latest revision) file format or another mutually agreed upon format and shall not be write-protected.

20.23 SUBMITTAL REQUIREMENTS AND APPROVAL PROCESS

20.23.1 Contractor Requirements

20.23.1.1 The Contractor shall establish an electronic data transfer system to enable the Contractor to submit all deliverables (e.g., documents, letters, and drawings) to SANBAG electronically **[CDRL 20-17]**.

20.23.1.2 All documents and submittals shall be submitted in English. Unless otherwise approved, all correspondence and submittals shall be submitted electronically in searchable PDF format (or approved alternate), with a paper copy following by mail for the official record.

20.23.1.3 Drawings shall be submitted in individual packages that pertain to a single subject. Each package shall have a separate transmittal letter. The drawing package shall be complete and shall include all interface and complementary drawings, including those for lower-order assemblies, unless such drawings have been submitted previously and their revision level remains current.

20.23.1.4 Individual drawings shall be prepared for each part designed and/or manufactured by or for the Contractor.

20.23.1.5 The Contractor shall submit all documentation as required elsewhere in this contract. The Contractor shall also provide additional information or documentation related to the design and production of the vehicles if reasonably requested to do so by SANBAG. In the event that the Contractor deems specific documents to be proprietary, the Contractor must demonstrate to SANBAG's satisfaction that the documents are proprietary, and shall enter into a suitable confidentiality agreement that is mutually acceptable. For the purpose of this paragraph, confidentiality agreements related to proprietary documentation shall provide SANBAG with sufficient access to readily verify compliance with contract requirements, and shall provide the Contractor with appropriate commercial protection for sensitive information.

20.23.1.6 Electrical schematic drawings shall be drawn in accordance with IEEE standards unless approved otherwise by SANBAG.

20.23.1.7 The Contractor shall thoroughly review and approve all submittals from Subcontractors before transmitting the documentation to SANBAG.

20.23.1.8 SANBAG will consider any draft submittals to be for information only, unless the Contractor specifically requests a review by SANBAG.

20.23.2 Approval Process

20.23.2.1 Submittals requiring approval by SANBAG prior to implementation will be reviewed and classified by SANBAG as follows:

a. Approved: SANBAG concurs with the information in its submitted form. The material may be incorporated into the program. An approval shall not be construed as:
    i. Permitting any departure from the Contract
    ii. Relieving the Contractor of the responsibility for any error, including details, dimensions, materials, and calculations.

b. Approved Conditionally: SANBAG conditionally agrees with the submitted information in principle, but technical and/or contractual reason require that some details must be revised to make the information fully approved. The material must be resubmitted in revised form for approval.
c. Disapproved: SANBAG does not concur with the submitted details. SANBAG's objections must be addressed and the material must be resubmitted in revised form for approval.
d. Insufficient Information: The information provided was illegible or insufficient to enable a complete review. Details regarding missing information or legibility issues must be provided.

20.23.2.2 Submittals classified by SANBAG as "Disapproved" or "Insufficient Information" shall be considered, for the purposes of schedule progress reporting, to have not been submitted.

20.23.2.3 All technical data, test schedules, test procedures, test results, progress schedules and reports, drawing lists, drawings, samples, and other data requiring review and approval will be handled in accordance with the above Technical Provisions.

20.23.2.4 SANBAG will respond within 30 working days to any review submittal, calculated from the date of receipt of documents by SANBAG to the date a response is sent to the Contractor, provided the Contractor submits such review material in a reasonable time sequence and manageable volume. Should SANBAG not disposition a submittal within the stated timeframe, the Contractor may pursue a delay claim against SANBAG if the Contractor can demonstrate that the delay of the documentation review directly and necessarily delayed the completion of a project milestone.

20.24 DESIGN REVIEWS

20.24.1 DRs will be conducted to evaluate the progress and technical adequacy of the design and compatibility with the performance requirements of these Technical Provisions.

20.24.2 The DRs shall take place as a series of meetings; individual sessions may require several days.

20.24.3 Completion of a DR step for specific sub-systems or the entire vehicle is defined as approval by SANBAG of the corresponding meeting minutes. The DR for each subsystem must be completed before production of that subsystem may begin.

20.24.4 An agenda of the topics to be covered during each DR shall be forwarded to SANBAG no later than 15 working days before the DR **[CDRL 20-18]**.

20.24.5 DR material shall be submitted no later than fifteen working days prior to each review meeting, and shall include the drawings, technical data, analyses, calculations and other items required for the review. Note that the requirement of TP 20.23.2 takes precedence over this requirement.

20.24.6 The Contractor is encouraged to submit DR information incrementally, as part of periodic in-progress reviews, to reduce the duration and impact of the formal DR meetings. Ideally, the formal meetings should be limited to confirmation of previously reviewed and approved-in-principle submittals, and to resolution of open items.

20.24.7 Subcontractors shall attend DR meetings as directed by the Contractor and by SANBAG.

20.24.8 The schedule for periodic DRs shall be included in the Master Schedule (as specified in TP 20.17). The location of meetings for DRs shall be distributed between SANBAG's offices, Contractor facilities and, as required, Subcontractor facilities.

20.24.9 The Contractor shall prepare the minutes of each design review and distribute them to each participant and SANBAG.

20.24.9.1 Meeting minutes shall be recorded by a person whose sole job is to accurately capture the discussion.

20.24.9.2 During the meeting, draft meeting minutes shall be projected simultaneously onto a wall or screen that is easily viewable by all participants.

20.24.9.3 Draft meeting minutes will be distributed at the end of each business day to all participants for comment.

20.24.9.4 Final meeting minutes shall be transmitted to SANBAG for approval within five working days of the last day of the meeting.

20.24.10 Design Review

20.24.10.1 DRs shall be conducted incrementally when the detailed design of a system or subsystem is complete and prior to the production drawings being released to manufacturing. The level of detail presented at each DR shall be sufficient to determine that the system under review will satisfy the design requirements established in these Technical Provisions and shall confirm the exact interface relationships between that system and other equipment or facilities.

20.24.10.2 The DR shall address, as a minimum, the following topics for each system or item of equipment on the vehicle:

a. Latest revisions of the drawings and documentation submitted for the DR.
b. Assembly drawings down to the LRU level.
c. Final design calculations showing compliance with the Technical Provisions for every subsystem.
d. Description of the functions implemented in the Software.
e. Load-flow analyses, shut-down and start-up sequences and details of any required load shedding for all electrical systems.
f. Electric wiring and schematic drawings, down to the individual signal or wire level, for each electrical circuit.
g. Flow schematics for each fluid or pneumatic circuit if applicable, showing control and check valves, test points, orifices, and other circuit details.
h. Functional descriptions, drawings, and diagrams of DTE, and a list of special tools.
i. Other items identified in these Technical Provisions for DR.

20.25 WEIGHT CONTROL PROGRAM

20.25.1 The Contractor shall establish and maintain a vehicle Weight Control Program. The Program shall provide for the review and control of design efforts to ensure that the vehicle complies with the weight requirements specified in TP 2.0, Design and Performance Criteria.

20.25.2 As a minimum, the Weight Control Program shall:

a. Set design weight goals for major systems and components
b. Communicate the requirements of the Program to all Subcontractors
c. Provide for periodic review of estimated and actual weights throughout the design and production phases.

20.25.3 The Contractor shall calculate the AW0 weight for each vehicle, truck weights, axle loads, and weight imbalance, and shall indicate the relative proportions of the totals that are calculated, estimated, or actual weights. The Contractor shall submit the weight and weight distributions for approval **[CDRL 20-19]**. Weight calculations shall be updated monthly until delivery of the first vehicle, and shall be included in each Monthly Progress Report.

20.25.4 The empty (AW0) weight of the first vehicle, completed and ready for shipment, shall be confirmed by actual measurement at the point of shipment. Certified weight tickets shall be provided to SANBAG.

20.26 VEHICLE HISTORY BOOKS

20.26.1 The Contractor shall provide a Vehicle History Book for each vehicle **[CDRL 20-20]**. Each Vehicle History Book shall contain the following information:

a. List of serially numbered apparatus
b. List of adjustment points and initial settings
c. Description of modifications and completion dates of incorporation
d. List of Defects noted and the disposition of each
e. List of non-conformances
f. Provision for recording malfunctions, inspection, servicing, and major overhaul
g. Summary of each vehicle-level test
h. Axle, wheel, journal-bearing, and gear-mounting certification records
i. Record of certifications for other certifiable items
j. List of repairs
k. Copies of all acceptance test reports.

20.26.2 The Contractor shall maintain Vehicle History Books until all the vehicles are accepted and all discrepancies are resolved. Individual Vehicle History Books shall be turned over to SANBAG at vehicle acceptance. Vehicle History Books shall be provided in standard D-ring binders.

20.26.3 Documentation recording changes made during the warranty period shall be submitted for inclusion in the Vehicle History Book.

20.27 DELIVERABLES

Contract deliverables required by this section of the Technical Provisions are summarized below:

CDRL 20-1	Systems Assurance Program Plan (ref. TP 20.3.1)
CDRL 20-2	Fire and Life Safety Report (ref. TP 20.4.6.1)
CDRL 20-3	Safety Standards Compliance Documents (ref. TP 20.4.7)
CDRL 20-4	Hazard Mitigation Traceability Matrix (ref. TP 20.5)
CDRL 20-5	Reliability report (ref. TP 20.6.3.3)
CDRL 20-6	List of LRUs and LLRUs (ref TP 20.7.1.1)
CDRL 20-7	Quality Assurance Program Plan (ref. TP 20.8.1.1)
CDRL 20-8	List of parts and material to be inspected by statistical quality control methods (ref. TP 20.9.6.2)
CDRL 20-9	FAI data package for each article to be inspected (ref. TP 20.9.7.5).
CDRL 20-10	Program Management Plan (ref. TP 20.14.2)
CDRL 20-11	Master Schedule (ref. TP 20.17.1)
CDRL 20-12	Monthly Progress Reports (ref. TP 20.19.4)
CDRL 20-13	Configuration Management Plan (ref. TP 20.22.1)
CDRL 20-14	Drawing tree and list of drawings (ref. TP 20.22.2)
CDRL 20-15	List of items to be serialized and serialization method to be used (ref. TP 20.22.6)
CDRL 20-16	As-built drawings (ref. TP 20.22.7)
CDRL 20-17	Electronic data transfer system (ref. TP 20.23.1.1)
CDRL 20-18	Design Review Agendas (ref. TP 20.24.4)
CDRL 20-19	Vehicle weight estimates and weight distributions (ref. TP 20.25.3)
CDRL 20-20	Vehicle History Books (ref. TP 20.26.1).

END OF SECTION

21.0 VEHICLE AND SYSTEMS TESTING

21.1 CITED REFERENCES

49 CFR Part 213	
49 CFR Part 223	Safety Glazing Standards--Locomotives, Passenger Cars and Cabooses
49 CFR Part 238	Passenger Equipment Safety Standards
ANSI/ASHRAE Standard 37	Air Flow Measurement Apparatus
APTA Standard SS-C&S-016-99	Standard for Seating in Commuter Rail Cars
ARI Standard 700	Specification for Fluorocarbon and Other Refrigerants
ASME Code	Boiler & Pressure Vessel Code
ASTM E 119	Standard Test Methods for Fire Tests of Building Construction and Materials
ASTM E165	Recommended Practice for Liquid Penetrant Inspection Method
ASTM E709	Standard Guide for Magnetic Particle Examination
FRA	Technical Criteria and Procedures for Evaluating the Crashworthiness and Occupant Protection Performance of Alternatively Designed Passenger Rail Equipment in Tier 1 Service (ETF1)
IEC 60077	Electric Equipment for Rolling Stock
IEC 60349	Rotating Electrical Machines for Rail and Road Vehicles
IEC 60623	Secondary Cells and Batteries Containing Alkaline or Other Non-acid Electrolytes - Vented Nickel-Cadmium Prismatic Rechargeable Single Cells
IEC 61133	Electric Traction Rolling Stock Test Methods for Electric and Thermal/Electric Rolling Stock on Completion of Construction and Before Entry into Service
IEEE Standard 112	Standard Test Procedure for Polyphase Induction Motors and Generators
NEMA MG 1-12.06	National Electrical Manufacturers Association (NEMA) Standard for Motors and Generators
SAE J1312	Procedure for Mapping Engine Performance - Spark Ignition and Compression Ignition Engines
SAE J1349	Engine Power Test Code—Spark Ignition and Diesel
SAE J1995	Engine Power Test Code-Spark Ignition and Compression Ignition- Gross Power Rating

21.2 GENERAL

21.2.1 All vehicles and their apparatus shall be subjected to a test program, as defined herein, to substantiate the design and performance requirements, and to determine compliance with reliability requirements specified under this Contract. Design Conformance tests will be performed according to EN 50215.

21.2.2 Inspections are defined in TP 20.0 of this Technical Specification.

21.2.3 If any of the required design conformance tests have been previously performed by the Contractor on essentially identical equipment and under conditions similar to those defined in this Contract, a copy of the test procedure and report may be submitted for SANBAG's evaluation. Alternatively, the Contractor may submit service data for essentially identical equipment and under conditions similar to those defined in this Contract as a basis of a waiver of selected test requirements. Upon review of such submittals, SANBAG may waive the actual performance of the test and accept the test results as being adequate to demonstrate compliance with the

requirements of this Contract. SANBAG will make every reasonable effort to accommodate and accept previously performed tests similar to these Contract requirements. Should submitted data not be acceptable to SANBAG, the Contractor shall complete the tests as specified, with no increase in contract cost or extension to the delivery schedule.

21.2.4 SANBAG may waive design conformance tests required by the Technical Provisions if compliance with the requirements can be demonstrated adequately by analysis. A formal waiver request shall be made for each instance, and approval will be at SANBAG's discretion.

21.2.5 All test plans, procedures, and reports shall meet the requirements of TP 21.3 and TP 21.4 and are subject to review and approval by SANBAG.

21.2.6 SANBAG will, at its option, witness all tests. At least fifteen days prior to the scheduled start of each design conformance test, the Contractor shall notify SANBAG in writing of the date, time, and location the test will be performed. SANBAG will absorb it and its designees' labor and travel expenses connected to witness testing. The Contractor shall however reimburse SANBAG for any actual travel expenses incurred by SANBAG or its designees for travel to test sites if tests are cancelled or re-scheduled within the fifteen day notification period.

21.2.7 Unless indicated otherwise, all costs associated with testing shall be borne by the Contractor. In the event of failure to meet the requirements of these Technical Provisions in any test, the Contractor shall make necessary corrections to the equipment and retest at his own expense.

21.3 TEST PROGRAM

21.3.1 The Test Program shall include all tests required to verify compliance with these Technical Provisions. In general, all specified requirements shall be subject to verification by test. Tests, by definition, include, but are not limited to: visual observation, nondestructive examination, equipment operation under extreme environmental conditions, accelerated life operation, normal and abnormal performance, and observation of normal operation and maintenance.

21.3.2 The Contractor shall submit to SANBAG, for approval, a Test Program Plan covering all tests and adjustments listed in these Technical Provisions **[CDRL 21-1]**.

21.3.3 All changes to the Plan shall be submitted in a timely manner for SANBAG's approval.

21.3.4 The Plan shall address as a minimum the requirements described below:

a. All tests, adjustments and inspections shall be identified by reference to the appropriate section numbers of these Technical Provisions as practicable.
b. A detailed schedule, in the form of a bar chart, shall be submitted to SANBAG showing the anticipated date and location of the tests. The schedule shall be updated as part of the Monthly Progress Report.
c. All Test Procedures and their identification method should be listed.
d. All Design Conformance tests shall be identified as to which tests are to be actually performed and which tests are planned to be covered by submittal for acceptance of previously obtained test results and reports.

21.3.5 The Contractor shall provide its own test facilities, equipment, and personnel. For all vehicle dynamic and system integration tests (vehicle on SANBAG alignment) the Contractor shall use the SANBAG infrastructure pursuant to SP 7.2.

21.3.6 The Contractor shall establish a test activities update and test schedule coordination system to ensure that all affected parties are informed of any pending or actual changes continually and are given the opportunity to reschedule their resources efficiently.

21.4 TEST PROCEDURES AND REPORTS

21.4.1 For each design conformance, vehicle acceptance and production conformance test, the Contractor shall submit a test procedure for SANBAG's approval. Any such test procedures shall be prepared by the manufacturer of the system or component to be tested. The Contractor shall thoroughly review any test procedure before submittal to SANBAG to ensure that testing also verifies system integration parameters **[CDRL 21-2]**.

21.4.2 Test procedures must be approved by SANBAG before the associated tests are conducted. Tests performed without an approved Test Procedure might not be recognized by SANBAG and might have to be repeated at the sole discretion of SANBAG.

21.4.3 The Contractor shall submit a written report of each design conformance, vehicle acceptance and production conformance test for SANBAG's approval **[CDRL 21-3]**.

21.5 TEST CLASSIFICATION

The tests to be performed on the vehicles and vehicle equipment supplied under this Contract are categorized as follows:

21.5.1 Design Conformance Tests

Design conformance tests also referred to as type tests, are to be conducted to demonstrate compliance with design requirements at operating and environmental design conditions and extremes. These tests shall be performed on production components, assemblies, subsystems, and vehicles, and shall be performed on the first level of assembly that will allow demonstration of design compliance. These tests are described in TP 21.6, Design Conformance Testing.

21.5.1.1 Inasmuch as it is possible, the Contractor shall provide existing test results or other data to demonstrate compliance with design requirements for service-proven equipment.

21.5.1.2 SANBAG shall reserve the right to request design conformance testing for any equipment for which design conformance cannot be clearly established through available test results or other available data.

21.5.2 Production Conformance Tests

Production conformance tests shall include all efforts necessary to demonstrate that each unit delivered operates within specified limits and is in compliance with design requirements.

Production conformance test requirements may vary from an inspection and functional demonstration for a simple component to a full system demonstration of a vehicle. These tests are routinely performed at ambient conditions unless a specific environmental or operating limit is necessary to demonstrate acceptable operation. These tests are described in TP21.7, Production Conformance Testing.

21.5.3 Vehicle Acceptance Tests

Acceptance tests shall be performed on SANBAG's property by the Contractor prior to acceptance of each vehicle to SANBAG. The Contractor's tests shall be completed prior to the start of SANBAG's burn-in testing period, described in TP21.10. The purpose of these tests is to verify that no damage has occurred during shipment and to ensure that vehicles are properly adjusted and in suitable condition for SANBAG's own testing. The acceptance tests are described in TP21.8, Vehicle Static Tests and TP21.9, Post Shipment Acceptance Tests.

21.6 DESIGN CONFORMANCE TESTING

21.6.1 General

21.6.1.1 The Contractor shall demonstrate that all components, subsystems, systems, and vehicles supplied meet the requirements of these Technical Provisions. At a minimum, the design conformance tests specified in this section shall be performed to demonstrate compliance of all components, systems and the complete vehicle with this Technical Specification. The scope of tests will be carried out according to EN 50215.

21.6.1.2 All combustible materials supplied for this vehicle shall be tested to the flammability and smoke emission requirements of TP 19.23, Material and Workmanship.

21.6.1.3 Test results for design conformance testing for prior projects may be submitted in lieu of repeating this test provided that the equipment design for that project is the same as the design proposed for the SANBAG vehicle.

21.6.2 Component Design Conformance Tests

21.6.2.1 Component qualification tests shall be conducted on production components and shall stress the components under extreme operating conditions as practicable. While stressed in this way, components shall demonstrate that they perform their intended functions without failure.

21.6.2.2 Any equipment attributes that can be tested during subsystem testing need not be tested at the component level.

21.6.2.3 Car Shell Structural Qualification Testing

21.6.2.3.1 General

a. The Contractor shall test one of the first production car shells (one of each different type used) to show that the vehicle structures comply with these Technical Provisions. The structural tests shall be conducted at an appropriately equipped facility with personnel having prior experience with such tests. The proposed facility shall be subject to SANBAG's approval.
b. The specimen shall be prepared such that all critical structural members can be viewed. The weight of underfloor and roof equipment shall be simulated by introducing equivalent loads at the corresponding locations. The test car shell shall be supported on trucks during the tests. Prior to installing the test equipment, the test specimen shall be weighed. All structural testing shall be conducted on this specimen.
c. All test equipment shall be calibrated, with calibration validity extending beyond the test completion date.
d. A data acquisition system shall be used to permanently record the test data and printouts shall be provided that allow ready and convenient review and analysis of the test results.
e. Each car shell (prior to equipment setup) shall be available to SANBAG for a period of 1 day for inspection.
f. If testing of the first production shell uncovers noncompliance in any material structural area, then a second car shell of the same type shall be tested if no corrective measures can be agreed upon. In such case, the Contractor shall be responsible for the cost of the test and for all modifications required to make this car shell and all other cars specification-compliant. The Contractor shall also reimburse SANBAG for all of its cost associated with the second and any subsequent test.

21.6.2.3.2 Crash Energy Management Design

If a CEM car shell design is proposed that does not comply with 49 CFR Part 238.203, The Contractor shall assist SANBAG in meeting the requirements of FRA's "Technical Criteria and Procedures for Evaluating the Crashworthiness and Occupant Protection Performance of Alternatively Designed Passenger Rail Equipment for Use in Tier I Service" report (ETF1) by preparing and providing the required test plans, descriptions and schedules to SANBAG in a

format ready for submittal to the FRA. The Contractor shall, on SANBAG's request, participate with qualified personnel in any subject related discussions or meeting to be held with the FRA.

The Structural Qualification Testing of a structure using a CEM design shall comply with the testing requirements described in the FRA's "Technical Criteria and Procedures for Evaluating the Crashworthiness and Occupant Protection Performance of Alternatively Designed Passenger Rail Equipment for Use in Tier I Service" report (ETF1).

21.6.2.3.3 Vertical Load Testing

a. Reserved.
b. The test car shell shall be supported on trucks and shall be loaded to have the equivalent total weight of the complete ready-to-run vehicle (AW0) minus the weight of the trucks.
c. One seat frame of each type shall be mounted in the car shell at the time the vertical load test is conducted on the car shell. To these seat frames, a load of 350 lbs. shall be applied at the midpoint of each occupant position in a vertical downward direction and it shall be shown that there is no excessive sidewall deformation.
d. Subsequently, loads equivalent to passenger loads AW2 and AW4 shall be added. The loads shall be distributed in proportion to the weight distribution of the finished vehicle.
e. The vertical deflection of the car shell shall be measured at each of the 3 load cases. The Contractor shall perform corrective action on the car structure or door elements, as required, to ensure that the doors can operate as specified. If corrective action is necessary, then the vertical load test shall be repeated in its entirety.
f. Carbody deformation testing shall be performed in accordance with EN 12663-1. There shall be no permanent deformation, fractures, cracks, or separations in the car structure.

21.6.2.3.4 Compression Load Tests

The car shell structure shall be tested according to the EN 12663-1 vehicle category II, to demonstrate compliance with the structural requirements specified in TP 3.0.

21.6.2.3.5 End Sill Load Test

The car shell structure shall be tested according to the EN 12663-1 vehicle category II, to demonstrate compliance with the structural requirements specified in TP 3.0.

21.6.2.3.6 Coupler Anchorage Test

The car shell structure shall be tested according to the EN 12663-1 vehicle category II, to demonstrate compliance with the structural requirements specified in TP 3.0 and TP 4.0.

21.6.2.3.7 Roof Load Test

The car shell structure shall be tested according to the EN 12663-1 vehicle category II, to demonstrate compliance with the structural requirements specified in TP 3.0.

21.6.2.3.8 Diagonal Jacking Testing

a. The test car shell, loaded to its AW0 weight and with all its trucks, or an equivalent weight, hanging from their mounting devices on the car structure, shall be supported symmetrically at all side sill jacking pads. The opening for the doors and selected side windows will be verified dimensionally in accordance with EN 12663-1.

21.6.2.4 Floor and Roof Structure Conformance Fire Testing

21.6.2.4.1 The Contractor shall test a representative floor structure sample, including penetrations and floor-to-wall junctions, to show compliance with the applicable requirements of TP 19.0.

21.6.2.4.2 The Contractor shall test the floor assembly in accordance with ASTM E 119 to demonstrate a 15-minute endurance rating, and to meet the following criteria:

a. The test specimen shall be a full-width vehicle section including side sills or that portion of the wall that extends below the floor, and shall completely represent the actual vehicle configuration. The specimen shall have a minimum exposed area of 100 ft^2 (9.29 m^2). If approved by SANBAG, 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 ft (3,353 mm).
b. No fewer than 2 typical penetrations, spaced at a distance from each other no greater than that that will exist in actual construction, shall be included in the test specimen. The specimen shall include typical floor splice configurations.
c. The test specimen shall be loaded to simulate AW3 passenger loading conditions. Concentration loads shall be applied to simulate underfloor equipment. The test specimen shall include at least 3 typical transverse supports.
d. The test specimen shall represent the actual construction utilized in production. This includes the floor covering, floorboards, floor structure, thermal and acoustical insulation, and floor pans.

21.6.2.4.3 The Contractor shall test the roof assembly, if required by 49 CFR, Chapter II, Part 238, Appendix B, in accordance with ASTM E 119 to demonstrate a 15-minute endurance testing. The following test criteria shall be met:

a. The test specimen shall be a full width vehicle section including the roof rail or that portion of the wall which extends below the roof rail. The specimen shall have a minimum exposed area of 100 ft^2. If approved by SANBAG, 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 typical penetrations, spaced at a distance from each other no greater than which will exist in actual construction shall be included in the test specimen. The specimen shall include typical panel joint configurations.
b. Test specimen shall represent the actual construction utilized in production. This includes the roof sheeting, thermal and acoustical insulation, air duct, and interior ceiling panels.

Conditions of acceptance for this test shall be those required for unrestrained assembly.

21.6.2.5 Structural or Weight Changes

21.6.2.5.1 Any structural changes or modifications made during construction, assembly, or testing shall be subjected to the entire test series.

21.6.2.5.2 If the unit's actual ready-to-run (AW0) weight exceeds the weight assumed for AW0 during structural testing by more than 2.5%, then the complete test series shall be repeated on one car shell using the actual AW0 weight where referenced. The re-testing shall be at the Contractor's expense. Any change in mass may also be assessed with calculations based on finite element models validated by structural testing subject to approval by SANBAG.

21.6.2.5.3 Any structural modifications resulting from testing or re-testing shall be incorporated into all vehicles manufactured before or after these tests.

21.6.2.6 Windows Qualification Testing

Vehicle end windows shall be tested in accordance with 49 CFR 223 Type I tests. Side windows and door windows shall be tested to 49 CFR 223 Type II tests. One sample of each type of window shall be tested.

21.6.2.7 Coupler System Components Qualification Testing

The coupler and draft gear system shall be tested to document compliance in performance and/or capacity. The following specific tests shall be performed in accordance with EN 16019:

a. Buff and Draft Loading Test
b. Draft Gear Deflection Test
c. Draft Gear Emergency Release Test
d. Gathering Range Test
e. Mechanical Coupling and Uncoupling Test
f. Electrical Coupling and Uncoupling Test
g. Centering Test
h. .

21.6.2.8 Truck Qualification Testing

21.6.2.8.1 One complete truck frame of each type, including the journal bearing housing, truck bolster, bearing/sliding pads and connecting elements such as traction rods shall be subjected to static and fatigue testing to demonstrate compliance with the loads in TP 11.4.3 or EN 13749.

21.6.2.8.2 The Contractor shall submit a detailed truck test procedure to SANBAG for review and approval. The test procedure shall clearly describe the following:

a. The truck configuration to be tested
b. The test equipment and the data acquisition system
c. The location and orientation of all strain gauges
d. The arrangement of the actuators, support framing and load reaction points relative to the truck
e. The input load values, load combinations, load phasing and number of cycles for each test sequence
f. A description of the calibration steps
g. A description of any periodic adjustment required during the test
h. Pass/ Fail criteria.

21.6.2.8.3 Areas of stress concentration shall be located using theoretical analysis, and an adequate number of strain gauges applied at these areas. Strain gauges shall also be positioned at known strain points and at other points at the discretion of the Contractor and SANBAG, readings shall be taken to determine that the stresses are within the design requirements. The test results shall be submitted to SANBAG.

21.6.2.8.4 A pressure test shall be performed if the truck bolster is used as part of the air suspension volume. The bolster pressure during the static test shall be the maximum possible service pressure as set by the safety valve in the compressor discharge line and, during fatigue testing, the service pressure required for a load equivalent to the truck share of full load on the carbody suspension.

21.6.2.8.5 All truck frames, including the bolster and other primary structural members, shall be qualified by radiographic inspection of all critical welds according to EN 15827 / EN 15085.

21.6.2.8.6 A fatigue test shall be performed on each type of truck frame to verify the design will meet the requirements defined in TP 11.4.3. The proposed test arrangement and table of loads and cycle frequency shall be submitted to SANBAG for review and comment. The test shall be performed according to EN 15827/EN 13749 **[CDRL 21-4]**.

21.6.2.8.7 At regular intervals during the fatigue tests, the trucks shall be visually inspected for developing cracks. A test shall be halted if evidence of crack initiation or progression is found and the Contractor shall determine the cause of such failures and propose corrective action to SANBAG. Any modifications shall be subject to SANBAG's approval. Test continuation or restart shall require SANBAG's consent.

21.6.2.8.8 A magnetic particle or dye-penetration inspection shall be performed on the truck test specimen before the test commences and immediately after the conclusion of the test. Identical inspection procedures shall be used for both inspections.

21.6.2.8.9 A load equalization test shall be performed on 1 power truck and 1 trailer truck installed on the first vehicle according to EN 14363 at AW0 load conditions, both with functional and failed secondary suspension system. For this test, 1 wheel of the truck shall be raised and then lowered according to EN 14363with respect to the plane formed by the other 3 wheels of the same truck as they rest on level track.

21.6.2.8.10 During the test, the other 3 wheel treads shall maintain contact with the rails. Additionally, with 1 wheel raised and lowered 2 inches (51 mm) with respect to the plane formed by the other 3 wheels, the neutral wheel load of the other 3 wheels shall not change by more than fifty percent (50%).

21.6.2.8.11 During the static load test, a Primary Suspension Test shall be performed to show that the primary suspension deflection and the material creep rate are within the design parameters.

21.6.2.9 Seat Qualification Testing

For each type of seat provided, at least one sample shall be tested in accordance with the seat testing requirements of APTA Standard SS-C&S-016-99.

21.6.2.10 Diesel Engine Qualification Testing

21.6.2.10.1 One diesel engine of each type, selected at random by SANBAG, shall be tested according to the procedures outlined in the latest revision of SAE J1995 standard “Engine Power Test Code – Spark Ignition and Compression Ignition – Gross Power Rating” and SAE J1349 standard “Engine Power Test Code – Spark Ignition and Diesel” to demonstrate that the engine(s) conform(s) to the gross and net power ratings published by the manufacturer and that the engine(s) is (are) sized correctly for the intended purpose.

21.6.2.10.2 The engine(s) shall be tested to determine the fuel flow rates versus the torque and power obtained at specific engine speeds and loads per the SAE J1312 standard “Procedure for Mapping Engine Performance – Spark Ignition and Compression Ignition Engines”.

21.6.2.11 Qualification Testing of Electric Motors

The first motor of each type and an additional 1 of each type be given an IEEE Standard 112 or IEC 60349 "type" test by the manufacturer, including a heat run, to demonstrate the motors' capability and power rating.

21.6.2.12 Transmission Qualification Testing

21.6.2.12.1 One transmission of each type, selected at random by SANBAG shall be subjected to qualification testing. The qualification testing shall verify the transmission efficiency and tractive effort curves (tractive effort vs. speed), and that the gear shifts are automatic and achieved without excessive interruption in tractive effort.

21.6.2.12.2 Data from the test shall be provided to verify the transmission’s durability under the range of duty cycles defined in TP 2.0. These tests may be performed in conjunction with the dynamometer testing of the assembled drive train (engine, transmission, and associated controls).

21.6.2.13 Traction Gear Unit Qualification Testing

21.6.2.13.1 The traction gear unit qualification test shall be a 100-hour test on two gear units, selected at random by SANBAG, and shall be mounted with torque load simulation. The test shall subject the unit to conditions that are in general twenty percent (20%) more severe than would occur under the most extreme operating conditions (i.e., torque is increased by twenty percent (20%) above normal operating maximum).

21.6.2.13.2 The test shall be started with the unit at room temperature 60 to 90 °F (16 to 32°C). A fan or other device may be provided so that in-service airflow conditions are simulated. The temperature rise measured in the oil sump shall not exceed the gear oil supplier's recommendations for maximum temperature consistent with the life between oil changes, as called out in the Contractor's maintenance manuals. The direction of rotation shall be reversed every 8 hours, until the 100-hour test is completed.

21.6.2.13.3 During the test, the gear units shall display no signs of exceeding the manufacturer's established limits for the oil temperature, and shall remain within the noise and vibration limits established by the manufacturer. After completion of the test, the gear units shall be disassembled and all parts examined.

21.6.2.13.4 Gear tooth mesh shall be checked and recorded before and after the test. Any sign of deterioration of any part shall be investigated jointly with SANBAG.

21.6.2.13.5 The test report shall include test records of running time, oil temperatures, and vibration and sound-level readings taken at such intervals as required to verify compliance with these Technical Provisions.

21.6.2.13.6 One gear unit shall be tested for acoustic noise, under load and at various speeds as well as sweep-through speeds. Overall noise level and pure tone noise shall be measured.

21.6.2.14 Equipment Noise Tests

Noise tests conducted on equipment prior to its installation shall be performed early in the production phase.

The test data shall be used by the Contractor to predict and mitigate, as necessary, the assembled vehicle noise emissions, to comply with the requirements of TP 2.0.

21.6.2.15 Battery Qualification Testing

One battery of each type supplied shall be tested to establish that the batteries will meet the requirements of this Technical Specification.

For each type of battery cell supplied, shall be given a capacity test at the point of manufacture in accordance with IEC 60623, Section 4.2.1.

21.6.3 System Design Conformance Testing

21.6.3.1 Major subsystems shall be assembled separate from the vehicle and shall be tested to verify compliance with these Technical Provisions. Related subsystems shall be tested together to verify compliance of the individual subsystems and to verify the design of the interface between them.

21.6.3.2 The interfaces between equipment and between subsystems are viewed as crucial aspects of the system design. To verify these interfaces, subsystem tests shall be designed to include as many system interfaces as possible.

21.6.3.3 The subsystems to be tested shall include, but are not limited to, the systems discussed under this section. The Contractor shall identify the subsystems to be tested in the Test Program Plan (as defined in TP 21.3), subject to SANBAG's approval.

21.6.3.3.1 Heating, Ventilation, and Air Conditioning (HVAC) Subsystem Qualification Testing

One complete HVAC unit shall be climate room tested by the manufacturer. A test laboratory independent from the HVAC unit manufacturer is required. The HVAC unit shall be tested according to ANSI/ASHRAE Standard 37 or equivalent industry practice. Sound and vibration levels shall be measured for all operating modes. The following tests shall be included as a minimum:

a. Scan
b. Control stability
c. Cooling capacity
d. Performance at extreme operating conditions
e. Modulation pressure switch operation verification
f. High-pressure cut-off switch function verification
g. Deleted.
h. Condensate carry-over
i. Refrigerant sample
j. Heating capacity
k. Test of protection devices operation under restricted or no-airflow conditions and over-temperature conditions
l. Watertightness
m. HVAC system startup in-rush current
n. Compressor start-up in-rush current.
o. The system maintains a positive pressure inside the vehicle

Climate chamber test reports of similar vehicles in combination with testing outside of the climatic chamber will be considered in lieu of this requirement.

21.6.3.3.2 The following HVAC subsystem tests shall also be conducted to confirm satisfactory subsystem performance:

a. Airflow
b. Induced shock and vibration
c. EMC
d. Vehicle monitoring system interface.

21.6.3.4 Auxiliary Power Supply System Qualification Testing

The first production set of auxiliary power generator, low-voltage power supply and battery charger shall be qualification tested to show proper operation as a total power-supply system. The following tests shall be performed as a minimum:

a. System output range and stability over the full range of input voltage
b. System capacity verification
c. System ability to provide start-up and in-rush power for simultaneous motor start loads (e.g. HVAC compressor motors)
d. Fault detection and annunciation
e. Heat run for worst-case loading (lowest input voltage with highest output load and highest input voltage with smallest output load)
f. Battery charging capacity and charging regulator

21.6.3.5 Propulsion System Qualification Testing

21.6.3.5.1 A comprehensive laboratory test shall be conducted either separately or as a unit with 1 engine and 1 generator of the propulsion equipment, using a dynamometer that simulates specific loads and load cycles.

21.6.3.5.2 The propulsion equipment shall be tested for acoustic noise under load and at various speeds as well as sweep-through speeds. Overall noise level and pure tone noise shall be measured for the propulsion components

21.6.3.5.3 Deleted.

21.6.3.6 Friction Brake System Qualification Test

21.6.3.6.1 The friction brake system verification and wheel or brake disc temperature test shall use a dynamometer or other approved test equipment to verify compliance with all of the Friction Brake System Qualification Test requirements.

21.6.3.6.2 The friction brake system shall be tested to verify the braking force, clamping force, time, power dissipated, and magnitude of response to all control inputs.

21.6.3.6.3 Dynamometer test runs shall be made for simulated vehicle weight AW0, AW2, and AW4 from each of the entry speeds of 10, 15, 30, 45, 60, and 79 mph (16, 24, 48, 72, 96, and 126 km/h). For each entry speed, input signals calling for 25, 50, 75, and 100% of full service braking effort and for emergency braking effort shall be used.

21.6.3.6.4 Each test shall be run starting with both cold and hot initial wheel or disc conditions.

21.6.3.6.5 Results shall be plotted to show both the instantaneous and average relationship between input signals and output braking effort over the speed and weight ranges for both motor and trailer trucks.

21.6.3.7 Brake System Capacity Qualification Test

A wheel and caliper assembly shall be tested on a dynamometer to verify the brake-system capacity with both cold and hot wheel initial conditions. The wheel and shoe surface temperature shall be measured and recorded throughout the test. At the completion of this test, the wheel and caliper assembly shall remain in an undamaged, fully operable condition. If brake components other than tread brake components are used, such components shall be subject to equivalent thermal capacity testing.

21.6.3.8 Brake System Endurance Qualification Test

A complete friction brake system including the electronic control unit shall be subjected to and shall successfully complete an endurance test of one half million cycles of normal apply and release applications. Brake reaction forces shall be simulated on the actuators.

21.6.3.9 Brake System Environmental Qualification Test

A test setup in an approved environmental laboratory shall be made to simulate the worst-case climatic conditions to be encountered during revenue service and shall include conditions of temperature and humidity fluctuations. The test schedule shall start with an overnight (8 hours minimum) soak at the minimum temperature with the power off. The equipment shall then be turned on and tested, after which the equipment shall be subjected to eight temperature and humidity cycles between minimum and maximum with each cycle to last 12 hours, including holding at the minimum and maximum temperatures for at least 1 hour each during each cycle. During environmental testing, system function, ambient temperature, and humidity shall be recorded.

Certificates for individual components stating environmental performance will be accepted in lieu of this test.

21.6.3.10 Communication System Design Conformance Test

Vehicle communication equipment, including public information system, radio interface, cab-to-cab communication and passenger emergency communication system shall be tested in a

laboratory set up simulating the equipment distribution and wiring of the actual vehicle to show compliance with the requirements of TP 13.0.

21.6.3.11 Door System Design Conformance Test

Door, door operator and door control design conformance tests shall include an accelerated life test of 1.5 million cycles for 1 complete set of door hardware.
These tests shall be completed before the first vehicle is ready for final assembly. Failures recorded during testing must correlate within specified reliability values. 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.

21.6.4 Vehicle Qualification Testing

Tests shall be conducted on the first completed unit to verify the performance of all vehicle subsystems and all interfaces between them. The Contractor shall conduct tests at the Contractor's facility to the maximum extent possible. The vehicle performance requirements to be tested shall include, but are not limited to, the requirements discussed in this section. The Contractor shall identify the performance requirements to be tested in the Test Program Plan, subject to SANBAG's approval.

21.6.4.1 Ventilation Watertightness Test

All ventilation intake devices on the vehicle shall be tested for their water exclusion properties. For this test, the associated fans shall operate at maximum speed, and water shall be sprayed for at least 5 minutes. Exterior enclosures shall be tested for water tightness at the point of manufacture.

21.6.4.2 Gangway Diaphragm Watertightness Test

The gangway diaphragm arrangement shall be tested for water tightness. As part of this test, the vehicle shall be placed on the tracks in a curve representing the smallest curve radius the vehicle will encounter on SANBAG's system.

21.6.4.3 Open

21.6.4.4 Vehicle Weight and Weight Distribution Test

The first unit shall be weighed and the weight distribution shall be determined to verify conformance with the requirements of Section TP 2.0, Design and Performance criteria.

21.6.4.5 Vehicle Dimension and Clearance Check

21.6.4.5.1 The outside dimensions shall be measured on the first unit and the static envelope shall be verified.

21.6.4.5.2 Clearances shall be verified between the carbody and truck components and between the truck and carbody components and the top of rail. These clearances shall be checked with the vehicle loaded to AW4 conditions or demonstrated by calculation.

21.6.4.5.3 Truck swing tests shall be conducted to verify the required degree of rotation (horizontally and vertically) and that cables and hoses are clear from any pinching, chafing and stretching.

21.6.4.5.4 The first two completed vehicles shall be coupled cab end to cab end and checked for proper inter-car and coupler clearance under the worst-case geometric conditions

21.6.4.6 Trainline Test

Once a sufficient number of vehicles are available, two units shall be tested to demonstrate that all trainline functions perform satisfactorily between units when they are coupled together. These tests shall include dynamic and static tests.

21.6.4.7 Door Operation Test

Before shipment to SANBAG, the first unit shall have all doors operated while loaded to AW3 conditions. Any door or door control failure occurring prior to completion of the test on each vehicle shall be corrected and the test performed a second time,

21.6.4.8 Light Intensity Test

Light intensity readings shall be taken (without light from other sources) on 1 unit to verify conformance with the requirements of TP 8.0.

21.6.4.9 Vehicle Performance Test

21.6.4.9.1 General

Vehicle running tests shall be performed on systems related to control, traction and braking on one unit. The tests shall verify the requirements of TP 2.0. This series of tests shall also be used to determine the equipment settings and calibrations to be used for the vehicle acceptance program.

Clearance tests will be conducted on SANBAG's system.

If any vehicle, under any load condition or train configuration, or any apparatus fails to satisfy the specified performance and design criteria, the vehicles, with the necessary adjustments, shall be re-tested at the Contractor's expense. If modifications are necessary, such shall be verified by appropriate retest, as determined by SANBAG, and implemented on a fleet-wide basis at the Contractor's expense.

21.6.4.9.2 FRA Requirements

The Contractor shall assist SANBAG in meeting the requirements of 49 CFR 238.111 (a) or (b) by preparing and providing the required test plans, descriptions and schedules to SANBAG in an appropriate format the parties need to agree upon submittal to the FRA. The Contractor shall, on SANBAG's request, participate with qualified personnel in any subject related discussions or meeting to be held with the FRA.

21.6.4.9.3 Instrumentation

Test instrumentation shall be selected and provided by the Contractor as necessary for the verification of all required parameters.

21.6.4.9.4 Traction Performance Tests

This series of tests shall be run at passenger loads of AW0 and AW3. Compliance with the performance requirements in TP 2.0 and TP 10.0 shall be demonstrated. (Braking shall be monitored during the traction tests.)

21.6.4.9.5 Braking Performance Tests

This series of tests shall be run at AW0and AW3. Compliance with the performance requirements in TP 2.0, TP 10.0, and TP 12.0 shall be demonstrated.

21.6.4.9.6 Thermal Capacity Tests

The first vehicle shall be instrumented and tested to verify compliance with the duty cycle requirements specified in TP 2.0, TP 10.0 and TP 12.0.

21.6.4.9.7 Wheel Spin and Slide Test

All power and braking modes shall be tested to verify compliance with TP 2.0, TP 10.0 and TP 12.0. Required data for the spin and slide test shall be monitored and recorded for each axle of the test vehicle.

21.6.4.9.8 AC APS Test

The Contractor shall operate the AC APS test to verify that the requirements of TP 2.0, TP 10.0 and TP 12.0 are met. The recordings so taken shall be available for inspection by SANBAG and shall be furnished to SANBAG by the Contractor upon delivery of vehicles for acceptance.

21.6.4.9.9 Operational Test

The first vehicle shall be given an operational test of 10 round trips through the entire SANBAG alignment before acceptance by SANBAG. The vehicle instrumentation during these tests shall be sufficient to determine that all systems are functioning properly. The test shall be conducted in simulated revenue service, with an AW2 passenger load, stopping at every station and cycling the doors. The raw data recordings shall become part of the permanent record for the vehicles and shall be turned over to SANBAG with the test report, along with any paper chart recordings that were made.

During the last 4 round trips of the test, there shall be no failures of equipment. If a failure occurs, the last 4 round trips shall be repeated following correction and documentation of the failure.

21.6.4.9.10 Parking Brake Test

A parking brake system test shall be performed on the first vehicle. Design compliance with TP 12.4 shall be demonstrated by measuring the force required to move the vehicle with the parking brake applied. The test shall be performed with bedded-in brake shoes.

21.6.4.9.11 Ride Quality Test

a. Ride quality tests shall be performed in accordance with EN 14343 on the first vehicle. The tests shall prove compliance with the ride quality requirements of TP 2.0.
b. At a minimum, ride quality tests shall consist of operating the vehicle at speeds up to 79 mph (127 km/h) over track segments selected by SANBAG, under two load conditions: AW0 and AW3.
c. Instrumentation capable of measuring the magnitude of the vertical, longitudinal, and lateral shocks and vibrations, shall be provided and monitored by the Contractor.
d. Sensing units shall be located on the vehicle floor above the intersection of the vehicle longitudinal centerline and a truck transverse centerline, at the center of the vehicle between trucks, and at 3 seat locations to be determined by SANBAG. Provision shall be made for recording vertical, lateral, and longitudinal shocks and vibrations concurrently.
e. In the event that the dynamic behavior of the vehicle does not meet the Technical Specification requirements, the Contractor and SANBAG shall arrive at an agreement to mitigate or eliminate the issue prior to the start of revenue service.

21.6.4.9.12 Noise and Vibration Test

a. After equipment installation, noise and vibration tests shall be performed on the first vehicle to confirm compliance with the requirements of TP 2.0.
b. Compliance with the Technical Specification is to be based on measurements taken in a free-field environment such as outdoors, away from any reflecting surfaces other than the ground, ties, and ballast, on track with newly ground, welded rail. All measurements shall be made with an ambient sound level in the vicinity of the test measurement locations of not less than 10 dBA below the noise produced by the equipment being measured, when evaluated using the same scale or octave band.
c. The results shall be evaluated and any corrective action required shall be approved by SANBAG. After corrective actions are implemented, the applicable tests shall be

repeated. If the corrective action is successful, they shall be implemented on all vehicles. If not successful, these steps shall be repeated until Technical Specification compliance is attained.

21.6.4.9.13 Warning Device Test

Warning devices, as mounted on a completed unit, shall be tested for compliance to the requirements of TP 5.0.

21.6.4.9.14 Vehicle Stability Qualification Test

Vehicle stability tests shall be performed on the first vehicle. The test shall demonstrate compliance with the stability requirements of 49 CFR Section 213.57 (d) for 3-inch (76.2 mm) unbalanced superelevation.

All equipment and instrumentation necessary to accurately measure tilt angle and wheel unloading shall be provided, set up, operated and monitored by the Contractor.

21.6.4.10 Electromagnetic Compatibility

An electromagnetic compatibility test shall be performed on the first vehicle by methods referenced in Section TP 2.0, Design and Performance Criteria, for compliance with those requirements.

During these tests, confirmation of appropriate emissions limits as previously developed shall be conducted by monitoring the signal and communication systems functions.

21.7 PRODUCTION CONFORMANCE TESTING

21.7.1 General

a. Functional and acceptance tests shall be performed on all major assemblies and on completed vehicles. Acceptance tests shall ensure that all aspects of the performance and manufacture are at least at the same quality level as the unit presented for first article inspection, which includes conformance to specification and cited reference requirements.
b. The specific tests to be conducted are analyzed and approved in FAI which SANBAG is welcome to attend. Copies of all factory acceptance tests or valid certificates, according to the EN 10204, shall be incorporated into the Vehicle History Books.
c. All qualification tests shall be completed before the first vehicles are shipped to SANBAG. Tests shall be conducted in accordance with approved test procedures. Acceptance testing procedures shall be updated based on experience gained from testing or vehicle operation.
d. Test procedures shall be expanded to focus on areas that prove to be troublesome. Tests may also be simplified in areas where a high degree of confidence is developed. The tests to be performed shall include, but not be limited to, those tests discussed in this section.

21.7.2 Electrical Apparatus Testing

Each component that is separately assembled, housed, and wired into a packaged unit prior to installation in the vehicle shall be tested at its point of manufacture as suitable and the corresponding certified test report, signed by the responsible Quality Assurance representative of the manufacturer, shall be furnished to SANBAG. As an alternative a valid certificate, according to the EN 10204, may be provided.

21.7.3 HVAC System Testing

All HVAC system components shall be functionally tested by the component manufacturer before shipment.

21.7.4 Alternator, Generator and AC/DC Motors Testing

Each alternator, generator and AC or DC motor shall be given a "routine" test by the manufacturer in accordance with IEC 60349. Motor balance shall be dynamically tested in accordance with NEMA MG 1-12.06. Alternatively routine testing can be carried out according to IEC 60349. Motor balance according to DIN ISO 1940 shall be performed.

21.7.5 Diesel Engine Test

Each completed diesel engine shall undergo a complete full load dynamometer production test. The test shall include a break-in period, as specified by the engine supplier, in which it is gradually brought up to its full rated power and RPM.

21.7.6 Final Drive Gear Unit or Gear Drive Test

Each final drive gear or gear drive shall be given the manufacturer’s "routine" test, which shall include, for example as a minimum, no-load operation at a speed and duration agreed upon.

21.7.7 Traction Control Test

With an external power supply connected, all electronic and electro-mechanical devices in each traction control system shall be tested for correct sequences of operation in both powering and braking modes.

21.7.8 Low Voltage Power Supply Test

Low voltage power supply production conformance tests shall include the following:

a. A high potential test in accordance with the requirements of TP 21.8.4 or IEC 60077.
b. Output voltage shall be adjusted to be within +1, -0% of the specified nominal output voltage.
c. Output current limit shall be adjusted to be within +10, -0% of the Contractor's stated nominal rated output current. In the event the power supply design for current limit function incorporates 2 or more break points, the current or voltage setting at the additional points shall be adjusted to be within +10, -0% of the Contractor's stated nominal value.
d. Over voltage and under voltage shut off points shall be adjusted to be within +1, -0% of the specified values.
e. A one-half hour run at nominal output voltage as adjusted above, rated output current, and nominal input voltage.
f. Proper functioning of safety interlocks shall be demonstrated.
g. All other features such as time delay relays, and layover shutdown, shall be exercised and adjusted, as required, to be within +10, -0% of the Contractor's stated values where appropriate.

21.7.9 Brake Equipment Test

All valves shall be test-rack tested and certified for performance in accordance with manufacturer's specifications and test codes, as approved by SANBAG.

All electrical and electronic assemblies shall be functionally tested and certified for performance in accordance with the manufacturer's specifications and test codes, as approved by SANBAG.

All reservoirs shall be tested and certified in accordance with ASME Codes.

21.7.10 Communications System Test

All electrical and electronic assemblies shall be functionally tested and certified for performance in accordance with the manufacturer's specifications and test codes, as approved by SANBAG.

21.7.11 Carbody Watertightness Acceptance Testing

The Contractor shall subject each vehicle to a complete test for water tightness. All exterior appointments or carbody seams that may affect water tightness of the carbody—such as

destination signs, indication lights, and crew switches—shall be installed at the time of this test. At a minimum, the test shall meet the following specifications:

a. Prior to the carbody water test, the doors shall be adjusted and tested to verify they meet the requirements of TP 6.0.
b. All spray applications shall run for 10 minutes before the inspection for leaks begins and shall run continuously during the inspection.
c. The flow of the water during the test shall be not less than 0.65 gal (2.46 L)/minute delivered to each 10 x 10 feet of surface being tested, and the nozzle velocity of the water shall not be less than 150 feet (45.72 m)/second.
d. Underfloor boxes, which are required to be watertight, shall receive a pressure water test similar to the water tightness test for the carbody.

Alternate proposals will be considered if above requirements cannot be achieved or are impractical due to specific issues with the vehicle design configuration.

21.7.12 Subsystem Functional Acceptance Testing

The Contractor shall demonstrate that all subsystems meet or exceed the functional requirements described in these Technical Provisions.

21.7.13 Coupler Electric Pin Signal Verification Functional Acceptance Testing

The Contractor shall demonstrate that the vehicle meets the functional coupler electric pin signal requirements.

21.7.14 Truck Quality Testing

21.7.14.1 All production truck welds including the frame, bolster and any other primary structural members shall be subjected to magnetic particle or dye penetrant inspection, except critical welds, which shall also be inspected by radiography, or by section and etch, on 2 trucks chosen at random by SANBAG. Magnetic particle inspection shall be in accordance with ASTM E 709 or EN 15085. Dye penetrant inspection shall be in accordance with ASTM E 165 or EN 15085. Cast trucks shall be one hundred percent (100%) magnetic particle inspected. Radiographic inspection shall be continued at a rate of one truck frame for each ten trucks produced. If Defects are found during sampling inspection, the Contractor shall positively locate the beginning of such Defects in previous truck frames and apply appropriate corrective action.

21.7.14.2 Bearing Lateral Clearance

A ten percent (10%) sample of mounted journal bearings shall be measured to verify conformance to installed lateral clearance requirements.

21.7.14.3 Wheel Back-to-Back Distance

All-wheel-axle assemblies shall be measured and the back-to-back distance shall be recorded and entered into the corresponding Vehicle History Book.

21.7.14.4 Shunt Resistance

All-wheel-axle-wheel assemblies shall be measured to determine the signaling shunt resistance from wheel to wheel. The results shall be submitted to SANBAG **[CDRL 21-5]** and a copy shall be inserted into the corresponding Vehicle History Book.

21.7.14.5 Axle Runout

All-wheel-axle assemblies shall be measured to verify conformance to axle runout (concentricity) requirements in TP 11.13.2.

21.7.14.6 Wheel Runout

All-wheel-axle assemblies shall be measured to verify conformance to lateral and radial runout requirements in TP 11.13.2.

21.7.14.7 Tram and Axle Parallelism

All truck assemblies shall be measured to verify conformance to the tram and axle parallelism requirements in TP 11.4.7.

21.8 VEHICLE STATIC TESTS

21.8.1 The tests listed in this section shall be performed on each vehicle prior to shipment to SANBAG. The Contractor's static tests shall include all tests and adjustments which can be made prior to shipment in order to keep the post-shipment acceptance testing, specified in TP21.9, and any subsequent adjustments, to a minimum.

21.8.2 Weighing

The Contractor shall weigh each vehicle at the time of shipment. The weight at each truck of the vehicle shall be provided separately. A weighing device which provides a permanent record of the weight shall be used, and the weight tickets shall be submitted to SANBAG. Copies shall be included in the Vehicle History Book. The weighing device shall be maintained within an accuracy of 0.2%. The Contractor shall submit written verification that the weighing device was calibrated as required over the life of this Contract.

21.8.3 Grounding Acceptance Testing

a. For each circuit with a nominal voltage above battery voltage, the circuit resistance to ground shall be measured according to the EN 50124-1 and EN 50215 with a 1,000-Volt Megger, a resistance bridge instrument, or other suitable method.
b. Battery circuit resistance to ground shall be continuously measured during normal operation of the vehicle in accordance with the IEC/EN 61557-8.
c. If the battery circuit resistance to ground is not continuously measured during normal operation of the vehicle, then tests need to be carried out also with the battery voltage circuit.

21.8.4 Hi-Potential Acceptance Testing

a. A high-potential ground insulation test shall be performed on all circuits above battery voltage and on associated apparatus in each vehicle. Auxiliary circuits and apparatus shall be tested at 2 times the highest-rated voltage plus 1,000 V AC (60 Hz) for 1 minute.
b. All wires, cables and/or equipment not meeting the requirements of the tests shall be removed and replaced by the Contractor. After replacement of any such Defective parts, materials, or equipment, the vehicle shall be subjected to re-testing.

21.8.5 Wiring Continuity (Ring-Out) Acceptance Testing

All wiring circuits shall be rung out to verify continuity and proper polarity after assembly and installation of all equipment. All frame grounds and terminal connections shall be checked for tightness.

21.8.6 Leakage Acceptance Testing

a. The Contractor shall perform a leak test on the assembled fuel and air piping system on each vehicle in accordance with IEC 61133. A copy of the test report for each vehicle, including retest reports if appropriate, shall be included with each Vehicle History Book.
b. Loss of main reservoir air pressure due to cumulative leakage in the entire pneumatic system—not including that required for system functioning, per vehicle—shall not exceed 10 psig in 15 minutes, following a 5-minute settlement period from the time at which the system was fully charged and the air compressor was shut off.
c. No leakage will be allowed in the fuel systems.

21.8.7 Doors, Operators and Controls Testing

21.8.7.1 The doors and their operating equipment shall be tested and adjusted on all vehicles to assure smooth functioning, attainment of the required speed of operation, and proper functioning of controls, signals and interlocks, as specified in TP 6.0.

21.8.8 HVAC System Acceptance Test

21.8.9 An HVAC system acceptance test according to the manufacturer's recommendation shall be performed on all vehicles. Exterior Lights Testing

All exterior lights on each vehicle shall be functionally checked, aimed and adjusted.

21.8.10 Interior Lights Testing

All interior lights shall be functionally tested. This includes, but is not limited to, the lighting equipment in passenger compartment and Operator cab. Emergency lighting shall be tested separately.

21.8.11 Traction Control Testing

With the diesel engine(s) operating, all electronic and electro-mechanical components of each traction control and reverser system of each vehicle shall be tested for correct sequence of operation in both powering and braking modes by operating the master controller, observing the functioning of the various pieces of apparatus involved. Any component that fails to function in the proper sequence shall be repaired and the test repeated until successful before proceeding to the next sequence of the traction test series.

21.8.12 Friction Brake Testing

The Contractor shall perform a complete functional test of the friction brake system of each vehicle from its facility. Tests shall include verification of the feedback command and load-weigh signals and the appropriate response; brake cylinder pressure settings; control and indicator checks; brake system leakage test; and a functional test of the brake fault detection system.

21.8.13 Communication System Testing

The PA system, cab intercom and the passenger information system of each vehicle shall be tested for proper function, volume level and clarity of voice transmission and reception.

21.8.14 Cab Signal System Testing

The Contractor shall functionally test the cab signaling system of each vehicle for proper signal reception, processing and subsequent action as defined by the supplier.

21.8.15 Trainlines Testing

The Contractor shall verify the accuracy of each vehicle's trainline connections by the use of a test panel or a second vehicle, which shall be connected to the coupler's electric head and indicate, by the illumination of lights, or other appropriate means, that the proper trainline wires are energized when all vehicle controls, and trainlined systems are operated.

21.8.16 System Functional Verification

21.8.16.1 After completion of each vehicle and prior to shipment, the Contractor shall demonstrate that each subsystem is operational and that each vehicle can be properly controlled from the Operator's console. The tests shall be conducted by using the vehicle's own power.

21.8.16.2 The test procedure for this test shall include and testers shall use a check list that shall become a record to show that all systems have been actuated and have functioned as required. The completed and signed checklist shall be inserted into the appropriate Vehicle History Book.

21.9 POST-SHIPMENT ACCEPTANCE TESTING

On-site acceptance tests shall comprise individual vehicle and train consist tests to be performed on SANBAG's property by the Contractor to demonstrate conformance of the vehicle and train consists with these Technical Provisions.

21.9.1 Vehicle Acceptance Testing

a. After receipt of a vehicle at the designated delivery point and before passing into regular operation, each vehicle shall be inspected and tested with SANBAG. Any part, device, or apparatus requiring adjustment, repair, or replacement will be called to the attention of the Contractor, who shall make adjustment, repair, or replacement at the Contractor's own expense.
b. All aspects of vehicle construction and manufacture that cannot be tested at the Contractor's facility shall be tested at this time. Test procedures for vehicle acceptance tests on SANBAG's property shall be submitted at least 3 months in advance.
c. SANBAG reserves the right to make, at its own expense, operating tests of each unit separately, or in trains. The Contractor may assign a competent representative to witness such operating tests. Any Defects disclosed by such tests in apparatus, materials, or workmanship shall be corrected at the Contractor's expense.
d. The Contractor shall bear all expenses and costs incurred in the removal of vehicles from the designated delivery point for correction of Defects. If any vehicle is delivered to SANBAG that has previously been rejected, the Contractor shall bear all expenses for acceptance testing that must be repeated.
e. During vehicle acceptance testing, each vehicle shall be operated by the Contractor to demonstrate proper performance of all equipment at all speeds necessary to cycle the control equipment. The following characteristics shall be monitored and recorded and the results shall become the property of SANBAG **[CDRL 21-6]**:

    - Time and distance
    - Acceleration rate
    - Diesel engine(s) rpm and coolant temperature
    - Transmission shifting and hydraulic fluid temperature
    - All auxiliary voltage levels
    - Brake rate
    - Analog rate control signal
    - Speed
    - Mode trainline signals.

21.9.2 Communication System Acceptance Tests

The Contractor shall perform the necessary tests to demonstrate compliance with the requirements for all carborne communication equipment as defined in TP 13.0. The PA system and the crew intercom system shall be tested for clarity of voice transmission and reception.

21.9.3 Open

21.9.4 Miscellaneous Body Tests and Adjustments

The following tests and adjustments shall be performed at the acceptance site on each vehicle prior to track operation at SANBAG:

a. Truck clearances, vehicle dimensions, and vehicle height shall be verified.
b. Couplers shall be verified for proper alignment and level.
c. Air springs, if used, shall be adjusted to within the specified air pressure design tolerance.

21.10 BURN-IN TESTS

Each delivered vehicle will be operated over SANBAG's system for no less than 1,000 miles (1,620 km) in simulated passenger service before subjecting the vehicle to the reliability demonstration. SANBAG will perform the burn-in tests with its own personnel. Any failure found shall be diagnosed and repaired expeditiously by the Contractor at the Contractor's expense.

21.11 DELIVERABLES

Contract deliverables required by this section of the Technical Provisions are summarized below:

CDRL 21-1	Master Test Plan (ref. TP21.3.2)
CDRL 21-2	Test Procedures (ref. TP21.4.1)
CDRL 21-3	Test Reports (ref. TP21.4.3)
CDRL 21-4	Truck Frame Fatigue Testing Damage Equivalence Validation (ref. TP21.6.2.8.6)
CDRL 21-5	Wheel to wheel shunt resistance (ref. TP21.7.16.4)
CDRL 21-6	Post-Shipment Acceptance Test Operating Records (ref. TP 21.9.1)

END OF SECTION

22.0 SYSTEM SUPPORT

22.1 CITED REFERENCES

No references are cited in this section.

22.2 GENERAL

22.2.1 This section specifies the requirements for system support, including:

a. Technical support
b. Operation, maintenance, and other manuals
c. Training requirements
d. Diagnostic and test equipment (DTE)
e. Special tools
f. Spare parts.

22.2.2 The Contractor shall submit a System Support Plan that identifies the activities, organization, schedule, and means for providing each element of system support **[CDRL 22-1]**.

22.3 TECHNICAL SUPPORT

22.3.1 General

Technical support personnel shall be available from the time the first vehicle is delivered to SANBAG through the end of the reliability testing and basic vehicle warranty period on all vehicles. The support personnel shall be in addition to those needed to perform warranty repairs. Periodic support shall also be available before the first vehicle is delivered to enable vehicle facilities criteria to be coordinated with vehicle requirements.

22.3.2 On-Site Personnel

22.3.2.1 On-site Contractor and Subcontractor personnel qualified to maintain the vehicles and their systems shall assist with testing and with resolving operational and maintenance problems. These personnel shall be thoroughly familiar with the operation of the vehicles.

22.3.2.2 The on-site personnel shall provide support during the test and reliability demonstration (TP 20.6.3) periods by isolating failures, providing replacement parts, and responding to any warranty claims, including initiation and follow-up of remedial actions.

22.3.2.3 On-site personnel shall include field service engineers, technicians, repair personnel, and support staff, as required. At least 1 full-time technician, fully familiar with all of the vehicle systems, shall be on site during the reliability demonstration period.

22.3.3 On-Call Personnel

22.3.3.1 During vehicle testing on SANBAG's property, during the reliability demonstration and during the basic vehicle warranty period, on-call personnel shall be on SANBAG's property within 2 working days of a request to the Contractor for additional technical assistance, for resolution of warranty-related repairs, or for investigation of repetitive failure or design Defects.

22.3.3.2 On-call personnel shall include Contractor and Subcontractor engineering personnel and technicians. All Contractor and Subcontractor personnel shall be fully qualified to work on the vehicles and their systems and shall be thoroughly familiar with the details of SANBAG's vehicles.

22.3.4 Spare Parts and Equipment

22.3.4.1 The Contractor shall ensure that sufficient spare parts and necessary equipment are available on site to support vehicle testing and warranty requirements.

22.3.4.2 A list of the proposed spare parts and equipment, including quantities, shall be submitted for approval by SANBAG **[CDRL 22-2]**.

22.4 MANUALS

22.4.1 General

22.4.1.1 All manuals and catalogs shall be provided in heavy-duty D-ring binders, suitable for continuous use in a shop environment. Operator's Instruction and Troubleshooting Manuals shall be provided in pocket size.

22.4.1.2 The Contractor shall provide the following hard copies of the manuals listed below in the quantities indicated **[CDRL 22-3]** no later than the first vehicle is delivered. The first release copies shall be clearly identified with the words 'First Release' printed conspicuously on each page.

Draft Issues

- Operator's Instruction and Troubleshooting Manuals 2 copies
- Running Maintenance and Servicing Manuals 2 copies
- Heavy Repair Maintenance Manuals 2 copies
- Training Manuals 2 copies
- Special Tools and Test Equipment Manuals 2 copies
- Illustrated Parts Catalogs 1 digital copy
- Electronic media copy of all draft manuals above 1 copy

22.4.1.3 Final issues of the manuals in the quantities listed below shall be provided upon acceptance of the last vehicle.

Final Issues

- Operator's Instruction and Troubleshooting Manuals 10- copies
- Running Maintenance and Servicing Manuals 10 copies
- Heavy Repair Maintenance Manuals 10 copies
- Training Manuals 10 copies
- Special Tools and Test Equipment Manuals 5 copies
- Illustrated Parts Catalogs 1 digital copy
- Electronic media copy of all manuals above 1 copy

22.4.1.3.1 A revision of the final issue of the manuals is to be delivered at the end of the warranty period of the last vehicle.

22.4.1.4 Pursuant to TP 22.4.1.3.1 the Contractor shall also provide copies of all final manuals and catalogs identified above, wherever possible, on electronic media, in a format that can be edited by SANBAG **[CDRL 22-4]**. The electronic version shall employ "hypertext" links to facilitate rapid movement within the manuals. The electronic copies shall not be password protected or otherwise locked to prevent editing. The file formats shall be native such as Microsoft Word, Microsoft Excel AutoCAD, Photoshop or Corel Draw.

22.4.1.5 The manuals shall be submitted in an electronic format that allows easy printing on letter-size white paper, printed on both sides, and numbered sequentially within units of training. Any graphic aids used in training shall be supplied along with the electronic copy. The Contractor will also provide copies of the student workbooks during each training session.

22.4.1.6 Specific safety cautions, special procedures, warnings, or other information needed to maintain safe conditions shall be included in the manuals. The safety-related information shall include all requirements identified in the safety analyses and hazard analyses defined in TP 20.0.

22.4.1.7 Block diagrams, drawings, illustrated parts breakdowns, and schematic drawings shall be used to augment descriptions of assemblies and the relationships of components, assemblies, and systems. If approved by SANBAG, photographs may be used to support specific descriptions.

22.4.1.8 The information provided in all of the manuals shall be totally integrated.

22.4.1.9 Parts lists and drawings provided by the Contractor in the maintenance manuals and parts catalogs shall include part numbers.

22.4.2 Submissions and Revisions

22.4.2.1 One year prior to delivery of the first vehicle, the Contractor shall submit to SANBAG, for approval, Tables of Contents and sample formats for each type of manual and for the Illustrated Parts Catalog **[CDRL 22-5]**.

22.4.2.2 The Contractor shall deliver accurate drafts of student workbooks, manuals and catalogs, submitted on CD-ROM and Hard Copy, 60 days prior to delivery of the first production vehicle to SANBAG. SANBAG's review time for the draft submittals shall be 60 days from receipt of each individual manual or catalog. The first release of all manuals and catalogs, incorporating all changes deemed necessary, shall be completed and delivered to SANBAG with the first vehicle.

22.4.2.3 Revisions to the first release and final manuals shall be recorded on a control list in the front of each manual. The list shall be issued with each revision and shall show the date of each revision and the page reference.

22.4.2.4 Manuals shall be numbered. Revisions to manuals shall be issued by replacing the pages that have changed as suitable. The Contractor shall supply a tracking chart that verifies which manual number has been updated to the latest revisions.

22.4.2.5 The Contractor shall be responsible for issuing revisions to the manuals until the basic warranty period expires.

22.4.2.6 The final versions of all lists, manuals, catalogs and their respective electronic versions shall be updated as based on the impact on of the needed changes, but not less than twice until the end of the warranty period.

22.4.2.7 Revisions related to systems modifications or assemblies shall be issued before or coincident with the arrival of components or retrofit packages.

22.4.3 Operator's Instructional and Troubleshooting Manual

22.4.3.1 The Operator's Instructional and Troubleshooting Manual shall contain all information needed for the proper operation of the vehicle. It shall include general vehicle familiarization material, such as:

- Location, function and operation of controls, gauges, indicators and switches;
- Discussion of the engines, transmissions, trucks, couplers, lights, environmental control, and other features of the vehicle which the Operator may not be in a position to control or adjust but of which the Operator should have some basic knowledge;
- Emergency procedures;
- Trouble symptoms and diagnosis methods; and
- Operator corrective action.

The Troubleshooting Manual shall be logically organized with systems and elements considered in descending order of importance. Care shall be taken that all statements and illustrations are clear, positive, and accurate, with no possibility of incorrect implications or assumptions.

22.4.4 Running Maintenance and Servicing Manuals

The Running Maintenance and Servicing Manuals shall enable the maintenance staff to have with them, in convenient form, all information needed for preventive maintenance inspections, on-vehicle running maintenance and adjustment, and on-line trouble diagnosis of each system including such data as troubleshooting guides, equipment specifications and schematics for the vehicle and each of its systems.

22.4.5 Heavy Repair Maintenance Manual

The Heavy Repair Maintenance Manuals shall contain a detailed analysis of each component of the vehicle so that the maintenance staff can effectively service, inspect, maintain, adjust, troubleshoot, repair, replace, and overhaul it. Suggested intervals for overhaul shall be provided. The description of the overhaul activities shall be as detailed as required or permitted by the design of the respective component. The Heavy Repair Maintenance Manuals shall include instructions for using portable test units (PTUs), bench testers, and shop test stands for maintenance, adjustment, test, and troubleshooting functions. It shall also include, in a separate section, all information needed for periodic inspection and servicing requirements, including lubrication, inspection and adjustment of all apparatus. Suggested intervals for periodic inspection and servicing shall be provided. The content shall be proposed by the Contractor and mutually agreed upon. Description of repair work shall be provided to a reasonable level of detail that shall be mutually agreed upon.

22.4.6 Illustrated Parts Catalogs

22.4.6.1 The Illustrated Parts Catalogs shall enumerate and describe every component with its related parts for the vehicles, PTUs, bench test equipment and special tools, including the supplier's number and the commercial equivalents.

22.4.6.2 Drawings showing cutaway and exploded views of subassemblies and components shall be used to permit identification of all parts. Parts common to different components shall bear the same Contractor's number, where used, in all components. Each part or component shall be identified as being part of the next higher assembly.

22.4.7 Training Manuals

Training manuals shall contain sufficient material to aid the Contractor in performing the requirements of TP 22.5.

22.4.8 Manuals for Special Tools and Test Equipment

Special Tools and Test Equipment Manuals shall be presented in the same format as required for all other manuals. The manuals shall include setup and testing procedures for each test device, as well as maintenance, troubleshooting and repair information and schematics for servicing and repairing the device.

22.5 TRAINING

22.5.1 General

22.5.1.1 The Contractor shall provide a modular training program using methodologies and formats that follow Instructional Systems Design (ISD) standards or equivalent approved formats. SANBAG’s safety regulations and all FRA requirements MUST be followed and where necessary integrated into all technical training content.

22.5.1.2 The Contractor shall provide training to educate SANBAG’s personnel in all details of the vehicle and its equipment. This training effort shall be sufficient to enable SANBAG to satisfactorily inspect, operate, service, and maintain or repair the vehicles.

22.5.1.3 All instructors shall be competent in the field in which they are providing training. All instructors shall have rehearsed the training course before arriving at SANBAG’s facilities. All instructors are subject to being approved by SANBAG, and shall be fluent in the English language. All courses of instruction shall be presented in the English language.

22.5.1.4 A primary objective of the program shall be to provide a training program of a quality and depth to develop within SANBAG the capability to perform similar training under its own training program (based on SANBAG's "Train the Trainer" philosophy) subsequent to the Contractor's involvement. The training shall be designed to be delivered by an instructor in the classroom and, when appropriate, in the field or shop when actual equipment is used.

22.5.1.5 The Contractor shall video record at least one complete sessions of each type of classroom training course, subject to agreement with the equipment supplier. SANBAG will retain ownership of the recordings, following a final editing by the Contractor. The Contractor and SANBAG shall mutually agree upon the content of the final version of the training recordings. The final version (including cover/disk artwork, titles, menus, and credits) shall be authored onto a DVD disk that can be read by a standard DVD player or computer and shall be submitted to SANBAG for approval prior to producing 5 production DVD versions of each training class **[CDRL 22-6]**.

22.5.1.6 The Contractor's program shall include formal and informal instruction, mock-ups, models, manuals, diagrams, and component catalogs as required. All materials used in the programs, such as models, manuals, mock-ups, videocassettes, and drawings, shall be of durable construction and shall become the property of SANBAG.

22.5.1.7 The Contractor shall update training materials as necessary or as required by SANBAG during the course of instruction.

22.5.1.8 The Contractor shall assume that SANBAG's personnel have no prior knowledge of the features of the supplied equipment. It may be assumed that maintenance personnel have the basic skills pertinent to their crafts.

22.5.1.9 Training for SANBAG-furnished equipment will be provided by SANBAG. However, the training provided by the Contractor shall cover the operational and functional interfaces of Contractor-supplied equipment with SANBAG-furnished equipment.

22.5.1.10 Computer-based training elements may be offered for SANBAG's approval, as an alternative to certain sections of the training program.

22.5.2 Training Requirements

22.5.2.1 Conduct of the courses listed hereafter shall be supported by the use of training manuals, guides, training aids, student and instructor workbooks, and Operator and maintenance manuals. It is the desire of SANBAG that, where applicable, the content and structure of the manuals defined in TP 22.4 shall be used as direct input into the training course.

22.5.2.2 All training courses shall include pre- and post-tests and hands-on practical exercises to determine the proficiency of the students in meeting the course objectives. The primary objective of testing all participants is to determine the extent to which students understand and can apply the information that has been taught. All tests shall be in a multiple-choice format with 4 answers. Answer keys and references to the location of the answer within the student manual shall be provided in each instructor manual. Three different tests shall be provided with all questions being equivalent but being formulated differently.

22.5.3 Items Furnished by SANBAG

22.5.3.1 Classroom and Practical Training Space

Space for classroom lectures and practical training on equipment will be furnished at SANBAG's facilities. The location and class times shall be scheduled for the convenience of SANBAG.

22.5.3.2 Projectors and Easels

Training equipment such as slide projectors, DVD players, screens, easels, and similar equipment will be furnished by SANBAG.

22.5.3.3 Use of Actual Equipment as Training Aids

The Contractor may use actual equipment or spare parts furnished under the Contract as training aids in lieu of mock-ups, and for demonstration of and practical exercises in adjusting, testing, disassembling, and assembling equipment. However, the Contractor shall be responsible for ensuring that such parts are not damaged or modified in any way, and the parts must pass re-inspection and acceptance tests after return to SANBAG.

22.5.3.4 Shop Space

SANBAG will make shop space available for instructional purposes.

22.5.3.5 Availability of Vehicles

SANBAG will make available, upon proper notice, vehicles and trains for instructional purposes and will also arrange for road operations, including furnishing fuel, dispatching, and operational supervisors, as necessary. However, the Contractor shall be responsible for ensuring that such vehicles are not damaged or modified in any way, and the vehicles must pass re-inspection and acceptance tests after return to SANBAG.

22.5.4 Training Program Plan

Within 180 days after NTP the Contractor shall submit for approval a Training Program Plan that includes the following **[CDRL 22-7]**:

a. Methodology for performing a skills assessment of SANBAG's maintenance and operational staff. The completed skills assessment shall be submitted to SANBAG for approval.
b. Terminal Learning Objectives for each training course.
c. Schedule of providing the various training submittals, including course outlines, lesson plans, instructor and student guides, and all other training aids.

22.5.4.1 Narrative Description

A narrative description shall be provided that documents the scope for training SANBAG's personnel, including supervisors, Operators, and maintenance and repair personnel. The description for each training program shall include:

a. Performance objectives that state the expected behavior, the conditions under which performance will occur, the measures and standards to be applied
b. The sequence of learning activities
c. An outline of the content
d. A training lesson plan
e. Learning strategies to be used (e.g., classroom presentation, hands-on practice, paper-and-pencil exercises)
f. Methods and criteria for evaluating performance, including an objective grading system to report progress of trainees during the training
g. Resources required (e.g., equipment, shop space, audio-visual equipment)
h. Approximate times required for training.

22.5.4.2 Training and Delivery Schedule

A schedule shall include the title of each course, a general description of the program; the intended audience (e.g., supervisors, Operators, maintenance and/or repair personnel); the size of the audience; SANBAG's facilities required (e.g., classroom size, shop and field requirements); the sequence of classroom and shop and field instruction and the estimated hours required for each; the number of sessions; and any other information that will facilitate planning for, and delivery of, the training programs.

22.5.5 Training Materials

22.5.5.1 The Contractor shall provide all materials to support each course in the training program, including: lesson plans, training aids, instructor guides, student workbooks, and Operator and maintenance manuals **[CDRL 22-8]**. Instructor guides, lesson plans, and student workbooks shall be submitted for SANBAG's approval for each category of training 30 days prior to the first training course.

22.5.5.2 The Contractor shall provide 5 copies of all training materials identified above, on electronic media, in a format that can be edited, wherever possible, by SANBAG **[CDRL 22-9]**. The electronic version shall employ "hypertext" links to facilitate rapid movement within the manuals. The electronic copies shall not be password protected or otherwise locked to prevent editing, wherever possible. The file formats shall be native such as Microsoft word, AutoCAD, Photoshop or Corel Draw.

22.5.5.3 The instructor guides and student workbooks shall be submitted in an electronic format that allows easy printing on letter-size white paper, printed on both sides, and numbered sequentially within units of training. Any graphic aids used in training shall be supplied along with the electronic copy. SANBAG will provide copies of the student workbooks as required.

22.5.5.4 The instructor guides for each course shall include course agendas; course objectives; procedures for managing training sessions; resources and facilities required; guidelines for preparing for training; detailed lesson plans, including scripted or outlined presentations and discussion guides; training aids and job aids; pre-tests and post-tests; criteria and methodology for measuring performance in the classroom and in the shop and field; instructions for using audiovisual support, mock-ups, and scale models; and detailed instructions for managing on-the-job training.

22.5.5.5 The student workbooks for each course shall include course agenda, course objectives, schedule of sessions, paper copies of overhead transparencies or PowerPoint slides, lecture outlines, lesson summaries, and any other information that will facilitate learning.

22.6 DIAGNOSTIC AND TEST EQUIPMENT

22.6.1 The Contractor shall furnish diagnostic and test equipment (DTE) required to maintain vehicle systems **[CDRL 22-10]**, including at least the capabilities shown in Table 22-1. Where a single DTE unit can provide 2 or more of the functions listed below, the total quantity may be reduced by twenty-five percent (25%). Integrated systems are encouraged. If universal portable computers are proposed as portable DTE for three or more systems, then the total number of portable DTE computers shall be six.

22.6.2 DTE shall perform the specified functions on the final configuration of the vehicle systems. Modifications shall be made to DTE and to DTE documentation as required to reflect all revisions made to the vehicle systems during the warranty period.

22.6.3 The functions of the PTUs and shop test equipment shall be integrated with the capabilities of the vehicle systems to form a cohesive maintenance system. Embedded fault monitoring systems shall detect and annunciate faults.

22.6.4 On-board diagnostics and annunciations shall be used with PTUs as required to identify a failed LLRU. Shop test equipment shall aid in identifying failed components and shall be used to verify that repaired equipment is ready for service.

22.6.5 Test procedures shall be provided to aid troubleshooting and to quickly verify proper operation of the equipment under test. A simple procedure or self-test feature shall be provided to verify the proper operation of each test fixture.

Table 22-1: DTE Capabilities

System	DTE	Minimum Test Capability	Min. Qty.
Side Door Operators and Controls	Door Control (Portable)	Check timing trainline and local operation, interlocking	2
HVAC	HVAC Control (Portable)	Verify temperatures, proper operation; simulate control inputs; check sequence and timing	2
HVAC	HVAC (Shop)	Check internal operation including refrigerant circuit, sensors, controls, condenser, compressor, and evaporator	1
HVAC	Flushing (Shop)	Provide for proper cleaning, flushing, and evacuating of system	1
LVPS	Low-Voltage Power Supply Control (Portable)	Check proper operations of circuits and voltage regulation; fault downloading	2
LVPS	Low Voltage Power Supply Control (Shop)	Verify proper operation of all subsystem elements	1
Auxiliary Alternator or Generator	Alternator/Generator Controls (Portable)	Verify proper operation of all subsystem elements	2
Auxiliary Inverter (if used)	Auxiliary Inverter Control (Portable)	Check proper operation of circuits, timing, voltage regulation; fault downloading	2
Propulsion Engine	Engine controls and diagnostics (Portable)	Verify proper operation of all subsystem elements; fault downloading	2
Propulsion Transmission	Transmission controls and diagnostics	Verify proper operation of all subsystem elements; fault downloading	2
Friction Brake	Friction Brake Control (Portable)	Verify proper control, safety features, trainline operation; fault downloading	2
Friction Brake	Friction Brake Control Rack (Shop)	Verify proper operation of all system elements	1
Communications	Passenger Information System (Portable)	Provide for audible and visible message programming	2
Communications	Passenger Information System (Shop)	Verify proper operation of all components	1
Communications	Diagnostic Monitoring System (Shop)	Verify proper operation of all components	1
Communications	Event Recorder (Portable)	Provide data downloading, processing, and graphing functions	2

22.6.6 The Contractor shall submit for approval functional descriptions, Manuals, specifications, drawings, and diagrams of DTE with each appropriate system's design review data submittal **[CDRL 22-11]**. Where DTE is microprocessor based and reprogrammable, the Contractor shall supply a full set of licensed copies of the commercial and industry specific software, each on a CD, for each DTE.

22.6.7 Each PTU or Shop DTE shall include 3 sets of clearly marked interface equipment. Cable assemblies shall be long enough to connect the test equipment from its test location to the test port. All software shall come with a self-install and an uninstall utility.

22.6.8 Portable Test Units

22.6.8.1 Whenever possible, embedded diagnostics and onboard annunciations shall detect and diagnose system failures. PTUs shall be provided where required, so that the combination of embedded systems and portable units will allow a technician to quickly verify proper operation of the system and to troubleshoot failures to the LLRU.

22.6.8.2 PTUs shall conform to the following guidelines:

a. Connections to the system under test shall be made via a single cable with a single multiple-pin connector (or equivalent), which shall be common among all systems. The Contractor shall provide at each end serial ports using RS-232-C or RS-422 interfaces or equivalent as approved by SANBAG for connection of the PTU.
b. Each PTU shall enable the user to fully check, troubleshoot and calibrate any subsystem that is being tested. It shall perform self-test and calibration upon startup. Where practicable, use of the PTUs shall not necessitate the breaking of any mechanical or electrical connection to or within the system under test. If troubleshooting and testing can be accomplished more quickly and accurately by breaking a connection, the PTUs shall provide a means for testing the integrity of that connection.
c. The primary functions of the PTUs shall be to verify the proper operation of a system and, if a fault condition exists, to quickly isolate the failed LLRU. The PTU shall be capable of producing the operating commands required to fully exercise functions and components of the particular subsystem that is being tested.
d. It shall be possible to use power from vehicle voltage sources.
e. The enclosure shall be suitable for use in a transit shop environment, and the unit shall not weigh more than 30 lbs. (13.5 kg).
f. Where practicable, the PTU shall display graphically measured data logger signals.

22.6.8.3 A cab located PTU connection point shall be provided for each microprocessor-based system. The Contractor shall provide all PTU connectors and wiring for all the subsystems listed in Table 22-1 to connectors located in cab area. The connector location in the cab shall be subject to SANBAG's approval.

22.6.8.4 It shall be possible for all data collected using the PTUs to be exported in MS Access or other widely available data acquisition format approved by SANBAG for remote analysis.

22.6.8.5 Where a PTU takes the form of a laptop computer, it shall be controlled by the state-of-the-art microprocessor available at the time of PTU delivery. The same type of laptop shall be supplied for all systems using this form of test equipment.

22.6.8.5.1 The software for each system shall be integrated into a single menu-driven user interface. When the equipment is delivered to SANBAG all computer-based PTUs shall have the latest release of Microsoft Networking Windows System, database for storage and display of fault data, and applications software operating within the Windows operating system environment.

22.6.8.5.2 All PTU computers shall be ruggedized for frequent use in a railroad maintenance shop environment and shall be provided in a suitable protective case that also contains all required power supplies and interface cables with matching connectors.

22.6.9 Shop Test Equipment

22.6.9.1 Shop-level test equipment shall be furnished for testing, troubleshooting, and calibrating electronic, mechanical, and electromechanical components of vehicle systems. The shop test equipment shall verify the proper operation of all system components and will enable fault detection to the LLRU level.

22.6.9.2 The functions and operation of shop test equipment shall facilitate the testing, troubleshooting, repair (if applicable), and calibration of system LLRUs. Shop test equipment shall conform to the following guidelines:

a. Provisions shall be made for rapid connection of meters, oscilloscopes, signal generators, and any other standard equipment required to perform tests.
b. All standard devices needed to perform all tests shall be included with the shop test equipment.
c. Test equipment may be designed to use shop-supplied compressed air and electric power.

22.7 SPECIAL TOOLS

22.7.1 The Contractor shall furnish all special tools required to maintain each vehicle system **[CDRL 22-12]**. Special tools are defined as tools that are not commercially available in the United States, and adapters needed for maintenance purposes.

22.7.2 The Contractor shall submit to SANBAG for approval lists of required and recommended special tools with each design review data submittal **[CDRL 22-13]**. The lists shall be grouped by system and shall identify the quantity of tools to be supplied, commensurate with tool use, system reliability, and vehicle fleet size; shall provide a description of the tool; shall indicate facilities requirements and any special requirements; and shall be cross-referenced to their callout in the maintenance manuals.

22.8 SPARE PARTS

22.8.1 Spare parts shall be interchangeable with their corresponding part. During the warranty period, all spare parts shall be reconfigured to the latest revision.

22.8.2 Spare parts furnished under this contract shall not be used to support vehicle testing nor warranty activities.

22.8.3 Packaging

Packaging shall consider the reliability of the parts and the requirements for inspection and inventory (e.g., the packaging selected for highly reliable parts shall be such that the parts can be identified, inspected, stored for long periods, and endure multiple inventories).

22.8.4 Recommended Spare Parts List

The Contractor shall submit a recommended spare parts list **[CDRL 22-14]**. This list shall include the following:

a. Grouping of parts by system, DTE, or special tools for stock identification.
b. Generic name, trade name, description, rating, accuracy, Contractor's part number, manufacturer's name, manufacturer's part number, drawing references, and cross-references to maintenance manuals.
c. Correlation of the recommended quantities with reliability requirements and lead time on the basis of the following classifications:
    i. Wear – Parts that may be expected to require regular replacement under normal maintenance schedules, such as mechanical parts subject to continuous operation
    ii. Consumables – Parts, including fluids, with an expected life of less than 5 years
    iii. One Shot – Parts that normally require replacement after performing their function 1 time, such as fuses

iv. Long Lead – Parts that are not readily available from distributors nor manufacturers
v. Exchange Assemblies – Assemblies that will be exchanged with failed units (or units that are not responding as specified) on the supplied equipment and that must be inventoried as complete assemblies
vi. Shelf Life – The Contractor or OEM shall maintain a supply of all spare parts that have a shelf life. The Contractor or OEM shall provide overnight delivery of spare parts to SANBAG (FOB SANBAG).

d. A cross-reference and indexing system for replacement components common to more than 1 system (whether vehicle, DTE, or special tool). Such components shall have only 1 part number.

22.9 DELIVERABLES

Contract deliverables required by this section of the Technical Provisions are summarized below:

CDRL 22-1	System Support Plan (ref. TP 22.2.2)
CDRL 22-2	List of proposed spare parts/equipment required to support vehicle testing and warranty activities (ref. TP 22.3.4.2)
CDRL 22-3	Draft and final hard copies of manuals (ref. TP 22.4.1.2)
CDRL 22-4	One electronic copy of each final manual and catalog (ref. TP 22.4.1.4)
CDRL 22-5	Table of Contents and Sample Formats for each type of manual and the Illustrated Parts Catalog (ref. TP 22.4.2.1)
CDRL 22-6	DVD recordings of training classes (ref. 22.5.1.5)
CDRL 22-7	Training Program Plan (ref. TP 22.5.4)
CDRL 22-8	Printed training materials and aids (ref. TP 22.5.5.1)
CDRL 22-9	Electronic copies of printed training materials and aids (ref. TP 22.5.5.2)
CDRL 22-10	Diagnostic and Test Equipment (ref. TP 22.6.1)
CDRL 22-11	Design information for Diagnostic and Test Equipment (ref. TP 22.6.6)
CDRL 22-12	Special tools (ref. TP 22.7.1)
CDRL 22-13	Lists of special tools (ref. TP 22.7.2)
CDRL 22-14	Recommended spare parts list (ref. TP 22.8.4)

END OF SECTION

23.0 PASSENGER EMERGENCY EQUIPMENT

23.1 CITED REFERENCES

49 CFR Part 238	Passenger Equipment Safety Standards
APTA RT-S-VIM-022-10	Low-Location Emergency Path Marking for Rail Transit Vehicles
APTA RT-S-VIM-026-12	Rail Transit Vehicle Passenger Emergency Systems

23.2 GENERAL

23.2.1 Purpose

23.2.1.1 This section summarizes the requirements for passenger emergency equipment.

23.2.1.2 This section is intended to serve primarily as a cross-reference for specific requirements that are contained in various other areas of the Technical Specification.

23.2.1.3 Vehicle systems shall meet whenever practicable the requirements of APTA RT-S-VIM-026-12.

23.3 PERFORMANCE

23.3.1 Specific Requirements

23.3.1.1 Emergency Egress and Access Provisions

23.3.1.1.1 Emergency egress and access shall be provided in accordance with 49 CFR Part 238.

23.3.1.1.2 Emergency door releases are specified in TP 6.0.

23.3.1.1.3 Emergency door releases shall be protected against inadvertent activation by frangible or other covers, but shall be easily operable, without tools by a member of the public not specifically trained in their use.

23.3.1.1.4 Emergency window exits are specified in TP 3.0.

23.3.1.2 Emergency Signage

23.3.1.2.1 Emergency signage on the vehicle interior and exterior shall be provided in accordance with 49 CFR Part 238.

23.3.1.2.2 Emergency exit path markings shall be provided in accordance with standard APTA RT-S-VIM-022-10.

23.3.1.2.3 Signage is specified in TP 15.0.

23.3.1.3 Emergency Lighting

23.3.1.3.1 Emergency lighting shall be provided in accordance with standard 49 CFR Part 238.

23.3.1.3.2 Emergency lighting is specified in TP 8.0.

23.3.1.4 Emergency Intercom

23.3.1.4.1 Emergency communication devices permitting communication between passengers and crewmembers and/or central control personnel are specified in TP 13.0.

23.3.1.5 Emergency Equipment

23.3.1.5.1 Fire extinguishers are specified in TP 5.0.

23.4 DELIVERABLES

None

END OF SECTION

APPENDIX

Sample Schedule

Sample String lines

Preliminary Track Layout

Track Charts-dated 1992

APPENDIX A: TRAIN SAMPLE SCHEDULE

Conceptual Redlands Passenger Rail Project Weekday Westbound Schedule-Stand-Alone Shuttle between University of Redlands and E Street

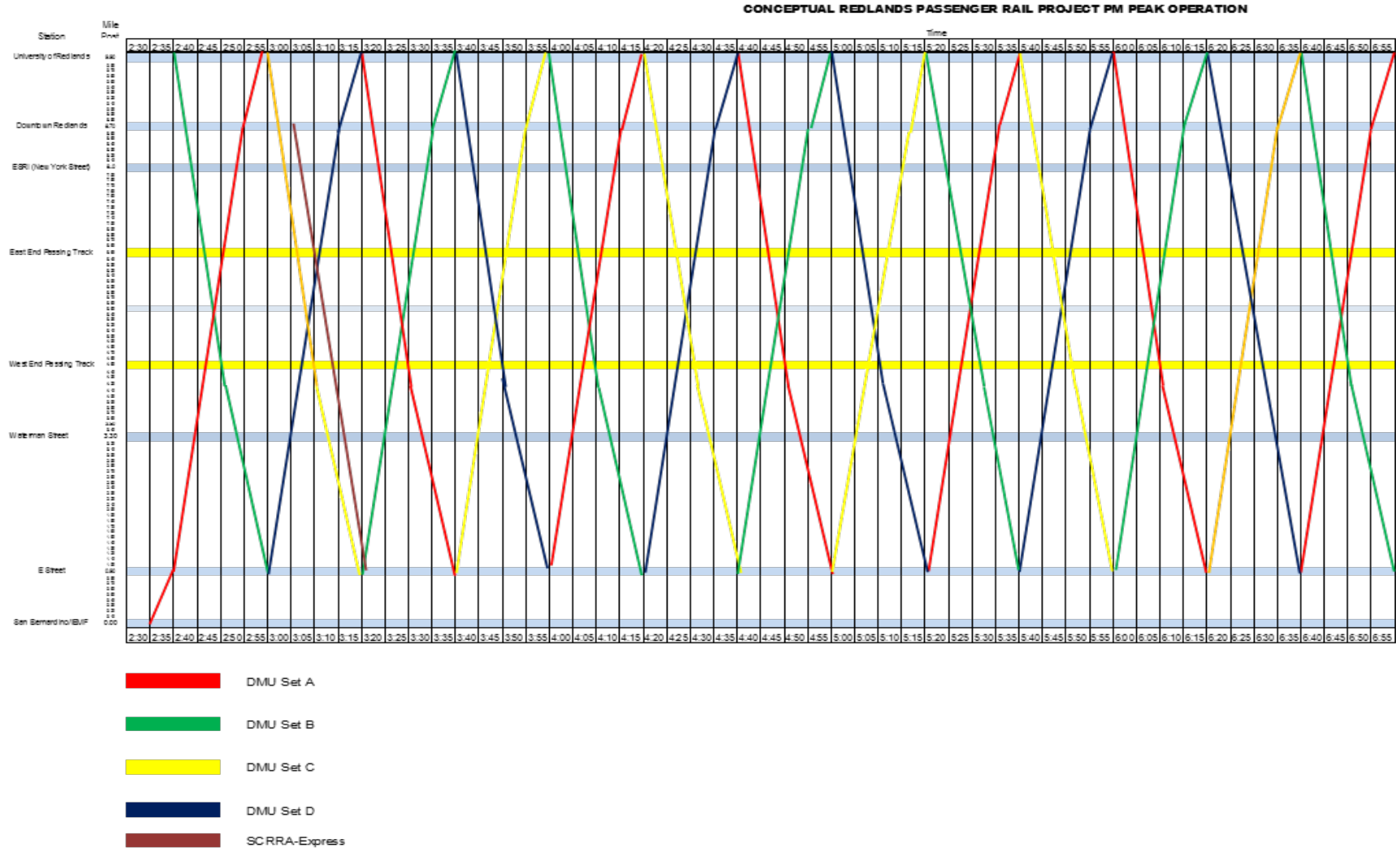
Train Number	101	103	105	107	109	111	113	115	117	119	121	123	125	127	129	131	133	135	137	139	141	143	145	147	149	151
University of Redlands	5:10	6:10	6:40	7:10	7:40	8:10	8:40	9:10	9:40	10:10	11:10	12:10	1:10	2:10	3:10	3:40	4:10	4:40	5:10	5:40	6:10	6:40	7:10	8:10	9:10	10:10
Downtown Redlands	5:12	6:12	6:42	7:12	7:42	8:12	8:42	9:12	9:42	10:12	11:12	12:12	1:12	2:12	3:12	3:42	4:12	4:42	5:12	5:42	6:12	6:42	7:12	8:12	9:12	10:12
New York Street (ESRI)	5:14	6:14	6:44	7:14	7:44	8:14	8:44	9:14	9:44	10:14	11:14	12:14	1:14	2:14	3:14	3:44	4:14	4:44	5:14	5:44	6:14	6:44	7:14	8:14	9:14	10:14
California Street	5:16	6:16	6:46	7:16	7:46	8:16	8:46	9:16	9:46	10:16	11:16	12:16	1:16	2:16	3:16	3:46	4:16	4:46	5:16	5:46	6:16	6:46	7:16	8:16	9:16	10:16
E Street (SBTC)	5:30	6:30	7:00	7:30	8:00	8:30	9:00	9:30	10:00	10:30	11:30	12:30	1:30	2:30	3:30	4:00	4:30	5:00	5:30	6:00	6:30	7:00	7:30	8:30	9:30	10:30
San Bernardino Depot									-																	
IEMF									10:15													7:15				10:45

Conceptual Redlands Passenger Rail Project Weekday Eastbound Schedule-Stand-Alone Shuttle between E Street and University of Redlands

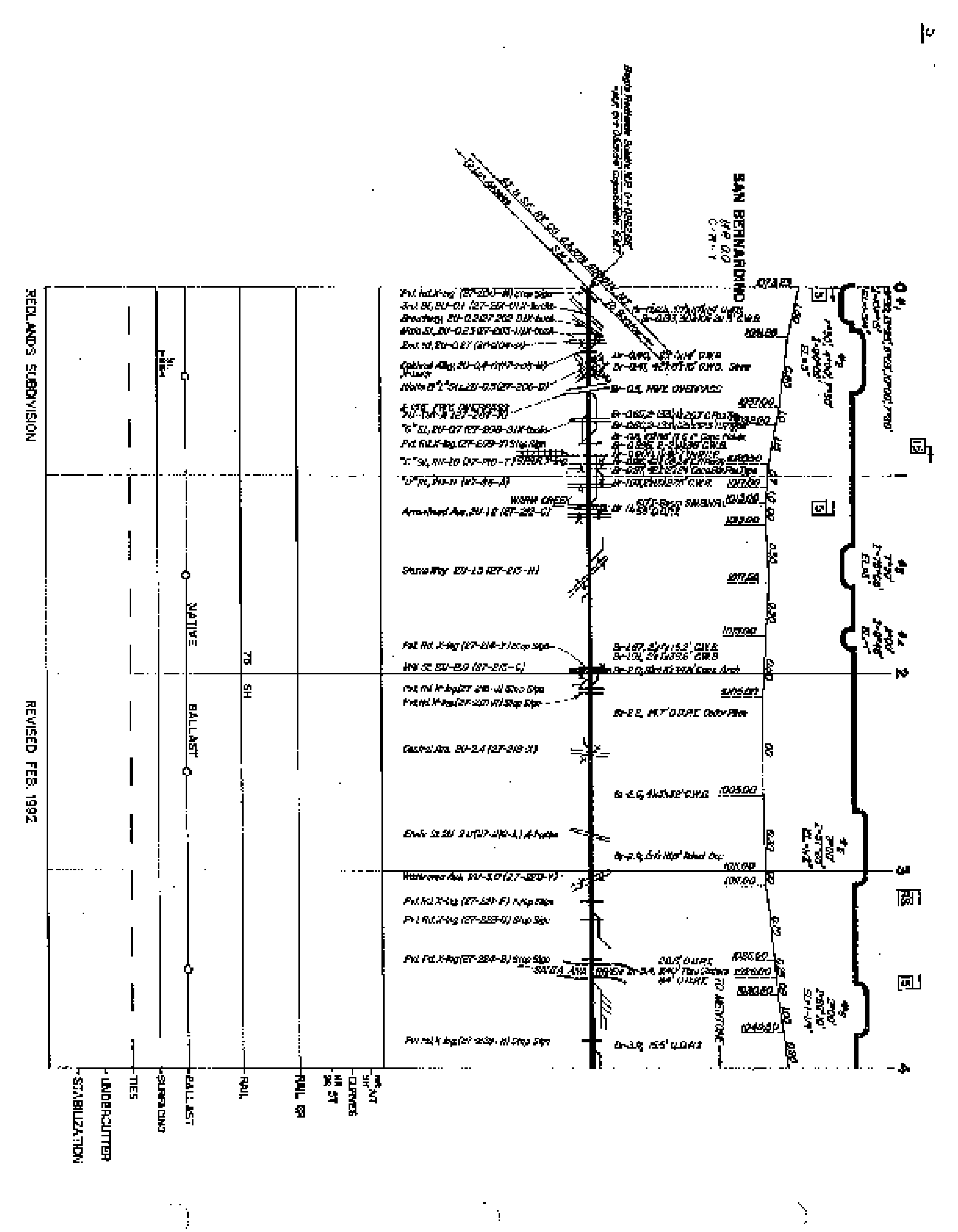
Train Number	DH 101	100	102	104	106	108	110	112	114	116	118	120	122	124	126	128	130	132	134	136	138	140	142	144	146	148
IEMF	4:30	4:50														2:50										
San Bernardino Depot	-																									
E Street (SBTC)	-	5:10	6:10	6:40	7:10	7:40	8:10	8:40	9:10	9:40	10:40	11:40	12:40	1:40	2:40	3:10	3:40	4:10	4:40	5:10	5:40	6:10	6:40	7:40	8:40	9:40
California Street	-	5:20	6:20	6:50	7:20	7:50	8:20	8:50	9:20	9:50	10:50	11:50	12:50	1:50	2:50	3:20	3:50	4:20	4:50	5:20	5:50	6:20	6:50	7:50	8:50	9:50
New York Street (ESRI)	-	5:23	6:23	6:53	7:23	7:53	8:23	8:53	9:23	9:53	10:53	11:53	12:53	1:53	2:53	3:23	3:53	4:23	4:53	5:23	5:53	6:23	6:53	7:53	8:53	9:53
Downtown Redlands	-	5:25	6:25	6:55	7:25	7:55	8:25	8:55	9:25	9:55	10:55	11:55	12:55	1:55	2:55	3:25	3:55	4:25	4:55	5:25	5:55	6:25	6:55	7:55	8:55	9:55
University of Redlands	5:00	5:30	6:30	7:00	7:30	8:00	8:30	9:00	9:30	10:00	11:00	12:00	1:00	2:00	3:00	3:30	4:00	4:30	5:00	5:30	6:00	6:30	7:00	8:00	9:00	10:00

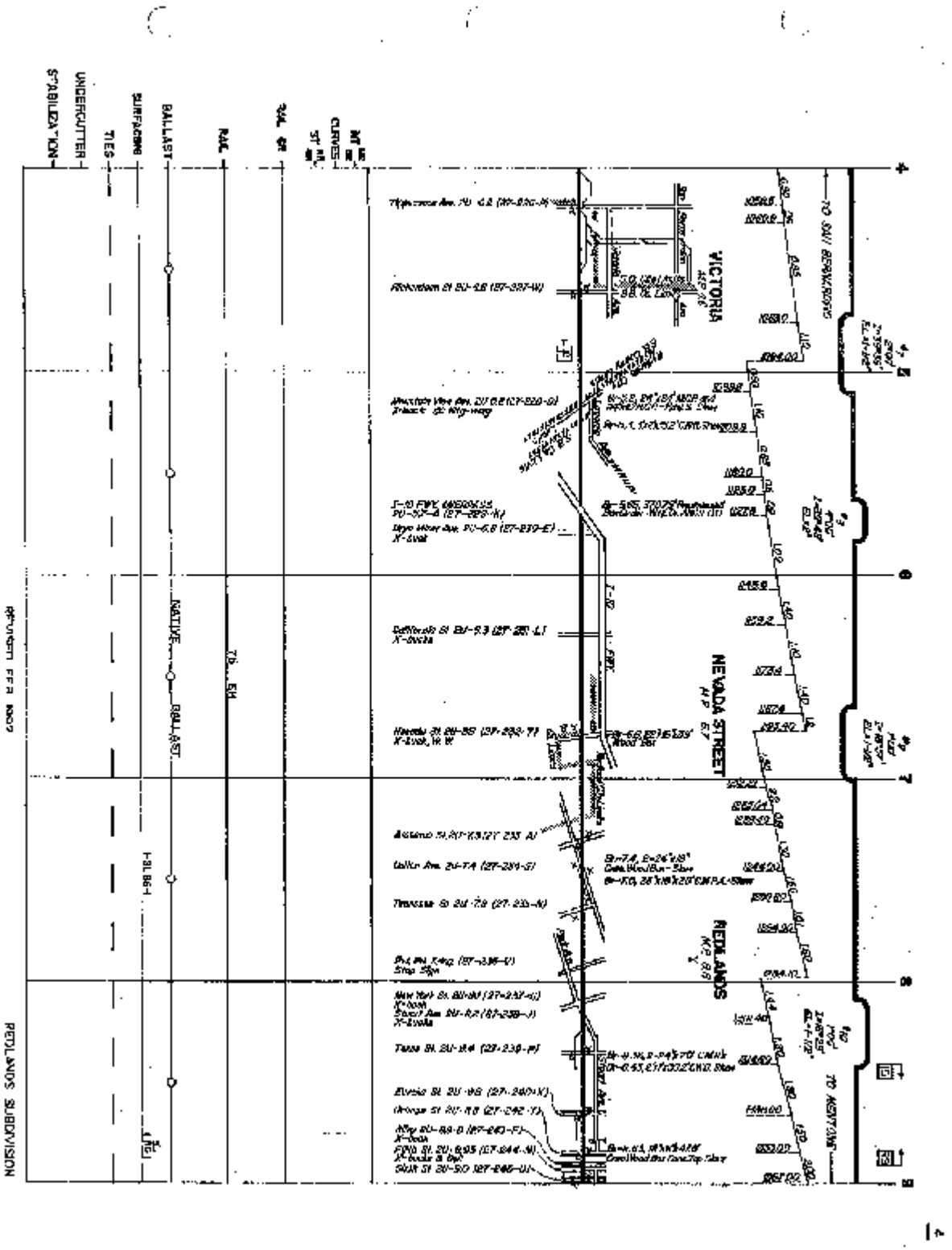
APPENDIX B: SAMPLE STRING LINE DIAGRAMS

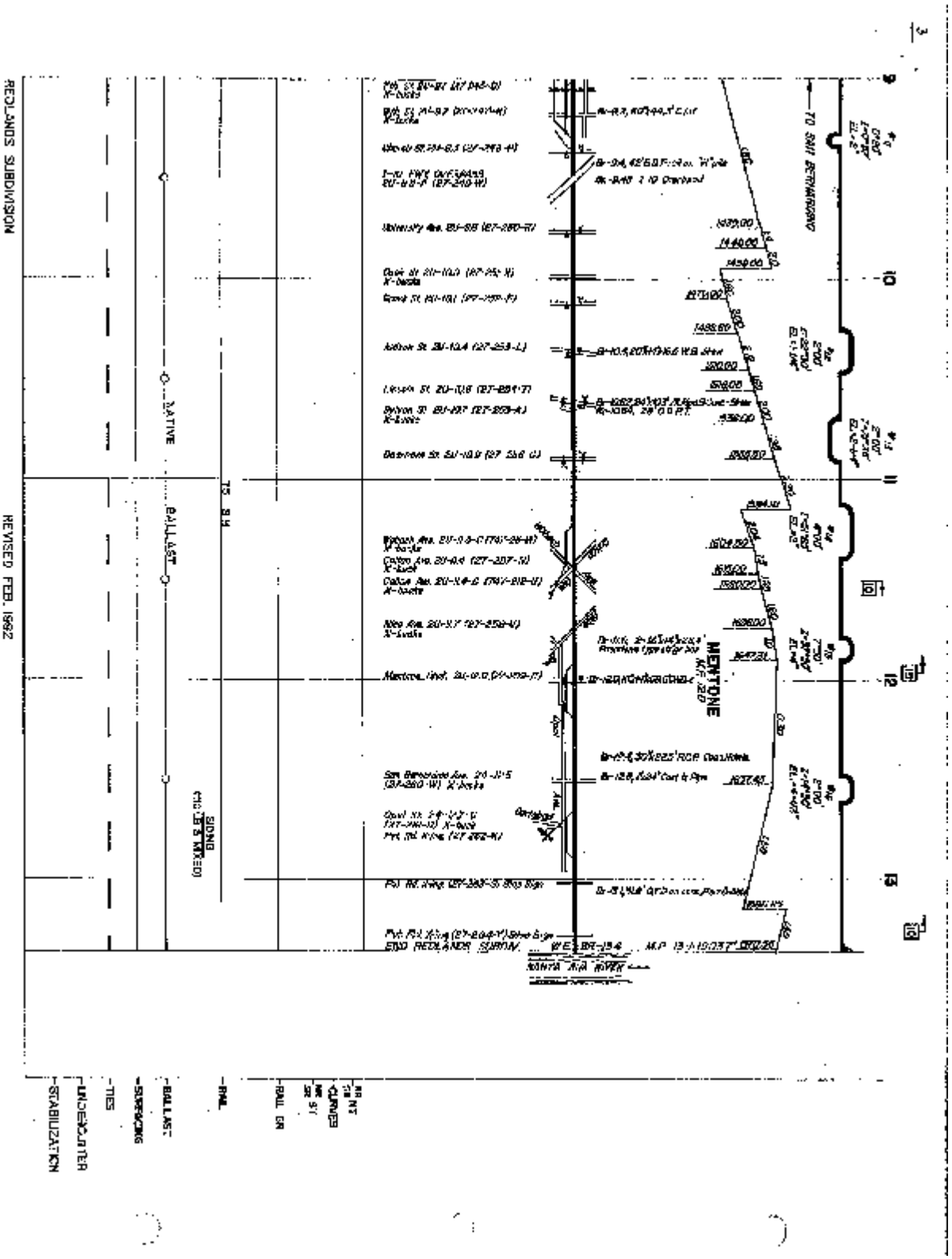
Track Charts from 1992. These are intended to give a general idea of the physical characteristics of the territory. All track work, structures and grade crossings are to be renewed or rehabilitated as part of the project.



APPENDIX C: PRELIMINARY TRACK LAYOUT


SAN BERNARDINO
REDLANDS SUBDIVISION
REVISED FEB. 1992
NATIVE
BALLAST
STABILIZATION
UNDERCUTTER
TIES
SURFACING
BALLAST
RAIL
CURVES


REDLANDS SUBDIVISION
UNDERCUTTER STABILIZATION
TIES
SURFACING
BALLAST
RAIL
CURVES
VICTORIA
NEVADA STREET
REDLANDS
TO SAN BERNARDINO
TO MENTONE
NATIVE
BALLAST


REDLANDS SUBDIVISION
REVISED FEB. 1962
MENTONE
NATIVE
BALLAST
TIES
RAIL
SURFACING
STABILIZATION
UNDERCUTTER
TO SAN BERNARDINO