TP-4: Passenger Vehicle Technical Provisions
Honolulu High-Capacity Transit Corridor Project

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Prepared for:
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List of Acronyms

ADA	Americans with Disabilities Act
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers
APC	Automatic Passenger Counting
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATC	Automatic Train Control
AVL	Automatic Vehicle Location
AW	Assigned Weight
AW0	Assigned Weight, empty vehicle
AW1	Assigned Weight, seated load
AW2	Assigned Weight, design load
AW3	Assigned Weight, crush load
AW4	Assigned Weight, structural load
AWS	American Welding Society
BSS	Boeing Safety Standard
CFC	Chlorofluorocarbons
CFR	Code of Federal Regulations
City	The City and County of Honolulu
DB	Dry Bulb (temperature)
dBA	Decibels, A weighted

DIN	Deutsche Industrie Norm (German Industrial Standard)
EER	Energy Efficiency Ratio
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
FAI	First Article Inspection
FAR	Federal Acquisition Regulation
FCC	Federal Communications Commission
FEA	Finite Element Analysis
FED STD	Federal Regulations and Standards
FMVSS	Federal Motor Vehicle Safety Standard
fps	Frames per second
FS	Federal Specification
FTA	Federal Transportation Administration (Previously UMTA)
GPS	Global Positioning System
HHCTCP	Honolulu High-Capacity Transit Corridor Project
HR	Heavy Repair (tracks)
HSCB	High Speed Circuit Breaker
HVAC	Heating, Ventilating, and Air Conditioning
Hz	Hertz
ICM	Interface Control Manual
IEC	International Electrotechnical Committee
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organization for Standards

Km/hr	Kilometers per hour
LAHT	Low-Alloy, High-Tensile Strength (Steel)
LAN	Local Area Network
LCD	Liquid Crystal Display
LED	Light-Emitting Diode
LLRU	Lowest Level Replaceable Unit
LRU	Line Replaceable Unit
LVPS	Low Voltage Power Supply
MDBF	Mean Distance Between Failure
MDBCF	Mean Distance Between Component Failure
MDS	Monitoring and Diagnostic System
MIL	Department of Defense-Military Standards and Specifications
mph	Miles per hour
MSF	Maintenance and Storage Facility
MTBF	Mean Time Between Failures
MTTR	Mean Time to Repair
NBS	National Bureau of Standards
NCSU	North Carolina State University
NDT	Non-Destructive Testing
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
OCC	Operations Control Center

O&S	Operations and Servicing
PA	Public Address
pphpd	Passengers per hour per direction
RMS	Root Mean Square
S&I	Service and Inspection (tracks)
SAE	Society of Automotive Engineers
SH	Sensible Heat
SI	International System of Measurement
TCE	Track Clearance Envelope
TOR	Top of Rail
T-TEL	Train-to-OCC Emergency Speakerphone
UL	Underwriters Laboratories, Inc.
UMTA	Urban Mass Transportation Administration (Now FTA)
USASI	United States of America Standards Institute
USDOT	United States Department of Transportation
Vac	Volts, alternating current
VdB	Vibration decibels
Vdc	Volts, direct current
VDE	Vehicle Dynamic Envelope
WB	Wet Bulb (temperature)

TP-4.1 *Introduction*

The purpose of these Technical Provisions is to define the basic performance, functional and physical characteristics of the high-floor light metro transit vehicle to be used for the Honolulu High-Capacity Transit Corridor Project (HHCTCP).

TP-4.1.1 Definitions

- Vehicle: The smallest passenger carrying unit that can operate independently.
- Train: A set of one or more vehicles coupled together and operated as a single unit, trainset or consist.
- System: The Honolulu Rail Transit System developed under the HHCTCP.

TP-4.1.2 Standards, Codes, and Recommended Practices

The governing version of the listed documents shall be the latest as adopted and administered by the City. Standards, codes and recommended practices not administered by the City, unless otherwise indicated, shall be the latest version or edition in effect.

In case of a conflict between the various standards referenced herein, the order of precedence shall be Federal, then State, then local requirements.

TP-4.1.3 Mandatory Requirements

The vehicles shall comply in all respects with the laws for federal, state, and county jurisdictions, including State Public Utility Commission and Department of Transportation.

TP-4.1.3.1 Accessibility and Ergonomics

The design of the vehicle shall meet all requirements and considerations pertaining to the Americans with Disabilities Act (ADA) as set forth in the document Department of Transportation 49 CFR 38 - Transportation for Individuals with Disabilities; Subpart D, Light Rail Vehicles and Systems, Sections 38.71 to 38.87.

Explanations and assistance in meeting these requirements may be found on the Architectural and Transportation Barriers Compliance Board website, where the document Light Rail Vehicles & Systems, Technical Assistance Manual, may be downloaded using the link www.access-board.gov/transit/manuals/PDF/Lightrail.pdf.

Vehicle ergonomic design shall be in accordance with the following:

MIL-HDBK-759C	Department of Defense Handbook – Human Engineering Design Guidelines
MIL-STD-1472F	Department of Defense Design Criteria Standard - Human Engineering

TP-4.1.3.2 Fire and Life Safety

Materials chosen for the vehicle construction shall have the lowest smoke emission characteristics and the highest flammability resistance consistent with the capability to perform the selected function.

Materials used on the interior of the vehicle shall meet the requirements of the Department of Transportation, 49 CFR 158 - Recommended Fire Safety Practices for Rail Transit Material

Selection as modified by the National Association of State Fire Marshalls recommendations of November 2008 (Project DC-26-5243-00) and the toxicity requirements of BSS-7239: Test Method for Toxic Gas Generation by Materials on Combustion.

In addition the vehicle shall comply with the requirements of Chapter 8 of NFPA 130:2007 - Fixed Guideway Transit and Passenger Rail Systems. This standard references the following documents that shall also be included in the mandatory requirements to the extent therein referenced:

ANSI / UL 1666	Tests for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts
APTA SS-PS-002-098 Rev.2	Standard for Emergency Signage for Egress / Access of Passenger Rail Equipment
ASTM C1166	Standard Test Method for Flame Propagation of Dense and Cellular Elastomeric Gaskets and Accessories
ASTM D2724	Test Methods for Bonded, Fused, and Laminated Apparel Fabrics
ASTM D3574	Test Methods for Flexible Cellular Materials - Slab, Bonded, and Molded Urethane Foams
ASTM D 3675	Test Method for Surface Flammability of Flexible Cellular Materials using a Radiant Heat Energy Source
ASTM E119	Method for Fire Test of Building Construction and Materials
ASTM E162	Method for Surface Flammability of Materials Using a Radiant Heat Test
ASTM E648	Test Method for Critical Radiant Flux of Floor Covering Systems Using Radiant Heat Energy Source
ASTM E662	Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials
ASTM E814 (UL 1479)	Standard Test Method for Fire Tests of Penetration Firestop Systems
ASTM E1537	Standard Test Method for Fire Testing of Upholstered Furniture
ASTM E1590	Standard Test Method for Fire Testing of Mattresses
14 CFR25 Appendix F, Part 1	Test Criteria and Procedures Showing Compliance With §25.853, or §25.855
California Technical Bulletin 129	Flammability Test Procedure for Mattresses for Use in Public Buildings
California Technical Bulletin 133	Flammability Test Procedure for Furniture Used in Public Occupancies
CSA C22.2, No. 0.3	Test Methods for Electrical Wires and Cables
ICEA S-19 / NEMA WC3	Rubber Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
IEC 60331-11	Tests for Electrical Cables Under Fire Conditions – Circuit Integrity – Part 11: Apparatus – Fire Alone at a Temperature of at Least 750° C

IEEE 11	Standard for Rotating Electric Machinery for Rail and Road Vehicles
IEEE 16	American Standard for Electric Control Apparatus for Land Transportation Vehicles
IEEE 1202	Flame Testing of Cables for Use in Cable Tray
NFPA 10	Standard for Portable Fire Extinguishers
NFPA 70	National Electrical Code
NFPA 101	Life Safety Code
NFPA 251	Standard Methods of Tests of Fire Resistance of Building Construction and Materials
NFPA 253	Standard Method of Test for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source
NFPA 262	Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air Handling Spaces
UL 44	Standard for Safety Thermoset-Insulated Wires and Cables
UL 83	Standard for Safety Thermoplastic-Insulated Wires and Cables
UL 1685	Standard for Safety Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables

TP-4.1.3.3 Shock and Vibration

All equipment shall be compliant with and tested as per the following standard:

CEI/IEC 61373:1999	Railway applications – Rolling stock equipment – Shock and Vibration Tests

TP-4.1.3.4 EMI/EMC Requirements

All equipment shall be compliant with and tested as per the following recommended practices:

UMTA-MA-06-0153-85-6	Recommended Practices for Rail Transit Intra-System Electromagnetic Compatibility of Vehicular Electrical Power and Track Circuit Signaling Subsystems, Volume II: Conductive,
UMTA-MA-06-0153-85-8	Recommended Practices for Rail Transit Intra-System Electromagnetic Compatibility of Vehicular Electrical Power and Track Circuit Signaling Subsystems, Volume I: Inductive,
UMTA-MA-06-0153-85-11	Radiated Interference in Rapid Transit Systems, Volume 2 - Suggested Test Procedures

TP-4.1.3.5 Supply Voltage Requirements

All electrical equipment shall be compliant with and tested as per the following recommended practices:

IEC-60850	Railway Applications – Supply of Voltages of Traction Systems

TP-4.1.3.6 Vehicle Structural Safety Requirements

The vehicle structural design shall meet the following requirements:

ASME RT-1-2009	Safety Standard for Structural Requirements for Light Rail Vehicles

TP-4.1.4 Recommended Practices and Specifications

Nationally recognized standards, codes, and specifications shall be utilized for the design and construction of the vehicles. Equivalent foreign Industrial and Railway Standards and Specifications may be proposed as substitutes when these are equivalent to or exceed the stated requirements. A side by side comparison of the requirements of the original specified standard or specification and the requirements of the proposed substitute standard or specification shall be submitted for City review. In addition a copy of the complete proposed substitute standard or specification shall be provided to the City in both a high-quality English translation and in the language of the country of origin.

The following standard is to be used for guidance purposes:

ASCE-21-98	Automated People Mover Standards – Part 2

TP-4.1.5 Standard and Directive Drawings

The following HHCTCP standard and directive drawings are referenced herein and shall be applicable to vehicle design work:

DD-N06-TD104	Contact Rail Installation Mounting & Pedestal Details
DD-N06-TD106	Contact Rail Installation Coverboard Assembly
DD-E03-WD275	Derail and Car Stop MSF Yard
DD-E03-WD650	Ballasted & Direct Fixation Track at Station Platforms
RTD-E03-WS101	Standard Rail Sections and Data
RTD-E03-WS102	Proposed Wheel Profile and Wheel/Track Interface Distances
RTD-E03-WS898	Friction Type (10EB) Buffer Stop Direct Fixation Track Installation
RTD-E03-WS899	DF Friction Buffer Stop Installation End of Track Details

TP-4.2 *Initial System Characteristics*

The First Project segment of the System will extend from Ala Moana Center in Honolulu to East Kapolei. The general System characteristics of this initial segment are more fully defined in TP-1: Core Systems Description and TP-3 Operations and Maintenance Performance Requirements.

The detailed specific operational performance of the vehicles, capacity, fleet sizing, reliability, availability and maintainability shall be such that all system requirements as defined in TP-3 Operations and Maintenance Performance Requirements are met.

TP-4.3 *Vehicle General Requirements*

The vehicle level general requirements, configuration, system interfaces, area climatic conditions, performance conditions, design approaches and reference drawings are to be found in this Section. All vehicles provided for the initial and subsequent fleets shall be essentially identical and shall operate interchangeably in any train and on any part of the System.

TP-4.3.1 Service Life

The vehicle shall have a minimum service life of 30 years of operation, provided that Contractor-specified periodic maintenance procedures and normal industry-accepted operating procedures are followed.

The Core Systems Contractor shall identify any requirements for mid-life overhaul to support the 30-year service life.

TP-4.3.2 Duty Cycle

The propulsion and braking systems shall be capable of operating continuously without exceeding the continuous rating of any equipment at AW2 loading, two or more vehicles per train, at nominal contact rail power as defined in TP-7, on a duty cycle comprised of full-power acceleration, full-brake deceleration, and dwell times, reflecting guideway profiles and curvature, operating conditions and loading stops. Each duty cycle shall assume a minimum 20-second dwell time at stations, that maximum allowable track speeds are maintained along the entire route, and a 3-minute turnaround at each end of the line. (See also TP-3 regarding station dwell time)

TP-4.3.3 Maximum Operating Speed

In normal revenue service, the maximum operating speed shall be 104.6 km/hr [65 mph].

TP-4.3.4 Annual Average Mileage

The estimated annual mileage is 102,193 km [63,500 miles] per vehicle.

TP-4.3.5 Units of Measure

As a general requirement, each subsystem shall be designed and manufactured to a single standard of measurement, and there shall not be a mixture of standards in any enclosure or on any component or sub-assembly for a subsystem within the enclosure. Subsystem and component designs and associated fasteners shall be either U.S. Inch Standard or ISO Metric Standard, except as specifically required in these Technical Provisions.

Fractional measurements shall not be used on drawings but shall be expressed as decimal values.

The vehicle body design drawings shall be ISO Metric Standard, with the U.S. Inch Standard noted in brackets or directly below the ISO Metric Standard, and all components and fasteners used in the vehicle construction shall be of that standard, unless otherwise stated.

Subsystems and components affixed to the vehicle body or the truck shall use fasteners of the same standard used on the affixed apparatus.

TP-4.4 *Vehicle General Characteristics*

TP-4.4.1 Vehicle Type

The vehicles shall be of a fully automated, high-floor, light metro transit vehicle type powered from a contact rail supply.

Each vehicle shall consist of a single section riding on two trucks with a high floor to allow level boarding from high-level station platforms. Vehicles shall be of two basic types, end vehicles and middle vehicles. See also Figure 4-1 below for further details.

End vehicles shall be classed as Type E vehicles and shall be equipped with ATC control equipment, Communications Controller, wireless LAN / high-speed data link equipment, windshield, forward facing camera and hostler Control Panel at leading end and wide gangway at trailing end. Each end vehicle shall be equipped with energy-absorbing auto-couplers at the leading end. The end vehicle structures shall also be capable of absorbing collision energy in event of a major collision.

Middle vehicles shall be classed as Type M vehicles and shall be without ATC control equipment, Communications Controller, or hostler Control Panel, but equipped with wireless LAN / high-speed data link equipment and with wide gangways at both ends.

All vehicles shall be capable of being semi-permanently coupled into multi-vehicle consists of two, three or four vehicles to form one single bi-directional operating trainset or consist with an end vehicle at each end, not to exceed 73.15 m [240 feet] in length between the first and last side passenger doors (i.e., all passenger doors shall be on the station platform). Possible train configurations shall thus be as follows:

- E – E
- E – M – E
- E – M – M – E

Passenger movement between vehicles in a trainset shall be via wide gangways, full-width designs being preferred so as to provide clear sightlines throughout the train.

It shall be possible to easily insert additional vehicles/sections into the trainset to increase capacity in the future.

Braking shall be provided by a combination of electrically-controlled friction disc brakes, dynamic regenerative braking. Electromagnetic track brakes may be provided if required to satisfy operational or safety criteria.

Propulsion shall be via microprocessor-controlled ac traction motors or equivalent.

Common items of trainset equipment, such as auxiliary power supplies, battery chargers, battery sets, etc. may be distributed among the vehicles making up the train.

ADA compliance is required for all aspects of the vehicle design and construction.

All vehicles shall be air conditioned using high-performance/energy-efficient HVAC units

The vehicle design shall include and utilize in its construction as much “service-proven” and “off-the-shelf” technology as possible.

The vehicle exterior and interior shall be of a modern and attractive design in harmony with the environment of O‘ahu and suitable for use in the local environmental conditions of the City and County of Honolulu.

TP-4.4.2 Passenger Doors

Four (4) to six (6) bi-parting, wide, power-operated passenger doors shall be provided for each vehicle, two (2) to three (3) per side directly opposite the doors on the other side. Fully glazed doors are preferred.

TP-4.4.3 Passenger Seating

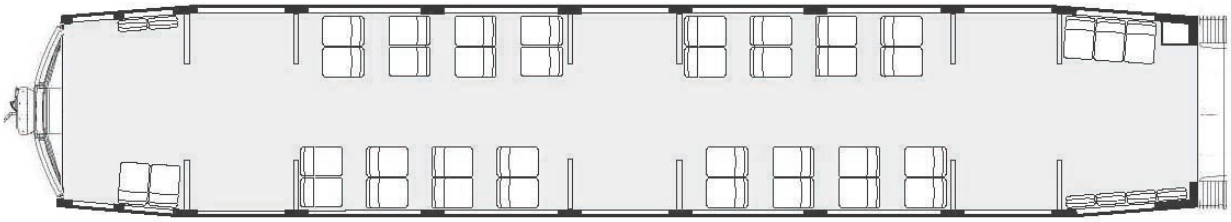
Vehicles shall provide the maximum number of seats available to passengers, including the provision of tip-up seats in standee/multi-purpose areas. A minimum of 20 percent of the design load (AW2) passengers shall be provided with seats (fixed + tip-ups). Tip-up seats shall be fitted with posterior rests on the underside to provide support for standees.

The passenger seating arrangement shall generally be transverse, knee-to-back, separated by a central aisle of at least 813 mm [32.0 in] width to allow passage of wheelchairs.

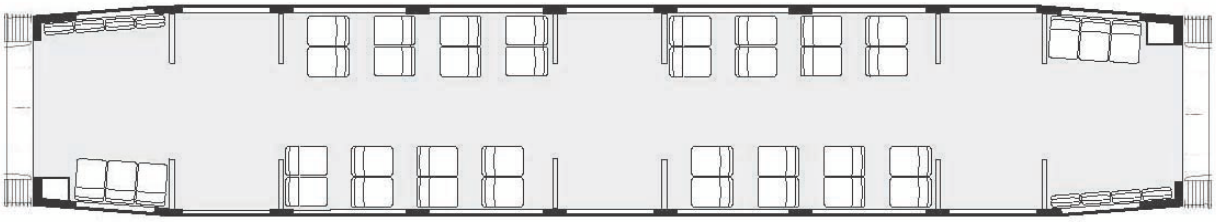
All passenger seating shall be suitable for use by US 5th percentile females and 95th percentile males. In particular, the knees of a 95th percentile male shall not be in contact with the seat back of the seat in front of him when seated. To achieve this, the distance from the lower seat back behind the seated passenger to the seat back in front shall not be less than 711 mm [28 inches].

The seating arrangement shall be designed so as to allow passengers with bicycles, wheelchairs or other large, awkward items to enter at any doorway and access a universal area with a minimum of effort. The preferred seating arrangement for a typical end vehicle is provided in Figure 4-1.

Figure 4-1. Preferred Seating Layouts



Type E (End) Vehicle



Type M (Middle) Vehicle

TP-4.4.4 Multi-Purpose Area

Each vehicle shall provide accommodations for baggage and at least two (2) wheelchairs, four (4) small to medium sized surfboards and three (3) bicycles. This may be accomplished by provision of multi-purpose areas, and all requirements need not be met simultaneously.

These areas shall be provided with longitudinal tip-up seats. These seats shall count in meeting the minimum requirement for seats per vehicle.

Special attention shall be given to provision of adequate wheelchair turning space for access to these spaces.

These areas shall also be provided with easy to use bicycle racks. When bicycles are placed in the racks provided, the aisle width shall not be reduced, and the bicycles shall not constitute a snagging hazard to passengers.

TP-4.4.5 Vehicle Identification

Each vehicle produced shall be numbered in order. Vehicle numbers shall be in sequence with vehicle body shell serial numbers. The numbering scheme shall utilize three-digit numbers, grouped by vehicle type, with E-type vehicles starting with 101 and M-type vehicles, starting with 501. The location for these numbers shall be highly visible and are likely to include exterior positions on the vehicle end, both sides and rooftop, as well as interior locations at the vehicle ends.

TP-4.4.6 Weight and Capacity

The structure of the vehicle body shall maintain the lowest possible weight consistent with the strength requirements. The structure shall be lightweight, integrated, and capable of resisting without permanent deformation, the buffing and other loads inherent in the type of service for which the vehicles are intended. Cost effective, lightweight, state of the art equipment, components and materials shall be utilized throughout the vehicle.

A rigorous weight control program shall be utilized by the Core Systems Contractor throughout the design and manufacturing process so that the weight requirements are met. A regularly updated record of equipment weight and center of gravity location shall be submitted to the City each month to monitor that overall low vehicle weight will be achieved and that this weight is being distributed to provide the lowest possible center of gravity in order to limit the tendency of the vehicle body to roll, and to optimize fore and aft weight distribution to maximize adhesion under all load conditions Prior to the delivery of the first vehicle, all actual equipment and component weights shall be known and introduced to the list. These weights shall be identified as “Actual”. These results shall be compared with the calculated vehicle weights.

TP-4.4.6.1 Total Vehicle

The ready to run (AWO) vehicle weight shall not exceed 32,666 kg [72,018 lbs]

TP-4.4.6.2 Weight Distribution

Equipment shall be arranged and installed so that vehicle overall weight is distributed to provide the lowest possible center of gravity height in order to limit the tendency of the vehicle body to roll, and to optimize fore and aft weight distribution to maximize adhesion under all load conditions.

- The difference in vehicle weight distribution between the trucks shall not exceed 1000 kg [2,200 lb].
- The lateral imbalance shall not exceed 290 kg-m [25,000 in-lb].

The maximum assigned weight (AW) and capacity of a vehicle shall be calculated as per Table 4-1, suitably adjusted for the contracted vehicle configuration. The standard average passenger weight utilized in these calculations shall be 69.85 kg [154 lbs].

Table 4-1. Vehicle Weights and Capacities for Design Purposes

Loading Condition	
AW0 (Ready to Run)	Maximum empty vehicle operating weight
AW1 (Seated load)	AW0 weight plus seated load of passengers
(Comfort load)	AW1 load plus standees at 3.2/m² [3.36 ft² of suitable standing space per standee]
AW2 (Design load)	AW1 load plus standees at 4/m² [2.7 ft²] of suitable standing space per standee
AW3 (Crush load)	AW1 load plus standees at 6/m² [1.8 ft²] of suitable standing space per standee
AW4 (Structural Design)	AW1 load plus standees at 8/m² [1.35 ft²] of suitable standing space per standee

The maximum allowable axle load, including maximum allowable weight imbalance, shall be 13,600 kg [29,983 lbs].

The standee area shall include all areas available to standing passengers. The standee area shall be calculated in accordance with TP Section 3.4.2.7.

TP-4.5 *System Interfaces*

The following interface details are given as a guide to initial vehicle concept design, but it remains the responsibility of the vehicle supplier to verify the accuracy of such information during the detailed design process.

TP-4.5.1 Critical Vehicle Dimensions

- The following are the limiting major dimensions for the light metro transit vehicle. Vehicles having different overall length, width and height dimensions and / or floor height dimensions may be considered, provided the associated changes to the guideway, station platform and MSF interfaces, including suitably revised vehicle static and dynamic envelopes as per Section 4.6.12, have been submitted and approved by the City.
  - Qverall length of vehicle: 18.28 m [60 feet] nominal
  - Overall width of vehicle: 3.048 m [10 feet] nominal
  - Clear width of passenger side doors:: 1,220 mm [48.0 in] minimum
  - Clear height of passenger side doors:: 1,980 mm [77.9 in] minimum
    2,030 mm [79.9 in] preferred
  - Passenger doors shall not protrude more than 63.5 mm [2.5 in] maximum from the vehicle side at the threshold level during any portion of the open or close cycle and shall not contact the platform at any time.
  - Height of floor above top of rail: 1150 mm [3.77 feet] nominal
  - Under-floor mounted equipment clearance: 289.56 mm [11.4 in] minimum (with collapsed suspension)
  - Interior height: center-line floor to ceiling: 2,030 mm [80.0 in] minimum
  - Truck / vehicle clearance (excepting wheels, obstacle deflectors and track brake), normal operating conditions of maximum wheel wear and primary suspension settlement: 50 mm [2 in] minimum above top of rail
  - Truck / vehicle clearance (excepting wheels, obstacle deflectors and track brake), worst-case conditions of wheel wear and suspension failure: 32 mm [1.25 in] minimum above top of rail
  - Maximum vehicle roll angle: 4.0 degrees
  - Dynamic clearances: Refer to Section 4.6.12

TP-4.5.2 Trackwork / Wheel to Rail Interface

- The basic trackwork characteristics shall be in accordance with Design Criteria Chapter 4.2.4.

TP-4.5.2.1 Track End Bumpers

Friction element type track end bumpers will be provided as per trackwork standard drawings RTD-E03-WS898 and RTD-E03-WS 899.

These bumpers are designed so as to first engage the vehicle autocoupler, utilizing the energy-absorbing capability of the coupler assembly, then the vehicle end anti-climbers. The vehicle supplier shall provide the trackwork supplier with sufficient information so that the

track end bumper elements are at the correct height, etc. for proper two stage contact upon collision.

TP-4.5.2.2 Rail Lubrication

An intelligent wheel flange and top of rail lubrication system shall be provided on each vehicle to automatically dispense an environmentally friendly liquid friction modifier on both sides of the wheel flanges of the leading powered axle on the leading vehicle in a consist only when passing through specific short curves with a radius less than 609.6 m [2000 ft] and in other locations of expected high rail wear or noise. Activation shall be via a suitable accurate vehicle location signal.

Alternatively, lineside flange lubrication units may be provided, subject to approval by the City.

Continuous/stick-type lubrication systems are not acceptable.

TP-4.5.2.3 Wheel Profile

The vehicle wheel profile shall utilize a standard Association of American Railroads (AAR) AAR-1B wheel profile with slight wheel width modifications, be suitable for satisfactory operation on the specified 115RE rail and similar to the wheel profile draft design as detailed in trackwork standard drawing RTD-E03-WS102.

The Core Systems Contractor shall finalize the profile and retain final responsibility for obtaining satisfactory wheel/rail interface performance and minimum rail/wheel wear rates. In particular, the vehicle supplier shall verify that the wheel flange dimensions are matched with the flange bearing frogs so as to provide quiet crossing of the frogs with a minimum of impact forces.

TP-4.5.2.4 Wheel Dimensions

The vehicle wheel dimensions shall be between 711 and 864 mm [28.0 and 34.0 in] in diameter. The wheels shall be the same diameter on all axles of the vehicle and the tires shall be interchangeable between the power and trailer trucks.

TP-4.5.2.5 Truck Dimensions

The vehicle truck wheelbase shall be within the range of 1900 to 2200 mm [74.8 to 86.6 in].

TP-4.5.2.6 Truck Centers

The vehicle truck centers shall be consistent with maintaining clearances within the specified dynamic envelope.

TP-4.5.2.7 Derailment Mitigation

The vehicle truck design shall provide a mechanical method so that the vehicle remains on the guideway in case of a derailment by entrapping the rail between the back of the wheel set and a major item of truck-mounted equipment, such as a traction motor or gearbox. Derailment mitigation shall be by mechanical means that restrict the movement of a derailed vehicle; mitigation that consists of detection without such mechanical means shall not be acceptable.

TP-4.5.3 Vehicle / Power Supply Interface

Power shall be supplied to the vehicle by means of a contact rail system supplied by a series of traction power substations as per TP-7, Section 34 20 01 – Traction Electrification – General Requirements and TP-7, Section 34 24 11 – Traction Electrification System Contact Rail Requirements, with associated drawings. All vehicle propulsion and auxiliary equipment shall be designed for operation at the specified contact rail system voltages without damage, failure of the equipment to function, or reduction of required service life.

All vehicles shall be equipped with dynamic braking capability. When the contact rail system is receptive, braking energy shall be regenerated back into the system. Regeneration shall be cut-off at 900 Vdc.

On-board or lineside braking resistors shall absorb any braking energy not utilized for regeneration.

TP-4.5.3.1 DC Contact Rail Voltages

Contact rail voltages shall be as specified in TP-7.

Vehicle-borne equipment shall be protected against damage from continued shutdowns or nuisance trips caused by random interruptions of the contact rail system power, due to isolation gaps, shoegear bounce, or other conditions. Under these conditions, the equipment shall recover automatically without delay to restart or initialize.

Vehicle equipment shall be protected from damage by transient over-voltages in accordance with the requirements of IEC 60850 (2007): Railway Applications – Voltages of Traction Systems.

TP-4.5.3.2 Maximum Line Current

The maximum line draw per vehicle shall not exceed 1200 A (propulsion plus auxiliaries including full air conditioning) at 750 Vdc.

TP-4.5.3.3 Operation Under Reduced Voltage Conditions

All vehicles shall provide forced reduced performance further limiting the vehicle maximum line current under low voltage conditions. The operation of the forced reduced performance feature shall be automatic, controlled solely by the level of the line voltage at the vehicle. The threshold voltage shall be 625 Vdc, and the forced reduced propulsion mode shall be activated if the line voltage falls below 625 Vdc.

The reduction of performance shall be in the form of a linear sliding limit on the maximum propulsion current.

If the line voltage falls below 625 Vdc, the propulsion current limit shall be lowered progressively at a rate of 0.5 percent per volt. Consequently, at the 525 Vdc level, the propulsion current shall be limited to 50 percent of the value corresponding to the maximum vehicle power at 750 Vdc.

The response to changes in the line voltage below 625 V shall be fast enough for the current clamping to be effective, and the propulsion current shall not exceed the theoretical limit corresponding to the present voltage. The forced reduced propulsion control algorithm shall be such as to result in dynamic stability of the current-limiting control process, without oscillations or whipsaws. The Core Systems Contractor shall demonstrate the proper operation of the forced reduced propulsion feature during vehicle qualification testing. The

test shall be performed near the end of the line with the last substation out of service. Plots of the dc line voltage and propulsion supply current shall be recorded during the test to prove compliance with the forced reduced propulsion requirements.

TP-4.5.3.4 Not Used

TP-4.5.3.5 Contact Rail Installation

Power will be supplied to the vehicles via a contact rail, configured for top running.

TP-4.5.3.6 Shoegear Characteristics

The selection of shoegear shall operate satisfactorily throughout all parts of the contact rail system, including all gaps occurring at crossovers, section breaks, etc. The operating range of the shoegear shall be coordinated with the ramps at contact rail gaps so that the initial contact point is approximately two feet from the lowest point in the ramp and that contact bounce and impact damage is minimal.

- Contact shoe type: Carbon
- Shoe contact force: 70 N to 130 N [15.736 lb-f] to 29.225 lb-f]
- Shoes per vehicle: Truck-mounted, 4 per vehicle
- Maximum current capacity (continuous) per shoe: 1350 A

TP-4.5.3.7 Operation Though Rail Gaps

The vehicle shall operate through rail gaps at crossovers, etc. where contact rail power may be momentarily interrupted without affecting the continuous operation of any vehicle systems, including lights, train control/traction/braking or communications equipment. Momentary interruption of HVAC equipment is allowed, but such systems shall quickly and automatically resume normal operation once contact rail power is restored.

The length of the gap in the contact rail will depend on the final special trackwork installation, but is expected to exceed 18.3m [60 ft].

Table 5-1. Typical Contact Rail Gap Details

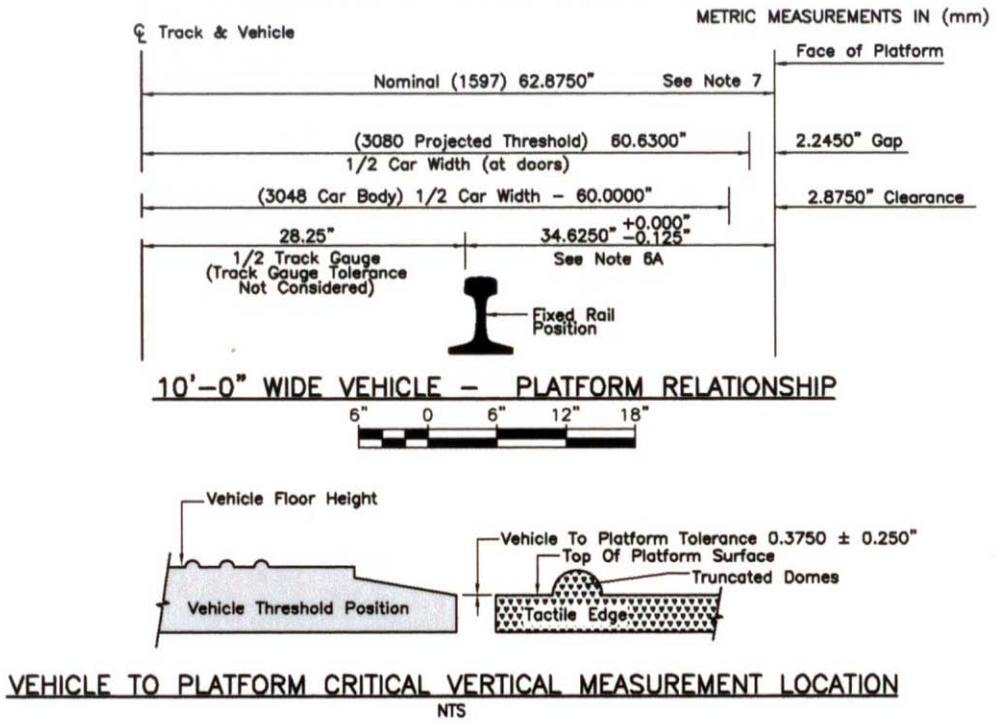
Type of Approach Ramp at Gaps	Application	Length of Ramp	Ramp Inclination Angle
Long	Main Line High Speed	2.74 m [9 ft]	1.33 degrees
Short	Low speed/crossovers	1.52 m [5 ft]	2.4 degrees

Shoegear should be adjusted so as to contact ramp approximately 0.61 to 0.91m [2 to 3 ft] from the low or entry end. Rail / Platform Interface

TP-4.5.4 Rail / Platform Interface

For dimensioned rail to platform interface details, refer to Figure 5-1 and trackwork directive drawing DD-E03-WD650. Any changes to the guideway and station platform interfaces, including suitably revised vehicle static and dynamic envelopes as per Section 4.6.12, must be submitted and approved by the City.

Figure 5-1. Rail / Platform Interface



TP-4.5.4.1 Platform Height

Passenger platforms will all be high-level, with a nominal 1150 mm [45.0 in] height above the top of the rail, to provide easy access for elderly or persons with disabilities, particularly non-ambulatory persons in wheelchairs. Exact platform height shall be coordinated with the City. Platform height will be constructed within a build tolerance band of ± 6.35 mm [±.250 in].

TP-4.5.4.2 Edge to Track Centerline

The nominal horizontal distance between the track centerline and the platform edge at the door threshold will be 1,540 mm [60.63 in]. Exact distance shall be coordinated with the City. This distance will be constructed within a tolerance of +0.0 mm/-3.00 mm [+0.0 in/-0.125 in].

TP-4.5.4.3 Length

Passenger platforms will be a maximum of 73.15 m [240 feet] in length.

A train of maximum length shall be accommodated at all platforms on the system with all doors on the platform side fully useable by passengers.

TP-4.5.5 NOT USED

TP-4.5.6 Automatic Train Control Interfaces

TP-4.5.6.1 Automatic Train Control System

An automatic train control system (ATC) shall be provided as per TP-7, Section, 34 44 00 – Train Control System, to provide unique vehicle identification, vehicle location, and fully automatic control of the vehicle when in normal revenue service.

As a minimum, seven operating modes shall be possible:

- Mode 1: Normal automatic driverless operation with automatic train protection at speeds of up to 65 mph.
- Mode 2: Degraded automatic operation with automatic train protection and at a reduced speed not to exceed 30 mph (failed vehicle limp home)
- Mode 3: Manual operation from a Control Panel, without ATP and with line-of-sight, at a safe operating speed determined by location and track conditions.
- Mode 4: Power outage automatic operation with automatic train protection at an optimum speed to move the vehicle to a station platform for safe unloading of passengers.
- Mode 5: Yard move manual or automatic operation at a maximum speed of 10 mph.
- Mode 6: Train wash manual or automatic operation at a maximum speed of 3 mph.
- Mode 7: Manual or Automatic couple/uncouple operation

The following types of inputs/outputs shall be provided as a minimum to/from the ATC equipment from other items of vehicle equipment, including manual Control panels where provided:

- Contact rail voltage
- Direction selection (forward/neutral/reverse)
- Vehicle speed/no motion information (from two independent sources)
- Control vehicle location
- Control vehicle ID
- ID of all other vehicles in the train
- Selected route (destination)
- Operating mode selection (auto/manual)
- Manual Master Controller position indications
- Passenger door control (open/close)
- Passenger doors open indication
- Passenger doors closed and locked indication
- Door status (Normal/fault/cut-out)
- Derailment detection
- Friction brake status (Normal/fault/cut-out)
- Propulsion status (Normal/fault/cut-out)
- Propulsion demand
- Propulsion cutout control

- Propulsion train wash control
- Brake demand
- Brake cutout control
- Brake status (Normal/fault/cut-out)
- Other vehicle systems status (Normal/fault)
- Other vehicle system bypass/cutout control status (Normal/bypass or cutout active)
- Communications control
- Lights control (internal/external)
- Couple/uncouple controls
- Radio / high-speed wireless LAN link (See Section 5.7)
- ATC equipment power (uninterruptible)

TP-4.5.7 Wireless LAN / High Speed Data Link Interfaces

Utilizing a high-speed data link as provided per TP-7, Section 27 70 00 – Wireless Communication System, the following information shall be transmitted from the vehicle to wayside communication equipment via this link:

Mobile

- Video camera feeds from an active T-TEL or manual door release
- Audio feed from an active T-TEL or manual door release
- On demand video streams from individual vehicle cameras to OCC
- Real-time Maintenance and Diagnostic data from the vehicle
- Basic vehicle travel log data such as vehicle ID, location, mileage, time, etc.
- ATC-related data

Fixed / MSF Yard

- All raw automatic passenger counter data
- Logged Maintenance and Diagnostic data since last download
- Any changes to the messages to be displayed on the vehicle destination or passenger information displays
- Any new audio messages to announced on the vehicle auto-announcer
- Any new advertising messages to be displayed on the vehicle advertising displays (future)
- Any changes to the operating points for the intelligent flange lubrication system

RF spectrum for this system is preferred to be licensed using 2.3, 2.5 or 4.9 GHz bands. Alternatively unlicensed 2.4, 5.8 or 5.9 GHz bands may be considered.

The vehicle supplier design the vehicle antenna installation to complement the trackside antenna patterns so as to maintain a minimum 35 Mbps data rate at a corrected bit error rate (BER) of $10e^{-6}$ over the entire system at vehicle speeds of up to 65 mph.

It is highly recommended that the design of the antenna installation include the following:

- Mounting so no rooftop metal objects or wires intrude into the critical antenna Fresnel zones

- Use of commercial grade microwave software to compute the actual Fresnel zone pattern of the antenna when installed on the vehicle and to verify via simulations that the required signal strengths are maintained throughout the System

TP-4.5.8 Vehicle / Workshop Interfaces

The following equipment/facilities will be provided by the City for maintenance activities on the rail vehicles at the Maintenance and Storage Facility (MSF).

The compact Operations and Servicing (O&S) Building shop area contains the following maintenance tracks:

- Heavy repair (HR) – 2 tracks – capacity 4 vehicles under cover per track
- Service and Inspection (S&I) – 2 tracks – capacity 4 vehicles under cover per track with high level access platforms
- Wheel truing – 1 track – capacity up to 4 vehicles with 2 under cover
- Cleaning (train wash, interior cleaning, sanding, daily inspection) – 2 tracks (outside of MOE building)
- Additional HR and S&I track capacity under cover, as well as a paint booth, are planned future additions.

Should the Core Systems Contractor require additional workshop facilities/equipment than that listed herein for the maintenance of its vehicle, this should be clearly identified in its submission.

Should vehicles having different overall length, width and height dimensions and / or floor height dimensions be offered, in accordance with Section 4.5.1, a suitably revised series of vehicle static and dynamic envelopes, as well as any other changes to the MSF interfaces, shall be submitted and agreed with the City.

TP-4.5.8.1 Wheel Truing

An in-floor wheel-truing machine will be provided in the MSF. The vehicle design shall allow for easy access to the wheel axle end centers.

TP-4.5.8.2 Jacking Points and Vehicle Lifting Devices

Vehicles shall be capable of being lifted by either of the following:

- Portable vehicle lifts provided (for occasional lifting inside the workshop)
- Fixed in-floor hydraulic LRV hoists provided on one HR track (normal means of vehicle lifting in the workshop) – capacity of 1-, 2-, 3- or 4-vehicle trainsets
- Portable jacks (for emergency lifting not in the workshop)

All vehicles shall be provided with dedicated, clearly identified jacking points suitable for lifting all or part of the vehicle.

TP-4.5.8.3 Overhead Cranes

Two overhead bridge cranes with a 15-ton capacity will be provided over the HR tracks to move trucks and other major vehicle components. A 5-ton overhead bridge crane will also be provided over the S&I tracks for rooftop equipment removal and major vehicle component movement.

TP-4.5.8.4 High Level Access Platforms

Two, three-vehicle-length fixed, high-level access platforms (on both sides of the vehicle) will be provided on the S&I tracks in the work bay area.

TP-4.5.8.5 Service Pits

Full-length service pits will be provided for the S&I tracks, adequate for the underfloor inspection/servicing of four vehicles.

TP-4.5.8.6 Shop Power Supplies

No contact rail or traction power stingers are to be provided within the confines of the shop for the movement of vehicles into and out of the workshop. Vehicle movement in and out of the shop shall be by means of a track mobile or a shuttle wagon.

Two types of shop power supply will be provided on all tracks, traction power and auxiliary power. As an alternative, a single, 750-V shop power feed may be provided, as long as a similar level of personnel safety is maintained.

Each vehicle shall be configured so as to limit power consumption and provide an optimal level of safety when operating on either of the shop power supplies. This shall include the following automatic vehicle interlocks/controls whenever shop power is connected:

For auxiliary shop power operation only: All HVAC units shall normally be off. Individual HVAC units may be operated by use of a maintenance switch which shall be interlocked so as to allow only one unit at a time to operate.

The traction power inverters shall normally be off. One or both of the traction inverters may be operated by use of a maintenance switch and the hostler controls. The maximum speed when using shop traction power shall be limited to prevent any propulsion trainline command higher than 0.134 m/s^2 [0.3 mphps] from being issued by the vehicle controls regardless of power position. This function shall limit the vehicle speed to 3.2 km/hr [2.0 mph] (train wash speed).

All shoegear and exposed high voltage connections shall be electrically isolated at all times.

Power shall be provided via an interlocked (make before energizing, de-energize before break) plug and socket arrangement.

Additional interlocks shall be provided so that auxiliary shop power is de-energized and disconnected from the vehicle before traction shop power can be applied.

Auxiliary and traction power plugs on the vehicle shall have male pins and it shall not be physically possible for the shop power supplies to be incorrectly connected to the vehicle or create an electrically hazardous environment.

All vehicle mounted receptacles shall be designed to prevent ingress of dirt and water, have adequate clearance for plugging in of the shop power cables, be adequately sized for the application, be located so as to be readily reached by a shop power cable from either side of the vehicle (i.e., one receptacle on each side of the vehicle), and be equipped with a spring loaded protective cover to automatically seal it when not in use.

Traction 750 Vdc, 140 A shop power shall be provided to individual vehicles via a plug located near the middle of the vehicle located below underframe level. A traction shop power connection shall enable all systems on that vehicle to be energized including the auxiliary

inverters and traction power equipment. Limited movement of the vehicle under traction power shall also be possible to check traction motor operation/direction, etc.

Auxiliary 208 Vac, 180A max, 92A continuous, 3 phase, 60 Hz shop power shall be supplied to individual vehicles via a plug located near the middle of the vehicle below solebar level. An auxiliary shop power connection shall energize all systems normally supplied by the auxiliary power supply, including the battery charger, and allow operation of one HVAC unit plus all essential ac and dc loads without the use of auxiliary inverters. The auxiliary supply shall be controlled using a control scheme and equipment similar to the example shown below in Figure 5-2. The vehicle auxiliary inverter(s) shall be automatically protected from any damage and suitably isolated to prevent any vehicle circuit feedback when auxiliary shop power is utilized.

Figure 5-2. Typical Auxiliary Shop Power Supply Design

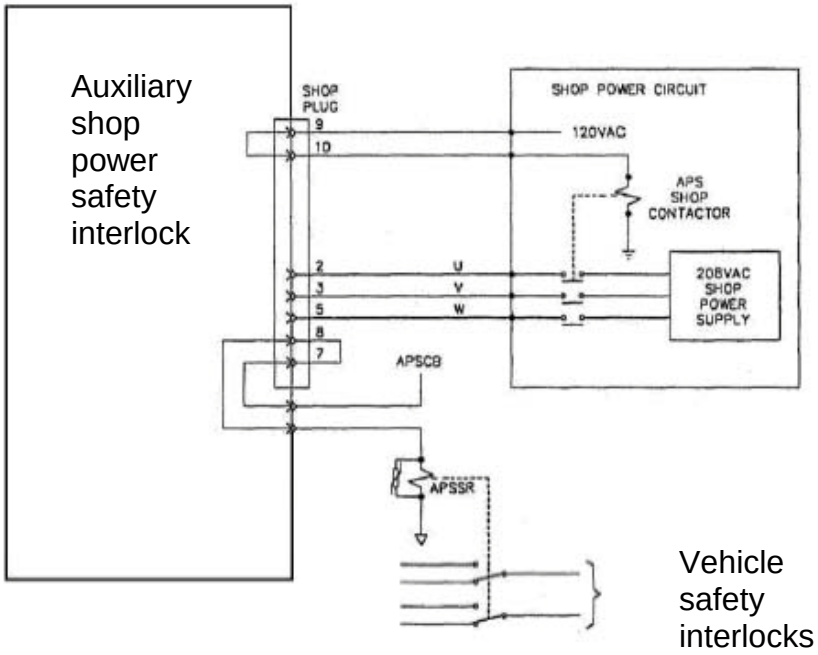
The case plug is AB Connectors' type number:

ABCIRH05EV49A10PCNF80M67.

The mating half (to be supplied by Faiveley Rail) is AB Connectors' type number:

ABCIRHP06GGL49A10SCNF80M67

The pinout is to be as shown in the diagram below:



The Core Systems Contractor shall provide 16 mating connectors with female pins for installation on the shop auxiliary power cables and 16 mating connectors with female pins for installation on the shop traction power cables.

TP-4.5.8.7 Special Tools and Test Equipment

Core Systems Contractor shall identify and supply any vehicle-specific special tools and equipment required for the maintenance of the vehicle as part of this Contract.

TP-4.5.8.8 Sanding Equipment

Sand refilling equipment, if required, will be provided on both cleaning tracks with sand filler nozzles on both sides of the vehicle. The interface of the filler nozzles with the vehicle sand boxes shall be confirmed by the Core Systems Contractor.

TP-4.5.8.9 Washing and Cleaning Equipment

A single-track, enclosed, uni-directional, water recycling vehicle washer will be provided near the cleaning tracks.

TP-4.5.8.10 NOT USED

TP-4.5.8.11 Testing Tracks

With suitable safety precautions, limited, low-speed vehicle testing may be performed in the MSF yard area using circulation and empty storage tracks. All high-speed testing shall be performed on the mainline.

TP-4.6 *Vehicle Performance*

TP-4.6.1 O‘ahu Climatic Conditions

The vehicle shall be capable of being operated at the performance levels specified in these Technical Provisions without any restrictions resulting from the climactic conditions to be found on the System.

It is the responsibility of the Core Systems Contractor to verify the validity of any climactic data used for vehicle system design work.

With maximum wheel wear, the vehicle shall operate without equipment damage or malfunction in water up to 51 mm [2 in] above top of rail at speeds of up to 16 km/hr [10 mph].

TP-4.6.2 Vehicle Dynamic Performance

The vehicle normal acceleration and braking performance shall be adequate to meet the system operational service requirements as defined in TP-3.4.

TP-4.6.2.1 Acceleration

The vehicle acceleration performance shall be adequate to meet the system operational service requirements as defined in TP-3.

Acceleration rates may decrease linearly for over AW2 through AW4 load weights. At line voltages below 750 Vdc, the speed to which initial acceleration rate is held may decrease proportional to contact rail voltage. At voltages below 625 Vdc, forced reduced propulsion as required per Section 4.5.3.3 shall apply.

The spin/slide system, load weigh compensation and jerk limitation shall function at all times the vehicle is accelerating.

Propulsion performance capabilities shall be provided over the full range of the following:

- Wheel wear
- Ambient temperatures
- Battery power supply voltages.

The spin/slide system, load weigh compensation and jerk limitation shall be active for all vehicle acceleration demands.

In case of the failure of one traction inverter, the following shall apply:

When dynamic braking is not available on any truck or vehicle, the vehicle and its associated train shall be automatically limited to a maximum operating speed of 48 km/hr [30 mph] ± 10 percent and, when in manual operation, the fault/speed limit annunciated to the operator.

TP-4.6.2.2 Braking

Service Brake

Service braking shall be accomplished using a blended combination of dynamic and friction braking, with dynamic braking being the primary source of braking effort in normal

operation. The vehicle braking rates shall be continuously variable as appropriate for the vehicle speed and circumstances.

In normal operation, the blended braking combination shall provide braking capability for all vehicle weights up to and including AW3 and over the entire operating speed range as follows:

- The vehicle service braking performance shall be adequate to meet the system operational service requirements as defined in TP-3.
- The instantaneous variation in blended braking rate shall not exceed ± 0.09 m/s² [± 0.20 mphps], at any speed dynamic braking is active, with any requested braking rate.
- The dynamic brake shall provide the total required braking effort for vehicle weights up to and including AW2. For higher rate requests and/or vehicle weights, the remainder of the blended braking effort shall be provided by the friction braking system.
- Dynamic brake fade shall not occur above 9.7 km/hr [6 mph]. The dynamic brake shall contribute braking effort down to 2 km/hr [1.2 mph].
- For vehicle loading above AW3, the average braking rate shall decrease linearly, the reduced rate being the ratio of AW3 to the actual vehicle load times the applicable normal AW3 rate.
- The spin/slide system, load weigh compensation and jerk limitation shall be active during all service brake applications.

In case of full or partial dynamic brake failure, the following shall apply:

- In the event of dynamic brake failure on a truck, the friction braking control system for that truck shall automatically provide a fixed deceleration rate.
- When dynamic braking is not available on any truck or vehicle, the vehicle and it's associated train shall be automatically limited to a maximum operating speed of 48 km/hr [30 mph] ±10 percent and when in manual operation, the fault/speed limit annunciated.
- With the dynamic brake disabled, the friction brake system shall have sufficient thermal capacity to complete one system round trip with an AW2 load at the reduced maximum speed.

Maximum Braking (B MAX)

Maximum braking shall be at the full service brake rate, plus the magnetic track brake (if provided), to produce the maximum braking rate possible.

The load weigh, spin/slide system (including automatic sanding, if required) and jerk limitation shall remain active.

The magnetic track brakes (if provided) shall automatically be released when vehicle zero speed is detected. If magnetic track brakes are not provided, The Core Systems Contractor shall demonstrate to the satisfaction of the City that trains under automatic operation will stop safely under all scenarios and operating conditions without such capability.

In maximum braking mode, the deceleration rates shall exceed and stopping distances shall be less than those specified for emergency braking specified below.

Emergency Braking (Panic Brake)

Emergency braking shall be accomplished using a combination of fixed force friction braking, supplemented by load compensated dynamic braking for vehicle weights above AW1, plus magnetic track brake and sanding, if provided, to produce a maximum rate brake application without the use of friction brake control electronics.

The emergency brake shall be separately trainlined and shall be fail-safe in operation.

In normal operation, the emergency braking combination shall provide braking capability for all vehicle weights up to and including AW3 and over the entire operating speed range.

- Sanding, if required, shall be automatically applied until zero speed is detected
- The spin/slide system and jerk limitation shall be inactive when Emergency braking effort is activated.
- The magnetic track brakes, if provided, shall automatically be released when vehicle zero speed is detected.
- In the case of total or partial dynamic brake failure, the friction brake system shall have the capability of providing Emergency braking rates for at least one stop from 88.5 km/hr [55mph].

TP-4.6.2.3 Jerk Limit

In response to an instantaneous input command signal, the rate of change of acceleration or deceleration shall be software adjustable between 0.45 m/s^3 [1.0 mphpsps] and 0.9 m/s^3 [2.0 mphpsps] ±10 percent for vehicle weights up to and including AW2 under all normal operating conditions.

TP-4.6.2.4 Balancing and Continuous Speed

The vehicles, when operated as a trainset, shall have a balancing speed of no less than 109.4 km/hr [68 mph] on level tangent track with any condition of wheel wear, nominal line voltage, weight AW0 through AW2, in still air.

TP-4.6.2.5 Spin / Slide Protection

Spin/slide protection shall be provided on each truck during both acceleration and braking (except for emergency brake initiation) to minimize damage to wheel treads caused by wheel slide or spin and to shorten stopping distances under adverse rail conditions under all vehicle weights and operating speeds as follows:

- The efficiency of the wheel spin/slide system shall be at least 85 percent when the wheel/rail coefficient of adhesion is 0.05 or greater over the entire vehicle operating speed range. The spin/slide efficiency percentage shall be defined as the actual average vehicle rate of acceleration/deceleration divided by the maximum theoretically possible rate the available adhesion is capable of supporting times 100 percent.
- Operation of the spin/slide system shall not produce sustained oscillations at frequencies above 1.5 Hz.
- The spin/slide system shall function properly with differences of up to 50 mm [2 in] in wheel diameter among the wheels of a vehicle.

TP-4.6.2.6 Motion Detection

The vehicle shall be provided with a motion detection system that shall generate a fail-safe signal, indicating that no-motion has been detected. The system shall detect motion down to, and including, 3 km/hr [2 mph] for vehicle systems that require motion detection information. A no-motion signal shall be generated when the vehicle speed is less than 3 km/hr [2 mph].

TP-4.6.2.7 Parking

The vehicle parking brake system shall be capable of holding an AW4 loaded vehicle on a 6-percent grade indefinitely.

TP-4.6.2.8 Normal Operation on Grade

An AW3 loaded consist of 2, 3 or 4 vehicles shall be capable of safely ascending or descending a 6-percent grade without causing damage or reduction in traction or braking equipment life for distances up to 3.2 km [2 miles] at a speed of at least 32.2 km/hr [20 mph].

TP-4.6.2.9 Failure on Grade – Vehicle Retrieval

An AW3 loaded four-vehicle consist shall be capable of pushing or towing a failed AW3 loaded four-vehicle consist from the point of consist failure to the next station, offloading all passengers, and continuing at AW0 load from the most distant point on the system to the end of the line or MSF.

Under these conditions, the vehicle shall operate at reduced performance, but without causing damage or reduction in traction or braking equipment life. This performance shall be as follows:

- For a 6-percent grade:

Starting on a 6-percent grade ascending and proceeding for a next station distance of up to 3.2 km [2 miles] at a speed of at least 8 km/hr [5 mph]

Starting on a 6-percent grade descending and proceeding for a next station distance of up to 3.2 km [2 miles] at a speed of at least 32.2 km/hr [20 mph]

- For level track:

Starting on level track and proceeding for a next station distance of up to 1.6 km [1 mile] at a speed of at least 48 km/hr [30 mph]

A ‘hill climb’ facility may be provided to allow short-term maximum tractive effort to assist in meeting these requirements.

TP-4.6.3 Heating, Ventilation and Air Conditioning

The HVAC system design shall make every effort to reduce the requirement for air conditioning capacity through utilization of vehicle passive and active measures that will reduce solar and radiated heat load, while minimizing cool air loss. Additional HVAC functional requirements are found in Section 4.7.9.

The vehicle heating, ventilation, and air conditioning (HVAC) system shall meet the following performance requirements:

- Air Conditioning: Each vehicle shall have an independent, modular (no split systems), roof-mounted air-conditioning system.
- Ventilation and Air Circulation: All of the ventilated air shall be introduced through the air-conditioning equipment and shall not include air introduced when the doors are open. There shall be no passenger openable windows.

- Heating: No heating system shall be provided.
- Condensation and Humidity: The HVAC system shall minimize condensation on interior surfaces, including windows. Reheat is permitted if required to limit the interior humidity and control condensation.
- Controls/Temperature Uniformity: Interior temperature shall be fully automatically controlled in cooling, ventilation and heating modes without manual intervention
- Air Flow, Diffusion and Discharge Temperature: The air distribution system shall provide sufficient diffusion at the outlet or diffuser so that air mixing will prevent direct impingement of air onto occupants.
- Environmental Emission Standards: The air-conditioning system shall meet all international environmental emission standards, and shall utilize environmentally friendly R-407C refrigerant or a City-approved alternative.

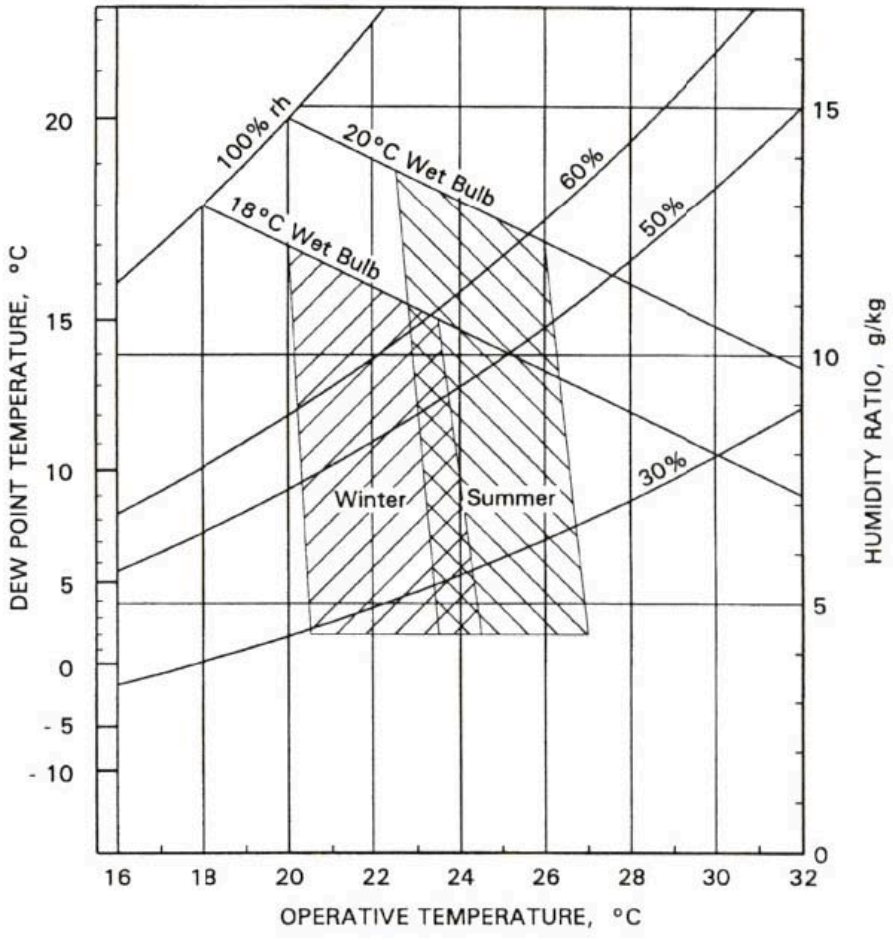
TP-4.6.3.1 Temperature Control

The HVAC system controls shall maintain the vehicle interior conditions so as to remain within the comfort zone of acceptable indoor operative temperature ranges as shown in Figure 6-1.

The maximum allowable variations in temperature in the vehicle passenger areas shall be as follows:

- Less than 2.2° C [4º F] variation at any height from 150 mm [6 in] to 1220 mm [48 in] above the floor
- Average vehicle temperature shall be within 1.1º C [2º F] of the comfort zone requirements within 2 minutes following a 30 second opening of all vehicle passenger doors on one side.

Figure 6-1. ASHRAE Summer and Winter Comfort Zones



Source: ASHRAE Fundamentals Handbook – 2001, Chapter 8, Fig. 5

TP-4.6.3.2 Interior Fresh Air Intake

Intake of filtered fresh air shall be provided for each vehicle, the required fresh air volume being between 34 m³/min [1200 ft³/min] and 40 m³/min [1400 ft³/min] regardless of vehicle position in a train or the vehicle speed and shall be adequate to maintain the positive pressurization requirements of Section 6.3.4 below.

TP-4.6.3.3 Interior Air Filtration

The HVAC system filter elements shall be capable of removing fine dust and allergens to an 85 percent efficiency level as per ASHRAE 52.2 – Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size.

TP-4.6.3.4 Interior Positive Pressurization

The ventilation system shall maintain a vehicle internal positive static pressure at all vehicle speeds and a minimum static pressure of 2.5 mm [0.10 in] of water when all doors and windows are closed.

TP-4.6.3.5 Interior Maximum Air Velocity

To increase system efficiency and minimize air noise, the maximum air velocity through the HVAC ductwork shall be 6 m/sec [1200 ft/min].

TP-4.6.3.6 Energy Efficiency

The HVAC system shall achieve an Energy Efficiency Ratio (EER) of 9.1 or better, where:

EER = Cooling Capacity (BTU/hr) / Input Power (Watts)

This shall be achieved by use of scroll compressors and variable speed air supply fans that automatically adjust speed depending on the temperature.

An automatic layover mode shall also be provided to reduce or drop entirely HVAC usage after a period of 15 to 30 minutes.

TP-4.6.3.7 Design Temperatures

For the purposes of the overall HVAC system design, the following design parameters shall be used:

- Honolulu Latitude: 21.35º, Longitude: 157.93°, Elevation: 4.88 m [16 ft]
- Summer Design Ambient: 31.66 ºC [89ºF] DB, 24.44 ºC [76ºF] WB
- Summer Vehicle Interior: 24.44ºC [76ºF], 50 percent RH
- Winter Design Ambient: 16.11 ºC [61ºF] DB

TP-4.6.3.8 Cooling Loads

For the purposes of HVAC cooling system design, the following thermal load parameters shall be used in calculating HVAC system performance and sizing HVAC units:

- Occupants: Assume vehicle AW2 loading
- Seated passengers: 117.2 W/hr [400 Btu/hr] TH, 71.79 W/hr [245 Btu/hr] SH per passenger
- Standees: 131.85 W/hr [450 Btu/hr] TH, 73.25 W/hr [250 Btu/hr] SH per passenger
- Fresh Air: as required by Section 4.6.3.2 above
- Vehicle body Conduction: The Core Systems Contractor shall provide 'U' factors and associated surface areas for the vehicle walls, doors, ceiling, floor, window glass (including tint), gangways, and vehicle ends (E type vehicles only) based on the worst-case vehicle skin temperature and the specified interior temperature for use in the HVAC calculations.
- Solar Gain: The attendant solar gain shall be calculated based on a Honolulu location on July 21st at 1600 hours with the maximum possible area of vehicle window, door, and windshield glass facing into the sun.
- External Radiated Heat Loads: Radiated heat loads generated by roof-mounted equipment and underfloor-mounted equipment, including the effect of any skirts, shall also be included. Radiated heat generated by the concrete guideway shall be included in the HVAC calculations with no deduction for any shading effects arising from the passing of the vehicle; i.e., the vehicle underfloor is fully exposed to this heat source.

- Door Opening Heat Loads: For an average duty cycle, the vehicle doors may be open for up to 15 percent of the journey time. Assume a worst-case loss of interior chilled air where all doors on one side of the vehicle are opened for 20 seconds at each station stop and that 8.5 m^3/min [300 ft^3/min] of cool air is lost per door. Cooling loss/heat gain arising from periodic door opening (convection and radiated) shall be included in the HVAC calculations. The vehicle duty cycle specified in Section 4.3.2 shall be used as the basis for modeling this phenomenon.
- Internal Heat Loads: Detailed information regarding heat generated inside the vehicle by lighting, control electronics, etc. shall be provided by the Core Systems Contractor and its suppliers and included in the HVAC calculations.

TP-4.6.4 Crashworthiness and Structural Strength

The System will operate primarily in elevated, reserved rights of way, thus the vehicles can be expected to experience the occasional vehicle to vehicle collision, most likely at low speed when being operated manually during maintenance and cleaning activities, although the potential exists for higher speed collisions under exceptional operating conditions. It is therefore prudent to adopt a vehicle Crash Energy Management design approach which shall focus on the following basic requirements:

- Emphasis on protection of the non-gangway ends of the end vehicles to reduce impact forces and to absorb collision energy.
- Provision of easily and quickly repairable vehicle non-gangway end components to minimize vehicle downtime in event of an accident.
- To meet the above safety requirements, the following design measures are to be provided:
- Secondary truck-mounted lifeguards shall be provided to prevent anyone who may have fallen underneath the vehicle from being run over by the trucks.
- Vehicle end-mounted anticlimber elements shall be provided to prevent vehicles overriding each other in the event of a vehicle-to-vehicle collision.
- The vehicle non-gangway end structure shall collapse in a controlled manner in order to absorb excess collision energy not absorbed by the couplers.
- Couplers with energy-absorbing elements shall assist in reducing structural damage to the vehicle and protection of the passengers from collision shock loads.

TP-4.6.4.1 Structural Design Loads

The structure of the vehicle body shall maintain the lowest possible weight consistent with the strength requirements.

The vehicle body shall be designed to meet or exceed, the following design loads for light rail vehicles based on Table 1 of ASME RT-1-2009: Safety Standard for Structural Requirements for Light Rail Vehicles*:*

- Vertical load: Allowable stress less than 65 percent of yield strength (AW4, without trucks). There shall be no buckling or loss of local stability.
- Vehicle shell end sill compression: 400 kN [90,000 lb] with AW4 vertical load. There shall be no permanent deformation of vehicle body structural members or sheeting (except in Zone 1 energy absorption area).
- Coupler bracket compression: 110% of maximum possible load. There shall be no permanent deformation of any structural member or sheathing.

- Coupling impact: Coupling at a vehicle closing speed of 8 km / hr [5 mph]. There shall be no permanent deformation of vehicle body structural members or sheeting (except in Zone 1 energy absorption area).
- Coupler anchorage tensile load: Loads shall meet the required duty. There shall be no permanent deformation of vehicle body structural members or sheeting.
- Collision post or protective collision wall structure shear load: 400 kN [90,000 lb] applied in the longitudinal direction to each post separately or to the collision wall structure at the top of the underframe at a lateral location of 30% of the end frame width as measured from the vehicle centerlione. Ultimate strength of carbody structure not to be exceeded.
- Collision post or protective collision wall structure loads: 133 kN [30,000 lb] applied 380 mm [15 in] above floor level. There shall be no permanent deformation of vehicle body structural members or sheeting.
- Corner post loads: A first load of 133 kN [30,000 lb] applied as a shear load just above the post's connection with the underframe, and a second load of 66.7 kN [15,000 lb] applied as a bending load at 380 mm [15 in] above underframe. The consecutive application of the above loads shall be: First load applied parallel with the longitudinal vehicle axis, and the second load applied inward in any direction from outside. There shall be no permanent deformation of vehicle body structural members or sheeting.
- Structural shelf below windshield: Longitudinal load of 66.7 kN [15,000 lb] at any point. There shall be no permanent deformation of the shelf.
- Side walls: Load of 178 kN [40,000 lb] applied at side sill distributed along an area 2.4 m by 150 mm [96 in by 6 in] including doorways and 44 kN [10,000 lb] distributed along belt rail (bottom of window openings) along an area 2.4 m by 150 mm [96 in by 6 in] excluding window openings. There shall be no yielding of vehicle body structure.
- Seat Mounting Rails: The cantilever/tip-up seat mounting rails shall be either part of the vehicle structural side walls or attached thereto and of sufficient strength that the deflection requirements of Section 4.6.4.6 below are met.
- Anticlimbers shall be designed so that two out of three anticlimber ribs, under a vertical load of ±178 kN [40,000 lb], combined with 400 kN [90,000 lb] longitudinal load uniformly applied to the total number of anticlimber ribs less one, shall remain fully intact and cause no permanent deformation of the vehicle body structure. For aesthetic considerations, these ribs should be covered with a dense foam or plastic cover that will readily deform under collision loads.
- Roof structure, sheeting, equipment covers, walkways shall have sufficient strength to withstand without permanent deformation with concentrated loads of 1.36 kN [300 lb], spaced over an area of 380 mm by 330 mm [15 in by 13 in], such as might be applied by maintenance personnel carrying tools and equipment while working on the roof.
- Vehicle jacking: Vehicle standing on lifting pads at AW0 with each of the lifting points lowered one at a time relative to the plane of the remaining supporting points until the load is 10 percent of the nominal load per point. No permanent deformation of vehicle body structure or damage to windows.
- Truck/running gear to Vehicle Body Connection: Applied load of 400 kN [90,000 lb] applied longitudinally and twice the truck weight mass vertically. No permanent deformation of vehicle body structure.

- Equipment attachments: Separately applied accelerations of ±5g longitudinal, ±2g transversely and ±2g vertically. Stress not to exceed ultimate strength of attachment.
- Collision Zone 1 – low severity impact: Closing speed between two like vehicles of 8 km/hr [5 mph]. No structural damage to either vehicle with possible exception of energy-absorbing elements (recoverable or replaceable)
- Collision Zone 2 – Moderate severity impact: Closing speed between two like vehicles of 24 km/hr [15 mph]. Maximum crush displacement measured from anticlimber not to exceed 300 mm [12 in].
- Collision Zone 3 – High severity impact: Closing speed between two like vehicles of 40 km/hr [25 mph]. Crush damage limited to non-gangway end sections with no loss of passenger compartment volume.

The vehicle body structural strength calculations/FEA analyses shall be submitted for review by the City.

TP-4.6.4.2 Energy-Absorbing Couplers

The coupler system shall permit trains to operate over all track profiles of the System main line and the MSF, including the worst-case combinations. The following operating conditions shall be met without damage to the coupler, other equipment, or the vehicle structure:

- All right-of-way constraints
- Any possible train consist up to and including a four-vehicle consist
- Variations between adjacent vehicles in a train resulting from uneven loading, full wheel wear, maximum suspension travel, and suspension failure.
- Couplers shall have energy-absorbing elements to reduce structural damage to the vehicle and protect passengers from coupling and collision shock loads. The coupler system shall be capable of withstanding coupling one AW0 loaded vehicle, to another parked AW0 vehicle at speeds up to 8.0 km/hr [5.0 mph] without causing any permanent deformation of the energy-absorption elements, damage to the bumpers or any engagement of the anticlimbers.
- Above 8.0 km/h [5.0 mph], coupled couplers shall remain coupled but, either through the use of break away bolts or additional stroke within the coupler absorbing elements, shall allow the assembly to move rearward to allow the anticlimbers on the colliding vehicles to engage.
- The travel length of the energy-absorbing element and coupler head shall be at least 25 mm [1 in] in excess of the travel required to permit the anti-climber bumpers to fully engage. Under normal operation, the draft gear deflection shall not exceed 50 mm [2.0 in] in draft and buff.
- The coupler and draft gear shall be strong enough to allow, under emergency conditions, a four-vehicle train with an AW3 passenger load operating at degraded dynamic performance, to push or tow an inoperable train of up to four vehicles with an AW3 passenger load, without damage to the coupler or vehicle body, over all grades and curves of any part of the System.
- The coupler assembly strength shall be compatible with a coupler mounting bracket compression rating of 450 kN [100,000 lb.] with AW4 load.
- All exposed parts of the coupler upon which it is possible to stand shall be able to withstand without permanent deformation or damage, a 180 kg [400 lb] load.
- The gathering range of the coupler and the centering and leveling device tolerances shall be sufficient for two vehicles with correctly adjusted couplers to automatically

couple on level tangent track under the worst-case combination of permitted wear and vehicle displacement.

The energy-absorbing auto-coupler arrangement, calculations/FEA analyses shall be submitted for review by the City.

Please also refer to Section 4.7.2 for further coupler details.

TP-4.6.4.3 Controlled Collapse Vehicle End

The vehicle non-gangway end structure shall collapse in a controlled manner to absorb excess collision energy not absorbed by the couplers. All deformation shall be confined to the vehicle non-gangway end area until the specified crash energies are absorbed.

The vehicle non-gangway end shall be designed to absorb at least 350 kJoules [285,000 ft-lb] of energy by means of a controlled collapse in a distance of between 500 and 700 mm [20 to 28 in] and maintain a survival space for any operator. The energy-absorbing elements shall be mechanically attached and easily replaceable with a minimum of time and labor.

The vehicle non-gangway end calculations/FEA analyses shall include a graphic visual simulation of the progressive end collapse on a CDROM and shall be submitted for review by the City.

TP-4.6.4.4 Vehicle Body Natural Frequency

The vehicle body natural frequency shall be between 2.5 and 7 times the secondary suspension natural frequency for AW4 to AW0 respectively.

TP-4.6.4.5 Truck Strength

The vehicle trucks shall be designed to meet the following design loads:

- The static strength design condition for the truck frame and bolster shall be based on the truck's share of the vehicle AW4 design load weight, minus the weight of the trucks, plus the truck's share of the vehicle AW4 design load multiplied by 0.25 (the vertical component of the dynamic load).
- The vertical load on the truck shall be no less than the truck's share of the design load, including weight transfer effects such as tractive effort reactions and any vertical loads arising from friction or track braking and any accessory loads.
- The longitudinal load, applied at the center of gravity of the vehicle, shall be no less than the maximum possible instantaneous braking effort (friction and dynamic plus track brake) with a vehicle AW4 loading and 50 percent adhesion, plus any longitudinal loads arising from accessory loads.
- The lateral load, applied at the center of gravity of the vehicle, shall be no less than that developed at vehicle overturning and include any lateral loads arising from accessory loads.
- Accessory loads, such as those produced by friction brake units, track brakes, and traction motors, shall be applied using their maximum values as a steady state condition. For example, maximum motor torque and brake unit weight, and maximum brake unit reaction and motor weight, or the worst combination (brake blending) of both.
- For steel trucks, the allowable stresses shall be as per AWS D1.1 or approved equivalent. Should the Core Systems Contractor propose a truck frame and bolster

design of other than steel, the Core Systems Contractor shall submit allowable stress design limits for their design that shall meet or exceed the intent of this section.

- The fatigue design of the truck frame and bolster shall be based on the vehicle AW2 design load minus the weight of the trucks, along with shock and vibration loads from flat wheels, trackwork limitations such as but not limited to switches and crossings, and any possible combination of accessory loads, when operating at 104.6 km/hr [65 mph].
- The truck lifeguard shall withstand the impact of a 80.5 kg [178 lb] sandbag at 20 km/hr [12.5 mph] without fouling the truck wheels or deforming in such a way as to cause vehicle derailment.

In advance to manufacturing truck and truck bolster the Core Systems Contractor shall present its stress analysis for review by the City. The Finite Element Analysis (FEA) should be the prime analytical tool used for this purpose, which, when deemed beneficial or necessary should be supported by manual calculations. All assumptions, i.e. loads, section properties, boundary conditions, allowable stresses, etc. shall be supplied for initial approval prior to the analysis.

The complete truck analysis shall include:

- The truck and bolster production drawings,
- A complete set of the fea outputs,
- A diagram showing loads to the track and truck bolster,
- A summary of stresses in all members,
- Separately, a table of stresses exceeding 80 percent of allowable stresses.

These submittals shall be used to determine the location of strain gauges for static and fatigues stress tests.

TP-4.6.4.6 Passenger Seat Strength

The passenger seat assemblies, including grab handles and the attachments to the vehicle body shall withstand, with a permanent deformation of less than 3.2 mm [0.125 in], the following loads applied simultaneously:

Seat base

Vertical load F1 distributed over the front edge

- Single seat: 1814 N [400 lb]
- Double seat: 3629 N [800 lb]

Seat back

Longitudinal and vertical loads F2 applied to the top of the seat backs, distributed along the length of the grab handle. Where there are no grab handles, the loads shall be distributed over the full width of the seat back.

Single seat

- Longitudinal load acting in either the fore or aft direction: 1361 N [300 lb]
- Vertical load: 900 N [203 lb]

Double seat

- Longitudinal load acting in either the fore or aft direction: 2722 N [600 lb]
- Vertical load: 1800 N [406 lb]

The seat fixings and mounting rails shall be designed to carry loads F1 and F2 simultaneously.

All transverse seats shall be constructed to withstand loads resulting from two 95th percentile US adult males being thrown against the seat with a longitudinal force of 2g. These loads shall be applied from both the front and back of the seat. Permanent deformation shall be allowed, but the seat shall not tear loose from its fastenings.

As an alternative to the above, the seat strength requirements of section 3 of APTA SS-C&S-016-99, standard for seating in Rail Commuter Cars, will be accepted.

TP-4.6.4.7 Door Panel Strength

The closed and locked door shall be able to withstand without deterioration a pushing force applied from inside towards the outside. The pushing force is simulated by application on the door of a force evenly distributed over a strip 200 mm [7.87 in] high, located at the mid-height of the zone accessible to passengers. The value of this force shall be 2400 N [539.54 lbf].

The allowable maximum deflection under these conditions shall be limited to 20 mm [0.75 in] maximum with no permanent deformation or damage to the door panel.

Additional specific passenger door functional requirements are defined in Section 7.8 below.

TP-4.6.4.8 Windshield Impact Strength

The windshields fitted to the non-gangway ends of the end vehicles shall be constructed to meet the Department of Transportation 49 CFR 223, Type I impact and ballistics requirements.

TP-4.6.5 Ergonomic / Universal / Accessibility / Aesthetic Design

Professional industrial design services shall be utilized by the Core Systems Contractor during the design and manufacturing phases of this contract shall be submitted for City review which addresses in detail the ergonomic, universal, and aesthetic design requirements of this section.

A series of studies shall be undertaken to demonstrate that ergonomic and universal design principles have been applied to the areas of the vehicle required by this section. This shall include scaled drawings and models to demonstrate sight lines, good layout of controls, and ease of use when manual operation from the Control Station is desired.

The vehicles, their systems and sub-systems shall be designed in such a way as to be easy to use, simple, efficient, reliable, accessible and safe for the widest possible range of passengers and system Operations personnel.

MIL-STD-1472F – Department of Defense Design Criteria Standard - Human Engineering, establishes detailed and easily understandable criteria. These design criteria shall be the basis for the absolute minimum ergonomic requirements for the vehicle design.

For ergonomic design purposes, the vehicle shall be able to accommodate, as a minimum, the range of passengers and System operations personnel ranging from the US 5th percentile female to the 95th percentile male. Current US anthropometric details to be used are in the latest edition of the Architectural Graphic Standards – Section 1: Human Dimensions. Where these details are insufficiently comprehensive, MIL-HDBK-759C – Human Engineering Design Guidelines, Section 5.6, Tables 16a though 16f, General Forces shall be used.

TP-4.6.5.1 Areas for Application of Ergonomic Design Principles

Specific key areas where the application of ergonomic design principles shall be required include, but are not limited to the following:

- Control Station, including layout of all controls, indicators, warning lights, sight lines and adequate short term seating/support.
- Roof and underfloor mounted equipment, especially as regards routine maintenance, access and replacement
- Door gear, lighting and other internally mounted equipment, especially as regards routine maintenance, access and replacement
- Passenger door height, width
- Passenger seat height, width, etc.
- External destination display visibility/sight lines
- Interior passenger information display visibility/sight lines, especially in a fully loaded (AW3) vehicle
- Standing passenger sight lines for location of route maps, Train Emergency Speakerphone (T-TEL) station, and door status lights, etc.

TP-4.6.5.2 Universal Design

The vehicle shall provide enhanced physical, sensory and cognitive features to accommodate a wide spectrum of people with diverse capabilities who may be expected to ride on a light metro transit vehicle. Passenger types using the vehicle may include:

- Very young children, with limited vocabulary, grammar and reasoning skills
- Fully fit individuals with excellent mobility, vision, and hearing
- Individuals with limited literacy
- Individuals whose first language is not English or who have different cultural backgrounds
- Older adults with diminished memory and reasoning skills
- Individuals who are tired, ill or distracted
- Individuals with reduced vision, color differentiation, or ability to cope with a busy visual environment
- Individuals with limited comprehension, memory, concentration or reasoning due to medical or birth conditions
- Individuals with diminished mobility, and chronic or temporary movement limitations such as reduced reach, and ability to grasp objects
- Individuals with impaired hearing or deafness
- Individuals of extreme body size or weight
- Women in later stages of pregnancy
- Older adults with diminished strength, stamina, and balance

- Individuals using assistive devices such as wheelchairs, canes, walkers, strollers and crutches
- Individuals using service animals such as seeing-eye dogs, etc.

TP-4.6.5.3 Principles of Universal Design

The seven basic principles of universal design are included herein as a reminder as to what guiding principles must be considered in the design process.

- Design is useable and appealing to people with diverse abilities without segregating or stigmatizing any users
- Design accommodates a wide range of individual preferences and abilities
- Design is simple and intuitive to use
- Design clearly communicates any needed information to the user regardless of user's sensory or language capabilities
- Design minimizes hazards and adverse consequences of accidental or unintended actions by user
- Design can be used efficiently and comfortably with a minimum of physical effort
- Design provides adequate positioning, size and space for use regardless of user's body size, posture or mobility

TP-4.6.5.4 Areas for Application of Universal Design Principles

Universal design principles shall be applied to the following specific areas:

- Handrails, grab poles, seatback handles, etc. (position, color, type, grips)
- All graphic elements, especially signage (color, location, visibility, understandability)
- Passenger seats (comfort, size, shape, finish, ease of fold-down and graphics on tip-up seats)
- Manual operating controls (position, color, visibility, ease of use)
- Destination displays (color, location, visibility)
- Public address system/auto-announcer (audibility, type of messages)
- Passenger doors (pushbutton location, operating force and height, operating logic, safety devices and timing, indicator lights and audible signals, graphics, size and position of glass in door leaf)
- Universal area (layout, intrinsic visibility, ease of use, user security, graphics)
- Choice of interior colors (contrast, colors)
- Warning/indicator lights (colors, location, visibility, graphics)
- Emergency stop handles (location, height, actuating force, color, operating logic, graphics)
- T-TEL station (location, height, audibility, color, operating logic, graphics)
- Bodyside windows (size, height, tinting, passenger sight lines and graphics)
- Emergency equipment (fire extinguisher location, any emergency de-boarding equipment, ease of access, ease of operation, color, graphics)

TP-4.6.5.5 Sustainability

The goal is to design, construct, operate and maintain a vehicle that uses the most cost-effective practices while providing the greatest environmental benefit using innovative

technologies as set forth in MP-8 – Sustainable Practices. The design of the vehicle shall be based on sustainable design approaches, methods of construction and selection of materials to achieve the following sustainability goals and objectives:

- Minimum energy use through use of efficient equipment, sealing and insulation/solar shielding
- Maximum energy recuperation during braking (regeneration plus on-board energy storage)
- Low-heat LED or high-efficiency fluorescent lamps throughout vehicle with automatic daylight controls to reduce interior lighting levels when ambient light is available.
- High efficiency HVAC units
- Automatic layover mode to reduce energy usage after vehicle is stationary in a yard or at the end of the line for 15 to 30 minutes
- Minimal noise production/wheel squeal
- Universal areas including bicycle and luggage storage capabilities
- Choice of materials to have a long life and minimize life-cycle costs
- Minimum use of volatile organic compounds in all adhesives, sealants, paints, coatings and finishes.
- Use of LED lighting wherever practical

TP-4.6.5.6 Design for Cleaning

To attract and retain passengers, vehicles must be kept clean and free from graffiti. By careful choice of materials and design, the effort involved in performing cleaning shall be minimized.

To make vehicle cleaning simple and efficient, the following vehicle design features shall be provided by the Core Systems Contractor:

- Provide passenger seats with no underseat obstructions, equipment cases, or legs attached to the floor.
- Provide vertical stanchions with no attachments to the floor
- Provide flooring with coving curving up the vehicle side. There shall also be no right angle joins.
- Weld together flooring sections and coving so as to prevent water and cleaning solutions from penetrating the floor and causing unseen damage to the vehicle subfloor.
- Avoid the creation of dead end corners, pockets, or other places where dirt and debris would readily accumulate. This is especially important in seat design, between individual cushions and cushions and the bodyside.
- Avoid ledges and other horizontal surfaces where dirt and dust will accumulate.
- Provide vandal resistant and easily cleaned seat coverings
- Provide vandal and graffiti resistant interior and exterior finishes.
- Provide two onboard 120 Vac outlets for use by cleaners in each main passenger compartment.
- Provide crew access key switches to allow entry to vehicle by cleaning staff.

TP-4.6.5.7 Aesthetic Design

Good overall vehicle aesthetic design is also an important element in gaining public acceptance and in blending in with the cityscape. The Core Systems Contractor is encouraged to create a fun, easy to use and attractive overall vehicle aesthetic interior and exterior design that respects the people who use it and the people it passes by. The vehicle design shall be visually distinctive and appealing to riders, reflecting a modern, forward thinking image.

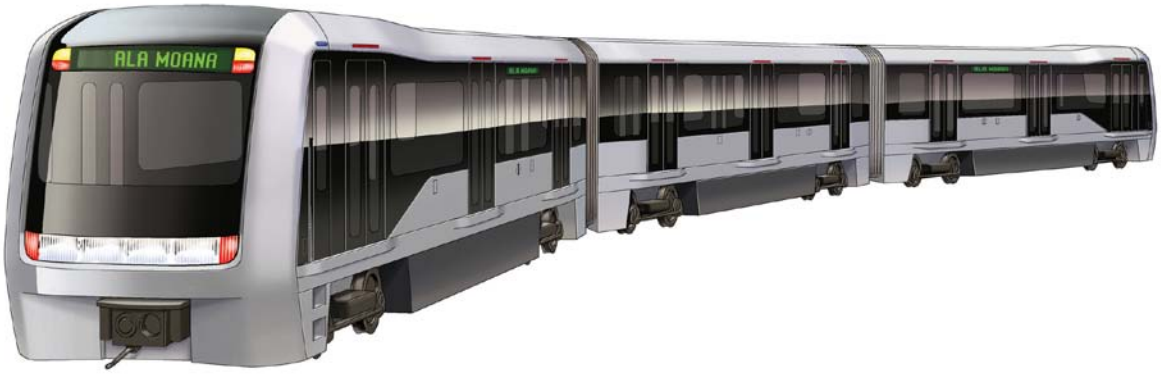
TP-4.6.5.8 Overall External Appearance

Two potential external vehicle aesthetic design concepts as illustrated in Figures 6-2 and 6-3 below were chosen for the vehicle.

The Core Systems Contractor shall develop a vehicle external design that reflects one of these concepts as closely as possible given the technical restraints of the basic vehicle shell design.

Figure 6-2. External Vehicle Concept 1

Figure 6-3. External Vehicle Concept 2



TP-4.6.5.9 Overall Internal Appearance

After the development of a number of professionally produced vehicle aesthetic designs and an internal evaluation, the interior design concept shown in Figure 6-4 below was chosen for this Contract.

The vehicle supplier shall develop an interior design that reflects this concept as closely as possible given the technical restraints of the basic vehicle design.

Figure 6-4. Interior Vehicle Concept 1

TP-4.6.5.10 Color Scheme/Palette

After the development of a number of professionally produced vehicle color schemes/palettes and an internal evaluation, a color scheme/palette will soon be chosen for this Contract. This shall be utilized for detailed vehicle design and reflected in the aesthetic design deliverables.

Aesthetic design deliverables shall include the following:

- A series of interior conceptual color renderings in the selected color palette and covering the entire passenger area. Special focus shall be made on the universal and vehicle end/hostler panel areas.
- A series of exterior color renderings in the selected color palette covering side, front and three-quarter views.
- A full 3D external and internal wireframe model of the vehicle for City use.

TP-4.6.6 Multiple-Unit Operation

The vehicle shall be capable of full performance multiple-unit train operation in consists of up to four (4) vehicles during normal daily operations. Under emergency conditions, a consist of up to eight (8) vehicles, 4 of which may be inoperable and without power or only partially operational, shall be capable of operating under reduced performance.

TP-4.6.7 Passenger Safety, Loading, and Unloading

TP-4.6.7.1 ADA Mandatory Accessibility Requirements

Full accessibility for all passengers shall be provided at all doors including elderly or persons with disabilities, including those using assistive devices such as wheelchairs in accordance with the ADA requirements of 49 CFR 38 - Transportation for Individuals with Disabilities, Subpart D, Light Rail Vehicles and Systems, Sections 38.71 to 38.87. These requirements shall include:

- The vehicle suspension system shall automatically maintain the level of the vehicle floor such that the door threshold shall be within ± 6.0 mm [±0.250 in] of the station platform height. Note if a sloping door threshold extension is used (as per Figure 5-4), the vehicle floor height shall be considered to be the height of the threshold extension at the platform interface in order for wheeled transport to easily enter / exit the vehicle.
- The vehicle step distance from the edge of the vehicle door threshold to the station platform shall not exceed 76 mm [3 in]. Design shall be for a nominal clearance of 57.02 mm [2.245 in] as per trackwork directive drawing DD-E03-WD650.
- The main aisle width shall be at least 813 mm [32 in] to permit access by a wheelchair from all passenger doors.

TP-4.6.7.2 Other Passenger Safety Requirements

The vehicle floor shall be covered with slip-resistant rubber flooring material and shall comply with all applicable ADA requirements for visibility and friction coefficients. Colors for the floor covering and step nosing shall complement the vehicle's overall interior design.

Corridors and aisles shall have a ceiling height of at least 2,030 mm [80 in]. All standing passengers shall have access to vertical stanchions or handholds. The window area shall be maximized to emphasize a feeling of openness.

The interior shall have no sharp corners or inaccessible areas at floor level and shall be easy to clean and maintain. Handholds, lights, air vents, armrests, and other interior fittings shall appear to be integral with the vehicle interior. There shall be no sharp, abrasive edges, corners, or surfaces, and no hazardous protuberances.

Interior panel material shall permit easy removal of paint, greasy fingerprints, and ink from felt tip pens, etc. Materials shall be strong enough to resist everyday use and shall be resistant to scratches and markings. Use of visible fasteners shall be minimal and any interior mullion trim, moldings, and trim strips shall match the adjacent panels/walls.

Seats shall be easily maintained and resistant to vandalism.

TP-4.6.8 Illumination Levels

Vehicle interiors shall be designed with lighting fixtures that are secure, rattle-free, energy efficient, low-heat and vandal-resistant. High-efficiency fluorescent lamps with electronic

ballasts or LED equivalents shall be used throughout the vehicle. Interior lighting shall be equipped with variable automatic daylight controls to reduce lighting output during the day when sufficient ambient light is available. Lamps shall be inaccessible to passengers. Diffusers shall be shatterproof. Illumination levels, as follows, shall be consistent and shall be measured with all light diffusing panels in place.

- The average intensity of the illumination within the vehicle at an elevation of 840 to 1,670 mm [33 to 66 in] above the floor shall be at least 320 Lux [30 Footcandles] at rated voltage.
- The light intensity at the floor throughout the vehicle, including the passenger aisles and gangways, shall not be less than 215 Lux [20 Footcandles].
- The average light intensity at the vehicle entrances and exits inside the vehicle within 500 mm [20 in] of the doors shall not be less than 215 Lux [20 Footcandles] at the floor.
- The average illumination intensity measured on the Control Station shall be 215 Lux [20 Footcandles].
- The illumination shall not be less than 22 Lux [2 Footcandles] measured on the surface of the platform in the door area, up to 910 mm [3 ft] away from the vehicle side in horizontal direction with the door open.
- The brightness ratio between the lighting fixtures and the adjacent ceiling shall not be greater than 40 to 1.
- The brightness ratio of the lighting fixtures to the walls (except windows) shall not be greater than 10 to 1.
- The headlight illumination shall be at least 15,000 Candela, but less than 20,000 Candela at a distance of 18.3 m [60 ft] on low beam and at least 20,000 Candela, but less than 75,000 Candela at a distance of 18.3 m [60 ft] on high beam in accordance with SAE J1383, Tables 3A and 3B.
- The taillight illumination shall be at least 2 Candela, but less than 18 Candela at a distance of at least 3m [9.84 ft] in accordance with SAE J2040, Table 1. The stop lamp intensity shall be no less than 5 times the luminous intensity of the taillight lamps.
- The clearance/marker light illumination shall be at least 1.2 Candela for yellow and 3.0 Candela for red lights at a distance of at least 3m [9.84 ft] in accordance with SAE J2042, Table 1.

It shall be possible for only authorized personnel to turn on or off interior lights.

TP-4.6.9 Ride Quality

During normal operation at any speed and all loadings, the vehicle performance shall be free from vibration and shock to the levels specified herein. All equipment shall be free from significant resonance during normal vehicle operation.

For any single station-to-station run (not including dwells), RMS accelerations between 1 and 80 Hz shall fall below the levels outlined in Evaluation of Human Exposure to Whole-Body Vibration, ISO 2631 for one (1) hour exposure to the Reduced Comfort Boundary.

The ride quality vibration measurements, derivation of frequency weightings, and evaluation shall be made according to ISO 2631/1 - Mechanical Vibration and Shock-Evaluation of Human Exposure to Whole Body Vibration, Part 1 – General Requirements supplemented by ISO 2631-4:2001- Mechanical Vibration and Shock – Evaluation of Human Exposure to

Whole Body Vibration, Part 4: Guidelines for the Evaluation of the Effects of Vibration and Rotational Motion on Passenger and Crew Comfort in Fixed-Guideway Transport Systems and ISO 10056:2001-Mechanical Vibration – Measurement and Analysis of Whole-body Vibration to Which Passengers and Crew are Exposed in Railway Vehicles and ISO 8041/Amd.1:1999 - Human Response to Vibration- Measuring Instrumentation.

Acceleration readings shall be taken in both seated and standing positions, facing both longitudinally and laterally in the passenger area and gangway area.

The rms acceleration values for each measurement point shall not exceed 0.32 m/s/s for seated and standing passengers.

Where appropriate, frequency weighting W_d may be used instead of W_k.

The acceleration data shall be evaluated over the frequency range of 0.5 Hz to 80 Hz.

The vehicle shall be evaluated with new wheels on non-corrugated welded rail.

Tests shall be performed with vehicle load conditions of AW0, AW1, AW2 and AW3, under all normal vehicle acceleration, braking and operating speeds over representative sections of new straight and curved track.

The tests shall be performed in both directions and with the test vehicle alone, in the lead vehicle of a two-vehicle consist and in the middle vehicle of a three-vehicle consist

TP-4.6.10 Noise

Special vehicle noise abatement measures, including resilient wheels and any other sound damping measures, shall be provided to minimize the emission of noise.

Noise levels shall not exceed the levels indicated below under normal operating conditions with all equipment functioning. Lower noise levels are desirable.

TP-4.6.10.1 Measurement

Overall noise levels shall be measured in decibels on the A scale (dBA) with slow meter response setting for stationary vehicle measurements. Moving vehicle measurements shall be measured with fast meter response. For measurements under steady operating conditions, the period of observation shall be five (5) seconds. ISO Standard 3095 - Acoustics-Measurement of Noise Emitted by Railbound Vehicles, shall be utilized for all noise measurements.

Measurement of exterior noise levels shall be made on level ground and in an essentially free field environment, 15 m [50 ft] from the centerline of track perpendicular to the vehicle, on newly ground welded rail, at a height of 1.5 m [5 ft], away from reflecting surfaces, and on adjacent ground other than ballast, ties, and track.

Measurement of interior noise levels shall be made at designated points 1 m [3 ft] from the left or right side wall, 1.2 m [4 ft] from the floor.

The specified noise limits shall be for normally operating equipment and do not apply to equipment that operates occasionally, such as a circuit breaker or pressure-activated devices.

TP-4.6.10.2 Pure Tones

There should be no significant audible pure tones. Pure tone noise shall be considered significant in this context if any one-third octave band sound pressure level is 5 dB, or more, higher than the arithmetic average of the two adjacent bands containing no pure tones.

The noise limit shall be reduced by at least 3 dB if significant pure tones in the range of the one-third octave band center frequencies from 250 Hz to 4,000 Hz are present in the noise.

TP-4.6.10.3 Interior Noise Limits

With all auxiliary equipment operating simultaneously under normal operating conditions, the noise level inside the vehicle shall average no more than the following levels on non-corrugated, tangent track:

- Vehicle stationary, empty, no auxiliary systems operating: 68 dBA
- Vehicle stationary, all auxiliary systems operating and all HVAC units in full cooling mode: 72 dBA
- Vehicle stationary, with any one system operating: 70 dBA
- Vehicle moving, empty, on horizontal tangent track at 65 km/hr [40 mph]: 75 dBA
- In maximum dynamic braking or maximum friction braking from 65 km/hr [40 mph] with new wheel conditions: 75 dBA

TP-4.6.10.4 Exterior Noise Limits

Average noise levels emanating from the vehicle shall not exceed the following levels on non-corrugated, tangent track with all auxiliary equipment operating simultaneously:

- Vehicle stationary, empty: 68 dBA
- Vehicle moving, empty, on horizontal tangent track at 65 km/hr [40 mph]: 75 dBA
- In maximum dynamic braking or maximum friction braking from 65 km/hr [40 mph] with new wheel conditions: 75 dBA

TP-4.6.10.5 Noise / Wheel Squeal Prevention

Special wheel profiles, wheel dampers and/or other noise mitigation measures shall be provided on the vehicle to ensure that wheel squeal in curves does not exceed 78 dBA.

Noticeable pure tones are not permitted.

TP-4.6.11 Shock and Vibration

TP-4.6.11.1 Vehicle Interior Vibration

The interior of the vehicle, including all wall and ceiling panels, floor, seats, lighting fixtures, HVAC ductwork, and other furnishings shall be free from rattles, creaking and any audible or visible vibrations at any speed from zero to 104.6 km/hr [65 mph] and at any acceleration or braking request except emergency braking.

Passengers and operators shall not experience interior vehicle vibration levels in excess of 75 VdB (Vibration decibels) at any speed from zero to 104.6 km/hr [65 mph] and at any acceleration or braking request except emergency braking.

Vibration decibels are directly related to vibration velocity by the following formula:

$$VdB = 20 \times \log (V/V_{ref})$$

V is the velocity amplitude in inches per second and V_{ref} ^{6} inches per second.

TP-4.6.11.2 Vehicle Equipment Shock and Vibration

Components mounted on the vehicle body, truck, or axle shall have structural integrity, and shall be operationally reliable over the life of the vehicle in the vibration and shock environment existing at the point of attachment of the component. Components and mounting arrangements shall prevent unacceptable vibration levels at any location in the vehicle.

All equipment shall be compliant with and tested as per IEC 61373-1999 - Railway Applications – Rolling Stock Equipment – Shock and Vibration Tests, including all functional and durability requirements.

TP-4.6.11.3 Vibration Transmission to Environment

The vehicle shall be designed to minimize transmission of vibration into the trackwork by minimizing unsprung mass and careful design of the vehicle suspension system. No more than 70 VdB shall be transmitted on the assumption that the overall LRV system shall be maintained against degradation which would adversely affect vibration levels, such as the condition of special trackwork, corrugated or worn track and flattened or out of round wheels.

TP-4.6.12 Vehicle Static and Dynamic Swept Envelopes

A nominal vehicle swept envelope has been developed which incorporates the critical dimensions and characteristics of 60 foot long by 10 foot wide high floor, light metro transit vehicle.

The resulting swept envelope has been calculated on both tangent, level track and on a variety of curves with various super-elevations. The worst-case swept point out of all these calculations is then identified and included in the swept envelope tables presented in this section.

The vehicle dynamic swept envelope shall not exceed the worst-case limits identified in the following diagrams and tables. These calculated values are subject to revision as the vehicle design/procurement process further refines the vehicle dimensional limitations.

TP-4.6.12.1 Vehicle Static and Dynamic Envelope on Level Tangent Track

The determination of the Vehicle Dynamic Envelope begins with a cross sectional outline of the vehicle standing (static) on level, tangent track, such as at a station platform. The dynamic outline of the vehicle is then developed by considering the vehicle body movements that can occur when the vehicle is moving (dynamic) on level, tangent track. These dynamic (sway) movements come from the truck suspension elements, wheel and rail wear, and tolerances in vehicle and track construction. The worst-case, not-to-exceed, dynamic body movements are shown in the following Vehicle Dynamic Envelope, Figure 6-5 and Table 6-1 below.

TP-4.6.12.2 Vehicle Dynamic Envelope on Curved Track

In addition to the dynamic vehicle body movements on level, tangent track, vehicle body overhang on horizontal track curvature also increases the lateral displacement of dynamic outline relative to the track centerline depending on the radius of the curve, the cross level variation, the degree of track superelevation, the wheel and track tolerances, and the suspension motion.

In determining the superelevation effects, the shape of the vehicle dynamic outline has not been altered and the effects have been limited to the vehicle lean introduced by the specified difference in the top of rail (TOR) elevation between the two rails of the track under consideration (cross level variation).

The resulting worst-case dynamic outswing and inswing values are given in Tables 6-2 and 6-3 which follow based on using 36.0 foot truck centers for outswing calculations and 39.37 foot truck centers for inswing calculations. These tables shall be utilized as the Vehicle Dynamic Envelope (VDE) in establishing the Track Clearance Envelope (TCE).

Figure 6-5. Vehicle Worst-Case Dynamic Envelope

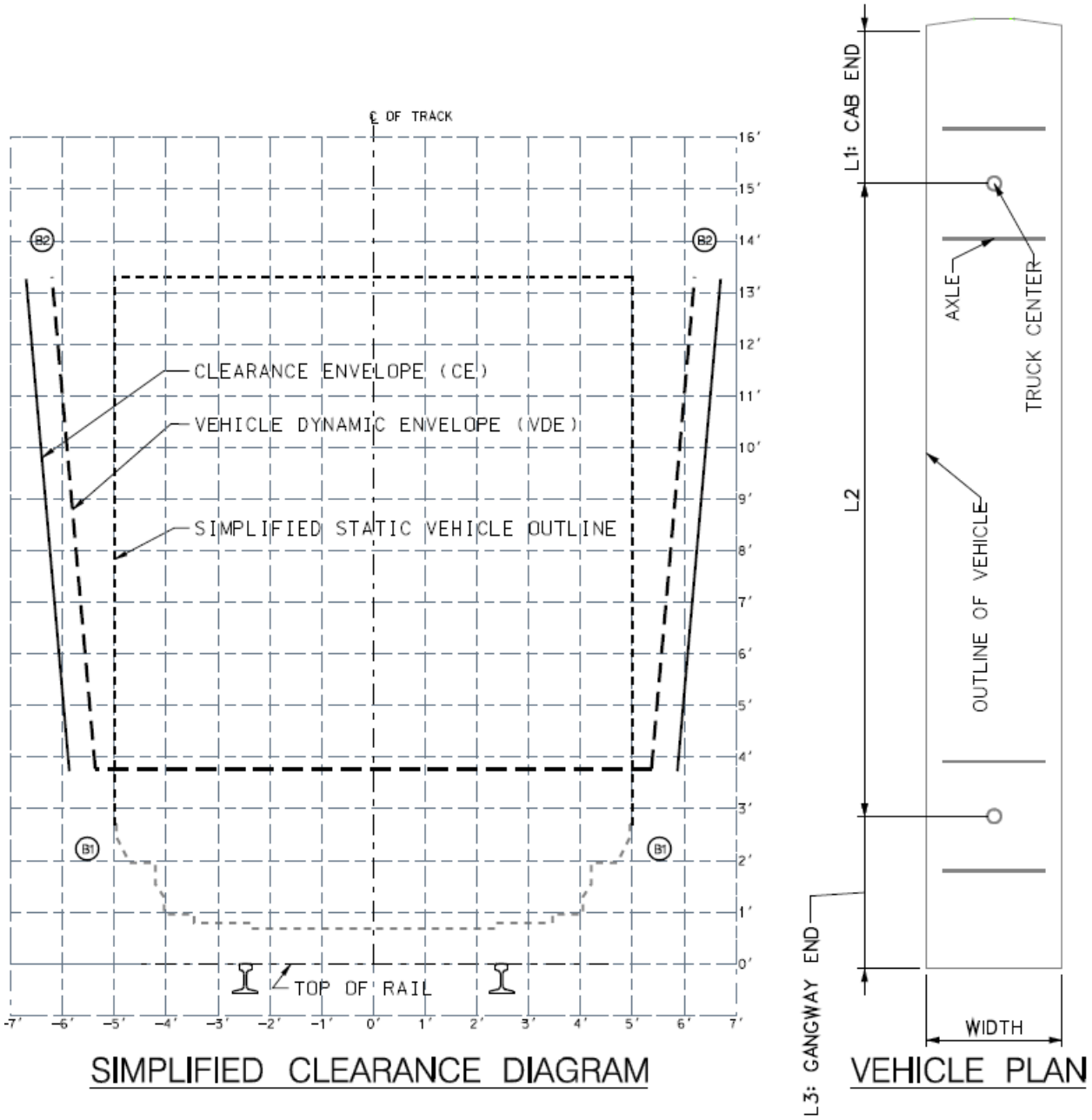


Table 6-1. Vehicle Min / Max Dynamic Envelope

Superelevation		0 inches		0.5 inches		1.0 inches		1.5 inches		2.0 inches		2.5 inches		3.0 inches		3.5 inches		4.0 inches		4.5 inches		5.0 inches		5.5 inches		6.0 inches	
Radius (ft)	Radius(mm)	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In
150	45720	-96.1	93.1	-94.8	94.3	-93.5	95.5	-92.3	96.8	-91.0	98.0	89.7	99.2	-88.4	100.4	-87.1	101.7	-85.8	102.9	-84.5	104.0	-83.2	105.2	-81.9	106.4	-80.6	107.6
200	60960	-90.2	87.8	-88.9	89.0	-87.6	90.3	-86.3	91.5	-85.0	92.7	-83.7	94.0	-82.4	95.2	-81.1	96.4	-79.8	97.6	-78.5	98.8	-77.1	100.0	-75.8	101.2	-74.5	102.3
250	76200	-87.2	84.6	-85.9	85.9	-84.6	85.8	-83.3	88.3	-82.0	89.6	-80.7	90.8	-79.4	92.0	-78.0	93.2	-76.7	94.4	-75.4	95.6	-74.0	96.8	-72.7	98.0	-71.3	99.2
300	91440	-85.2	82.5	-83.9	83.8	-82.6	85.0	-81.3	86.2	-80.0	87.5	-78.7	88.7	-77.3	89.9	-76.0	91.1	-74.7	92.3	-73.4	93.5	-72.0	94.7	-70.7	95.9	-69.3	97.1
400	121920	-82.6	80.2	-81.4	81.5	-80.1	82.7	-78.8	84.0	-77.5	85.3	-76.2	86.5	-74.8	87.8	-73.5	89.0	-72.2	90.2	-70.8	91.5	-69.5	92.7	-68.2	93.9	-66.8	95.1
500	152400	-81.1	79.2	-79.9	80.4	-78.6	81.7	-77.3	83.0	-76.0	84.2	-74.6	85.5	-73.3	86.8	-72.0	88.0	-70.7	89.2	-69.3	90.5	-68.0	91.7	-66.7	92.9	-65.3	94.1
550	167640	-80.6	78.8	-79.3	80.1	-78.0	81.4	-76.7	82.6	-75.4	83.9	-74.1	85.1	-72.8	86.4	-71.5	87.6	-70.1	88.9	-68.8	90.1	-67.5	91.3	-66.1	92.5	-64.8	93.7
600	182880	-80.1	78.5	-78.8	79.8	-77.6	81.0	-76.3	82.3	-75.0	83.6	-73.6	84.8	-72.3	86.1	-71.0	87.3	-69.7	88.6	-68.3	89.8	-67.0	91.0	-65.7	92.2	-64.3	93.4
700	213360	-79.4	78.0	-78.1	79.3	-76.8	80.6	-75.5	81.8	-74.2	83.1	-72.9	84.3	-71.6	85.6	-70.3	86.8	-69.0	88.1	-67.6	89.3	66.3	90.5	-64.9	91.7	-63.6	92.9
800	243840	-78.9	77.6	-77.6	78.9	-76.3	80.2	-75.0	81.5	-73.7	82.7	-72.4	84.0	-71.1	85.2	-69.8	86.5	-68.4	87.7	-67.1	88.9	-65.7	90.2	-64.4	91.4	-63.0	92.6
900	274320	-78.5	77.4	-77.2	78.6	-75.9	79.9	-74.6	81.2	-73.3	82.4	-72.0	83.7	-70.7	84.9	-69.3	86.2	-68.0	87.4	-66.7	88.7	-65.3	89.9	-64.0	91.1	-62.6	92.3
1000	304800	-78.1	77.1	-76.8	78.4	-75.5	79.7	-74.2	81.0	-72.9	82.2	-71.6	83.5	-70.3	84.7	-69.0	96.0	-67.7	87.2	-66.3	88.4	-65.0	89.7	-63.7	90.9	-62.3	92.1
1200	365760	-77.6	76.8	-76.3	78.1	-75.0	79.4	-73.7	80.6	-72.4	81.9	-71.1	83.1	-69.8	84.4	-68.9	85.6	-67.2	86.9	-65.8	88.1	-64.5	89.3	-63.1	90.5	-61.8	91.7
1250	381000	-77.5	76.7	-76.2	78.0	-74.9	79.3	-73.6	80.5	-72.3	81.8	-71.0	83.1	-69.7	84.3	-68.4	85.6	-67.1	86.8	-65.7	88.0	-64.4	89.2	63.0	90.5	-61.7	91.7
1450	441960	-77.2	76.5	-75.9	77.8	-74.6	79.1	-73.3	80.3	-72.0	81.6	-70.7	82.8	-69.4	84.1	-68.1	85.3	-66.7	86.6	-65.4	87.8	-64.1	89.0	-62.7	90.2	-61.4	91.5
1500	457200	-77.1	76.5	-75.8	77.7	-74.5	79.0	-73.2	80.3	-71.9	81.5	-70.6	82.8	-69.3	84.0	-68.0	85.3	-66.7	86.5	-65.3	87.8	-64.0	89.0	-62.6	90.2	-61.3	91.4
2000	609600	-76.6	76.1	-75.3	77.4	-74.0	78.7	-72.7	79.9	-71.4	81.2	-70.1	82.5	-68.8	82.7	-67.5	84.9	-66.2	86.2	-64.8	87.4	-63.5	88.6	-62.1	89.9	-60.8	91.1
2500	762000	-76.3	75.9	-75.0	77.2	-73.7	78.5	-72.4	79.7	-71.1	81.0	-69.8	82.3	-68.5	83.5	-67.2	84.7	-65.9	86.0	-64.5	87.2	-63.2	88.4	-61.8	89.7	-60.5	90.9
3200	975360	-76.0	75.7	-74.8	77.0	-73.5	78.3	-72.2	79.6	-70.9	80.8	-69.6	82.1	-68.2	83.3	-66.9	84.5	-65.6	85.8	-64.3	87.0	-62.9	88.3	-61.6	89.5	-60.2	90.7
5000	1524000	-75.7	75.5	-74.4	76.8	-73.1	78.1	-71.8	79.3	-70.5	80.6	-69.2	81.8	-67.9	83.1	-66.6	84.3	-65.3	85.6	-63.9	86.8	-62.6	88.0	-61.2	89.3	-59.9	90.5
10000	3048000	-75.4	75.3	-74.1	76.6	-72.8	77.9	-71.5	79.1	-70.2	80.4	-68.9	81.6	-67.6	82.9	-66.3	84.1	-65.0	85.4	-63.6	86.6	-62.3	87.8	-60.9	89.0	-59.6	90.3
Tangent		-75.1	75.1																								

Basic Assumptions / Criteria

1. Cross level variaton: 1.0 inch
2. Maximum vehicle roll angle: 4 degrees
3. Vehicles do not have cameras or mirrors.
4. Envelope based on the following Light Metro Vehicles (Berlin U-Bahn H Series, Bilbao Metro S / 550, Docklands Light Railway B07, Dubai Metro (as proposed for Honolulu), JFK AirTrain, Munich U-Bahn C1.9, Oslo T-Bane MX3000, Valencia Metro 4300 Series, Palma Metro and Vancouver Canada Line)
5. Calculations include wheel and track tolerances including wheel wear, track wear, rail gauge tolerance, wheel gauge tolerance, nominal sideplay and lateral suspension motion totalling 69 mm
6. Resulting values are worst case calculated values

Table 6-2. Vehicle Outswing Values

Superelevation, Inches		0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
Radius (ft)	Radius (mm)	Out	Out	Out	Out	Out	Out	Out	Out	Out	Out	Out	Out	Out
150	45720	-96.9	-95.5	-94.1	-92.6	-91.2	-89.7	-88.3	-86.8	-85.4	-83.9	-82.4	-80.9	-79.4
200	60960	-91.3	-89.9	-88.5	-87.0	-85.6	-84.1	-82.7	-81.2	-79.8	-78.3	-76.8	-75.3	-73.8
250	76200	-87.9	-86.5	-85.1	-83.7	-82.2	-80.8	-79.3	-77.9	-76.4	-74.9	-73.5	-72.0	-70.5
300	91440	-85.7	-84.3	-82.8	-81.4	-80.0	-78.5	-77.1	-75.6	-74.2	-72.7	-71.2	-69.7	-68.3
400	121920	-82.9	-81.5	-80.0	-78.6	-77.2	-75.7	-74.3	-72.8	-71.4	-69.9	-68.4	-67.0	-65.5
500	152400	-81.2	-79.8	-78.4	-76.9	-75.5	-74.1	-72.6	-71.2	-69.7	-68.2	-66.8	-65.3	-63.8
550	167640	-80.6	-79.2	-77.8	-76.3	-74.9	-73.4	-72.0	-70.5	-69.1	-67.6	-66.2	-64.7	-63.2
600	182880	-80.1	-78.7	-77.2	-75.8	-74.4	-72.9	-71.5	-70.0	-68.6	-67.1	-65.6	-64.2	-62.7
700	213360	-79.3	-77.9	-76.4	-75.0	-73.6	-72.1	-70.7	-69.2	-67.8	-66.3	-64.8	-63.4	-61.9
800	243840	-78.7	-77.3	-75.8	-74.4	-73.0	-71.5	-70.1	-68.6	-67.2	-65.7	-64.2	-62.8	-61.3
900	274320	-78.2	-76.8	-75.4	-73.9	-72.5	-71.1	-69.6	-68.2	-66.7	-65.3	-63.8	-62.3	-60.8
1000	304800	-77.8	-76.4	-75.0	-73.6	-72.1	-70.7	-69.3	-67.8	-66.3	-64.9	-63.4	-61.9	-60.4
1200	365760	-77.3	-75.9	-74.4	-73.0	-71.6	-70.1	-68.7	-67.2	-65.8	-64.3	-62.9	-61.4	-59.9
1250	381000	-77.2	-75.8	-74.3	-72.9	-71.5	-70.0	-68.6	-67.1	-65.7	-64.2	-62.7	-61.3	-59.8
1450	441960	-76.8	-75.4	-74.0	-72.5	-71.1	-69.7	-68.2	-66.8	-65.3	-63.8	-62.4	-60.9	-59.4
1500	457200	-76.7	-75.3	-73.9	-72.5	-71.0	-69.6	-68.1	-66.7	-65.2	-63.8	-62.3	-60.8	-59.3
2000	609600	-76.2	-74.7	-73.3	-71.9	-70.5	-69.0	-67.6	-66.1	-64.7	-63.2	-61.7	-60.3	-58.8
2500	762000	-75.8	-74.4	-73.0	-71.6	-70.1	-68.7	-67.2	-65.8	-64.3	-62.9	-61.4	-59.9	-58.4
3200	975360	-75.5	-74.1	-72.7	-71.3	-69.8	-68.4	-66.9	-65.5	-64.0	-62.6	-61.1	-59.6	-58.2
5000	1524000	-75.1	-73.7	-72.3	-70.9	-69.5	-68.0	-66.6	-65.1	-63.7	-62.2	-60.7	-59.3	-57.8
10000	3048000	-74.8	-73.4	-72.0	-70.5	-69.1	-67.7	-66.2	-64.8	-63.3	-61.9	-60.4	-58.9	-57.4
Tangent		-75.1												

Basic Assumptions/Criteria
1. Cross level variation: 1.0 inch.
2. Maximum vehicle roll angle: 4 degrees.
3. Vehicles do not have cameras or mirrors.
4. Envelope assumes the following: a Light Metro Vehicle with a 10 ft. wide, 60 ft. long body centered over trucks (axle spacing of 6.89 ft.) spaced at 36.0 ft. centers. The floor height is 3.77 ft above top of rail and the body is a maximum of 13.3 ft. above top of rail.
5. Calculations include wheel and track tolerances including wheel wear, track wear, rail gauge tolerance, wheel gauge tolerance, nominal sideplay and lateral suspension motion totaling 69 mm.
6. Resulting values are worst-case calculated values.

Table 6-3. Vehicle Inswing Values

Superelevation, Inches		0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
Radius (ft)	Radius (mm)	In	In	In	In	In	In	In	In	In	In	In	In	In
150	45720	90.5	91.9	93.3	94.7	96.1	97.5	98.9	100.2	101.6	102.9	104.3	105.6	107.0
200	60960	86.5	87.9	89.3	90.7	92.1	93.5	94.9	96.2	97.6	98.9	100.3	101.6	103.0
250	76200	84.1	85.5	86.9	88.3	89.7	91.1	92.5	93.8	95.2	96.5	97.9	99.2	100.6
300	91440	82.5	83.9	85.3	86.7	88.1	89.5	90.9	92.2	93.6	94.9	96.3	97.6	99.0
400	121920	80.5	81.9	83.3	84.7	86.1	87.5	88.9	90.2	91.6	92.9	94.3	95.6	97.0
500	152400	79.3	80.7	82.1	83.5	84.9	86.3	87.7	89.0	90.4	91.7	93.1	94.4	95.8
550	167640	78.9	80.3	81.7	83.1	84.5	85.8	87.2	88.6	90.0	91.3	92.7	94.0	95.4
600	182880	78.5	79.9	81.3	82.7	84.1	85.5	86.8	88.2	89.6	90.9	92.3	93.6	95.0
700	213360	77.9	79.3	80.7	82.1	83.5	84.9	86.3	87.7	89.0	90.4	91.7	93.1	94.4
800	243840	77.5	78.9	80.3	81.7	83.1	84.5	85.8	87.2	88.6	89.9	91.3	92.7	94.0
900	274320	77.1	78.6	80.0	81.4	82.8	84.1	85.5	86.9	88.3	89.6	91.0	92.3	93.7
1000	304800	76.9	78.3	79.7	81.1	82.5	83.9	85.2	86.6	88.0	89.3	90.7	92.1	93.4
1200	365760	76.5	77.9	79.3	80.7	82.1	83.5	84.8	86.2	87.6	88.9	90.3	91.7	93.0
1250	381000	76.4	77.8	79.2	80.6	82.0	83.4	84.8	86.1	87.5	88.9	90.2	91.6	92.9
1450	441960	76.1	77.5	78.9	80.3	81.7	83.1	84.5	85.9	87.2	88.6	90.0	91.3	92.7
1500	457200	76.1	77.5	78.9	80.3	81.7	83.1	84.4	85.8	87.2	88.5	89.9	91.3	92.6
2000	609600	75.7	77.1	78.5	79.9	81.3	82.7	84.0	85.4	86.8	88.1	89.5	90.9	92.2
2500	762000	75.4	76.8	78.3	79.6	81.0	82.4	83.8	85.2	86.5	87.9	89.3	90.6	92.0
3200	975360	75.2	76.6	78.0	79.4	80.8	82.2	83.6	85.0	86.3	87.7	89.1	90.4	91.8
5000	1524000	75.0	76.4	77.8	79.2	80.6	81.9	83.3	84.7	86.1	87.4	88.8	90.1	91.5
10000	3048000	74.7	76.1	77.5	78.9	80.3	81.7	83.1	84.5	85.8	87.2	88.5	89.9	91.2
Tangent		75.1												

Basic Assumptions/Criteria
1. Cross level variation: 1.0 inch.
2. Maximum vehicle roll angle: 4 degrees.
3. Vehicles do not have cameras or mirrors.
4. Envelope assumes the following: a Light Metro Vehicle with a 10 ft. wide, 60 ft. long body centered over trucks (axle spacing of 6.89 ft.) spaced at 39.37 ft. centers. The floor height is 3.77 ft above top of rail and the body is a maximum of 13.3 ft. above top of rail.
5. Calculations include wheel and track tolerances including wheel wear, track wear, rail gauge tolerance, wheel gauge tolerance, nominal sideplay and lateral suspension motion totaling 69 mm.
6. Resulting values are worst-case calculated values.

TP-4.6.13 NOT USED

TP-4.6.14 NOT USED

TP-4.6.15 Reliability

The Core Systems Contractor shall have the overall responsibility for reliability, consistent with requirements for overall rail system availability in TP-3: Operations and Maintenance Performance Requirements.

TP-4.6.16 Maintainability

The vehicle shall be designed and built so as to minimize maintenance and repair time and overall costs over the vehicle life, as well as meet or exceed the rail system availability and fleet maintenance requirements of TP-3: Operations and Maintenance Performance Requirements.

TP-4.6.16.1 Maintainability Design

The following shall be considered good practice in designing for maintainability and shall be utilized in the vehicle design:

- Use of modular main equipment modules with quick disconnects.
- All systems and components serviced as part of periodic preventive maintenance shall be readily accessible for service and inspection.
- Removal or physical movement of components unrelated to the specific maintenance and repair tasks involved shall be unnecessary.
- Relative accessibility of components, measured in time to gain access, shall be inversely proportional to frequency of maintenance and repair of the components.
- Assemblies and components that are functionally interchangeable shall be physically interchangeable.
- Modular or plug-in assemblies and components that are not functionally interchangeable shall not be physically interchangeable.
- Systematic fault isolation procedures shall be developed for inclusion in the maintenance manuals.
- Local built-in test points and fault/status indicators shall be provided and clearly marked for all major systems including train control, HSCB, propulsion, friction braking, HVAC, passenger doors, auxiliary power, low voltage power supply, battery charger, PA, video, destination and information displays, communications controllers, air compressors (if used), ATC equipment, monitoring and diagnostics equipment and event recorders.
- All test points, fault indicators, modules, wire junctions, piping, tubes, wires, etc., shall be identified by name plates, color coding, number coding, or other means to assist the maintenance personnel.
- Component placements in equipment cabinets, enclosures, or confined places shall give the most accessible positions to those items requiring the most frequent maintenance or adjustment.
- Door panels and openings shall be of sufficient quantity, size, and placement to permit ready access from normal work areas.

- Standard, commercially available industrial components and hardware shall be used wherever possible.
- Captive fasteners shall be used on covers and access panels where periodic maintenance and inspection are to be carried out. Use of captive fasteners shall be minimized where exposed to passenger view and requiring special tools for removal.
- Access shall be provided, to the greatest extent possible, to structural components to allow inspection for cracks and corrosion.
- Major components shall be designed for ease of removal. Handles and lifting eyes shall be provided as applicable, on heavy equipment and components not readily accessible.
- Means shall be provided to verify the operability of redundant hardware components, and their switching devices, during maintenance, troubleshooting and testing.
- Provisions shall be made to adjust vehicle height, etc, to account for wear or wheel turning using shims.
- Requirements for special tools and fixtures shall be minimized.

TP-4.6.16.2 **Maintainability Plan**

The Core Systems Contractor shall prepare and submit for review, a Maintainability Program Plan utilizing design standards that minimize Mean Time to Repair (MTTR), cleaning and maintenance costs throughout the vehicle's intended useful life.

The plan shall include the system MTTRs and vehicle goal for the proposed vehicle. An overall quantitative maintainability requirement goal for the vehicle's corrective maintenance shall be the weighted average of the MTTR (Mean Time to Repair) of the key system elements. Diagnostic and set-up time shall be included in the MTTR. Please refer to Section 4.6.16.3, Table 6-6 for the minimum MTTR requirements.

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

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

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

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

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

TP-4.6.16.3 Mean Time to Repair Requirements

The Mean Time to Repair (MTTR) a vehicle fault (any non-scheduled vehicle maintenance activity) shall not average more than 1.5 hours per fault, including diagnostic time.

The following Table 6-4, Weighted Average of MTTR Values, shall indicate the weighted average of the MTTR values for the specified subsystem elements:

Table 6-4. Weighted Average of MTTR Values

System	Mean Time to Repair (hours)
Propulsion System	1.5
Friction Braking System	1.8
Passenger Doors	0.75
HVAC System	2.0
Video Monitoring, Communications, PA and Passenger Information	1.0
Couplers	2.5
Trucks and Suspension	1.5
Monitoring/Diagnostic and Event Recorder	1.0
ATC/Train Control Equipment	1.5
Auxiliary Power System	1.5
Lighting	0.5

TP-4.6.16.4 Maintainability Demonstration

The adequacy of the vehicle design for maintainability shall be demonstrated to the satisfaction of the City using product components and equipment, mock-ups and actual vehicles during the design phase.

This demonstration shall include a shop exercise including troubleshooting, change out of components, corrective maintenance, and the use of Core Systems Contractor-supplied special tools and equipment. Vehicle movement/retrieval under various failure mode conditions shall also be demonstrated.

The following systems shall, as a minimum, be demonstrated:

- Propulsion Equipment (including traction motors, gearboxes, spin/slide, dynamic brake resistors)
- Trucks (powered and un-powered)
- HVAC
- Brakes (friction and electromagnetic track)
- Wheels and Axles (including tire change)
- Auxiliary Electric Equipment (including auxiliary. inverter, low voltage power supply, battery charger, battery)
- Automatic Vehicle Leveling
- Windows (all locations, including windshield)
- Doors

- Coupler
- Contact rail shoegear
- Automatic train control
- PA
- T-TEL stations
- Communications controllers
- Destination displays
- Passenger information displays and auto-announcer
- Video monitoring/recording
- Air compressor (if used)
- Windshield wash/wipe

The Core Systems Contractor shall prepare and submit a Maintainability Demonstration Plan for City review.

The Maintainability Demonstration shall commence upon acceptance of the second vehicle burn-in period to the end of warranty period of the last accepted vehicle.

During the demonstration, the vehicles shall be maintained by qualified maintenance personnel according to the Maintenance Plan and Maintenance Manuals provided by the Core Systems Contractor.

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

TP-4.6.16.5 Accident Repairs

To minimize the resulting vehicle out-of-service downtime in the event of a significant collision, the end of the vehicle shall be fitted with prefinished, easily replaceable elements. In the majority of collisions (minor to medium in severity), these features shall allow the return of the vehicle to revenue service in less than 24 hours. This must be demonstrated as part of the Maintenance Demonstration.

TP-4.6.16.6 Future Spares Availability

The Core Systems Contractor shall guarantee the availability of all vehicle software, components and subsystems for a minimum period of 10 years. Recognizing that electronic components may become quickly obsolete and manufacturers may cease construction of equipment, the supplier shall as an alternative provide equivalent or superior replacement equipment modules and subsystems. Should any equipment cease being manufactured or produced during this period of time, the City shall have the right to obtain any remaining inventory, software, molds, fixtures, plans, drawings, etc. from the original supplier to allow further spare parts to be manufactured by another supplier.

TP-4.6.17 NOT USED

TP-4.6.18 NOT USED

TP-4.6.19 Warning Devices

Warning devices are expected to be used during manual operation only. An electronic combined warning bell/horn may be provided to save weight and space.

TP-4.6.19.1 Warning Bell

The warning bell shall produce a repeating sound at a level of at least 80 dBA at a distance of 15 m [50 ft] anywhere in front of an end vehicle, and for multiple-vehicle consists, front of the lead vehicle and the rear of the trailing vehicle.

TP-4.6.19.2 Warning Horn

The warning horn shall produce a strident, attention-getting sound at a level of at least 97 dBA at a distance of 30 m [100 ft] anywhere in front of the leading end vehicle.

TP-4.6.20 Passenger Doors

TP-4.6.20.1 Door Emergency Release Force

An interior manual release mechanism shall be provided to permit all passenger doors to be opened locally without the use of electrical power. The force required to open the released door shall not exceed 45 N [10 lb] exerted on each panel simultaneously.

TP-4.6.20.2 Door Closing Force

The maximum door closing force shall be 135 N [30 lb].

TP-4.6.20.3 Door Cycle Times

The door operating time, from time of first motion to the point of completion, shall be 3.0 ± 0.5 seconds for 48-inch opening width, linearly adjusted for wider door opening width.

TP-4.6.20.4 Obstruction Detection

The sensitivity of the obstruction detection system with both door leafs closing simultaneously shall be as follows:

- Detect a flat bar, 6 mm [0.25 in] wide and 75 mm [3 in] high, held rigidly between and perpendicular to the door panels, as a hand might be held to stop the doors. This sensitivity shall be required everywhere along the length of the door panels except the uppermost 75 mm [3 in] and lowermost 25 millimeters [1 inch] of the nosing seal.
- Detect a round bar, 10 mm [0.375 in] in diameter, held rigidly between the door panels at all locations along the length of the door nosing seal, except the uppermost 75 mm [3 in] and lowermost 25 mm [1 in] of the seal.
- Permit a thin flexible object to be pulled free from the leading edges of the doors that are fully closed and locked.

TP-4.7 *Vehicle Functional Requirements*

TP-4.7.1 Vehicle Body

This section defines the requirements of the vehicle body, which includes the basic shell and related elements.

TP-4.7.1.1 General Construction

The complete vehicle body structure with energy-absorbing couplers and trucks shall prevent overriding and telescoping in the event of collision and shall meet the structural performance requirements of Section 4.6.4.

The structure of the vehicle body shall maintain the lowest possible weight consistent with the strength requirements.

The vehicle body and the attached equipment shall be designed to provide positive clearances for the trucks under worst-case operating conditions, except for any stops attached to the vehicle body for the purpose of limiting truck movement in case of derailment. Worst-case conditions are those resulting from horizontal and vertical curves, track superelevation, worn wheels, maximum passenger loads, sway, derailment, suspension, leveling, and system failures, either singly or in combination.

Sufficient clearance shall be provided in the truck areas such that there shall not be contact with any wheel by any part of the vehicle when the secondary suspension system is deactivated. It shall also be possible to lift one end of a vehicle with deactivated secondary suspension to roll out or roll in an end truck or running gear.

The vehicle shall be provided with jacking pads and/or pockets to facilitate routine maintenance operations. The jacking pads shall also be utilized for emergency lifting or rerailing.

TP-4.7.1.2 Materials and Structural Connections

The vehicle structure shall be manufactured of low-alloy, high-tensile steel, stainless steel, aluminum, or a combination thereof. The structure shall be manufactured using recognized industry standards such as jigs and fixtures and automated machines for maintaining consistent size and location of all structural members, and equipment mounting brackets. Structures shall be welded using connections designed in accordance with AWS D1.1, or equivalent alternative standards as applicable for the materials used.

Mechanical fastening is also allowable between major structural assemblies provided the technique used is service-proven in rail applications. The Core Systems Contractor shall demonstrate that this mechanical fastening design approach will remain tight and maintenance-free through-out the 30 year life of the vehicle.

The use of FRP bodyside and end sheathing shall be allowed provided the water-tightness requirements below are met.

TP-4.7.1.3 Water Tightness/Drainage

The vehicle shall be designed to prevent the accumulation and ingress of water at any point through the vehicle shell, especially the roof area.

All seams shall be continuously welded wherever physically possible.

No part of the vehicle water tightness shall rely solely on an adhesive/sealant filled joint.

Any roof drains shall be substantial, always accessible, easily cleaned, require a minimum of maintenance and protected from blockage by leaves or other foreign material.

The drain discharge point shall be below the vehicle floor and shall not splash on to passengers or underfloor equipment.

Water drainage over the sides of the main body sections and ends shall be prevented by installation of rain gutters or other devices.

Gutters shall be either separately formed and attached, or integral with the roof structure.

Gutters shall be installed to empty into concealed drainage conduits, which shall be fully insulated to prevent condensation. Drainage conduits shall not run through electrical equipment lockers.

Drainage conduits and the gutter system shall be sized so as to prevent the accumulation of water from overloading the system during vehicle acceleration and braking.

TP-4.7.1.4 Corrosion Prevention

The materials used in the vehicle shall be protected from corrosion. Dissimilar metal joints shall be protected against electrolytic corrosion. The structure shall be designed to eliminate all water traps, and all steel components subject to corrosion shall be rust proofed. Any closed structural sections shall be coated with an interior rust preventative coating after assembly.

TP-4.7.1.5 Bodyside Flatness

All metal vehicle body exterior surfaces shall be free of any visible ripples before any fillers are applied.

For any vehicle body surface not hidden by covers or shrouds, the maximum allowable deviation from a straight line or designed curve line as appropriate, shall not exceed 2.5 mm [3/32 in] over 1 m [39 in].

Where the vehicle body surface will be hidden, a maximum of 8 mm [5/16 in] over 1 m [39 in] measured in any direction is allowed.

TP-4.7.1.6 Floors

The sub-floor shall be constructed of lightweight phenolic composite sheets or similar panels. The edges of the sheets shall be sealed to prevent moisture and other damage. The sub-floor panels shall be attached to the floor structural members with screws. The use of rivets will not be permitted.

Transverse beams shall be provided to provide support for the floor and sub-floor panels and transmit vertical floor loads to the side sills.

Protective stainless steel sheets shall be provided on the bottom of all structural members, forming a continuous cover on the underframe. The protective sheets shall be of sufficient thickness to resist damage. All seams and edges shall be sealed to be watertight. Thermal and acoustical insulation shall be installed under the floor.

TP-4.7.1.7 Floor Coverings and Trim

The floor of the vehicle shall be covered with a continuous, slip-resistant rubber sheet, curved up the side wall for ease of cleaning. The floor covering shall be hard wearing, non-staining and non-discoloring.

The covering shall meet ADA visibility and coefficient of friction requirements, with a static coefficient of friction of at least 0.6 on level surfaces and 0.8 on ramps, even when wet.

Color and marbling shall run completely through the low gloss flooring material.

Continuous lengths of floor coverings shall be used. Joints and seams shall be kept to a minimum. Joining or splicing of pieces that are intended to cover entire lengths according to approved drawings is prohibited.

Where joints are to be made, the sections of floor covering shall be permanently joined together by heat welding or an equivalent process so as to be impervious to fluids or cleaning agents.

The floor coverings shall also met the fire performance requirements of Section 4.6.14.

Side door thresholds shall have an anti-slip abrasive surface with contrasting safety markings, and shall incorporate the interface with the door arrangement.

Thresholds shall have drain holes or alternative design to prevent any retention of water.

At all the door openings, the flooring shall be covered by the threshold plates, and shall be sealed to prevent entry of water, including when the vehicle is subjected to the horizontal jets of the train washing facility.

The use of latex or water based adhesive to adhere the floor covering to the floor is prohibited.

TP-4.7.1.8 Interior Mounting Rails

Bodyside

Dual function bodyside seat mounting rails/side impact bars below the windows shall be provided wherever practical for the mounting of cantilevered seats, handrails, and other interior fitments at any point along the rails.

Ceiling

Ceiling mounting rails shall be provided for the attachment of grabpoles, handrails, grab handles, etc. at any point along the rails.

TP-4.7.1.9 Roof

The vehicle roof structure shall provide the strength to support any roof mounted equipment and the weight of any maintenance personnel required for maintenance.

Any roof mounted antennas shall be located so as to minimize the likelihood of damage when roof mounted equipment is serviced or replaced.

Welding shall be continuous to prevent water ingress between the bracket or rail and the roof sheath. Fasteners that penetrate the roof will not be allowed.

Roof openings for HVAC air ducts shall be reinforced with flanges that extend at least 25 mm [1 in] above roof level, and sealed by use of one-piece gaskets to be watertight.

Any roof drains shall be provided to prevent the accumulation of water on the roof arising from monsoon rains or the train wash. These drains shall discharge waste water at track level and shall not splash passengers waiting to board at platforms.

The roof equipment installation, including any wiring and pipework, shall be designed and installed in such a way so as to present a clean and simple appearance when viewed from above. The entire roof area shall be painted the same color.

Any roof equipment shall be bolted to suitable fixed roof brackets or rails to facilitate removal. Bracket mounting holes shall be jig-drilled to allow interchangeability of similar equipment.

TP-4.7.2 Couplers

TP-4.7.2.1 Autocouplers (Type A coupler)

The non gangway end of each end vehicle shall be equipped with a type A energy-absorbing auto-coupler and associated draft gear system, with a self-centering device and meet the performance requirements of Section 4.6.4.2. The system shall provide fully automatic electrical and mechanical coupling and uncoupling functions. This system shall provide electric trainline connections to enable any one vehicle to control all other vehicles in a train. The coupler equipment and controls shall provide, at a minimum, for the following functions:

- Automatic coupling and centering
- Operator-activated uncoupling
- Manual uncoupling
- Connection of electrical trainlines
- Connection of pneumatic lines (if used)
- Isolation for the electrical portion
- Damped or buffered coupling and operation when coupled
- Self-centering device bypass.

TP-4.7.2.2 Mechanical Details

The mechanical coupler shall be a slack-free, tightlock design, with a flat contact face and guide pins, cantilevered from the draft gear. Designs that utilize a slide or radial bar for support of the coupler head shall not be permitted. The coupler assembly shall be cast steel or fabricated from steel plate. Uncoupling shall be accomplished even under residual tension loads.

Lubrication shall be provided for the coupler, draft gear, and anchorage. All bearing and wear surfaces of the coupler assembly and its attachment shall be provided with shims, replaceable bushings, plates, or other means to compensate for wear. All alignment surfaces of the coupler assembly shall use replaceable bushings. Corrosion-resistant materials shall be used for all hardware, other than castings and weldments.

The mechanical latch shall be designed to not require the buffing or compression of vehicle couplers prior to uncoupling.

Lateral stops shall be provided to positively limit coupler swing and prevent damage to the coupler assembly, vehicle body structure, skirt, and other equipment in normal operation. In the event of a derailment or other unusual occurrence, the stops shall be designed to fail before the structure to which they are attached.

The draft gear shall have cushioning in both buff and draft

TP-4.7.2.3 Electrical Details

Each coupler assembly shall be provided with duplication for trainline connections through the side or top-mounted electrical coupler heads. The electric heads shall be capable of making all necessary trainline low-voltage electrical connections between adjacent trainsets, and shall permit normal trainline control of all vehicles, up to a four-vehicle trainset coupled to another four-vehicle trainset.

The electrical portion and controls of the coupling equipment shall:

- Provide a minimum of 10 percent spare contacts including electrical wiring in the flexible cable assembly.
- Monitor the uncoupled state and the coupled state of all coupled trainsets
- Establish trainset ends
- Provide electrical isolation between trainsets that are mechanically coupled together.
- Prevent unintentional uncoupling during normal operations.
- Automatically extend the electrical coupler head forward to the front face of the mechanical head when coupled and retract the electrical coupler head prior to mechanical uncoupling.
- Be connected to the vehicle body by means of flexible cables with locking-type connectors for easy replacement.

If any pneumatic trainline connections are provided, the coupler to vehicle body connection shall be via braided hoses.

TP-4.7.2.4 Trainline Low-Voltage Electric Contacts

Silver-faced contacts shall be used. The contact tips shall be replaceable by removal through the front of the coupler block without disassembly of the coupler or its wiring.

TP-4.7.2.5 Coupler Electric Contact Block

The electrical coupler contact block shall be fabricated of a non-hygroscopic insulating material, of adequate strength to withstand, without damage, mechanical forces imposed by normal revenue service operation. The block design shall minimize creepage and be readily removable for repair or replacement. Each contact pin shall be identified by a permanent number adjacent to the contact pin. These numbers shall be applied using a high contrast color for visibility. Alternatively, the Core Systems Contractor shall provide templates for contact pin identification as part of the special tools and equipment package.

TP-4.7.2.6 Coupler Electric Contacts Cover

Each electric coupler head shall be provided with a weather-resistant cover to protect the coupler electrical contacts from dirt, dust, and water, in the uncoupled position.

The cover shall automatically close when uncoupling and open during coupling.

Electrical coupler seals shall also prevent dirt, dust and water from accumulating between the contact blocks while in coupled operation.

TP-4.7.2.7 Coupler Operation

Automatic Coupling

The autocouplers shall be ready to automatically couple mechanically and electrically without further action by an operator except moving the vehicle forward. Should air be utilized on the vehicle, any required pneumatic connections shall also be made automatically.

Electric Uncoupling

The uncoupling operation shall be electrically controlled from the Control Station at the point of uncoupling through activation of a spring-loaded switch. This shall cause the electric heads on the couplers of both the vehicles being uncoupled to move to the isolated position and allow mechanical uncoupling to be initiated.

Once the uncoupling button is released, the operator may place the Direction Switch into the reverse position and back away. It shall not be necessary to compress the couplers to achieve mechanical uncoupling.

In the event of unintentional train separation, each vehicle of the consist shall automatically apply a B MAX braking effort until the vehicles are completely stopped.

Manual Operation Requirements

Devices shall be provided to permit the operation of the mechanical coupler (uncouple only) and electrical head (isolating and reconnecting) without the use of tools, in the event of power loss or control failure.

TP-4.7.2.8 Energy-Absorbing Mechanism

Each coupler shall be provided with an energy-absorbing mechanism as per the requirements of Section 4.6.4.2. A self-restoring, gas-hydraulic absorption system without the need to replace absorption elements at collision speeds of 8 km/h [5 mph] or less is preferred.

TP-4.7.2.9 Centering Mechanism

Each coupler shall be provided with a self-centering device to retain the unconnected coupler head within the gathering range to permit automatic coupling on level tangent track. When coupled, the centering device shall not restrict coupler movement necessary for normal operation. The centering device shall be designed to allow the coupler to be manually positioned for coupling on curved track.

Emergency restraining devices shall be provided in case of centering device failure.

TP-4.7.2.10 Manual Couplers (Type B Coupler)

The gangway ends of each end (E-type) and middle (M-type) vehicle shall be equipped with a type B energy-absorbing manual coupler and associated draft gear system, with a self-centering device and meet the mechanical performance requirements of the Type A coupler. Coupling of vehicles into a trainset will be semi-permanent. The coupler shall provide manual mechanical coupling and uncoupling functions. Electrical trainline connections between vehicles shall be by means of jumper cables.

TP-4.7.3 Gangways

The gangways include all the elements that make up the flexible connections between vehicles.

The wide gangway shall be designed to maximize ease of passenger access from one vehicle to another. The interior width of the gangway shall match the height, width and profile of the vehicle body as closely as possible.

All elements of the gangway shall move without audible noise or vibration under all conditions.

TP-4.7.3.1 Gangway Bellows

The gangway bellows shall blend in with the interior and exterior of the vehicle to provide a consistent look to the vehicle. The gangway bellows shall be color coordinated with the interior of the vehicle.

The interior bellows shall be designed to prevent injury to or entrapment of passengers and System operations personnel.

The gangway bellows shall seal against water, drafts, and noise. The unit shall also provide for the automatic draining of any liquids which may bypass the seals or arise from other sources inside the vehicle.

TP-4.7.3.2 Gangway Floor Bridgeplates

The bridgeplates in the gangway shall not present a tripping hazard to vehicle occupants in any combination of horizontal and vertical curves allowed on the System, combined with any resulting vehicle dynamic motion.

The bridgeplate covering shall match that used in other passenger areas to the maximum degree practical.

TP-4.7.4 Interior Fittings and Finishing

Interior equipment, fittings, and furnishings for the vehicle exposed to passengers shall be fabricated of high-durability and low-maintenance materials.

The interior design shall emphasize making the interior as passenger friendly as possible, by use of resilient components, elimination of sharp corners and elimination of tripping hazards to make the interior as safe as possible in event of collisions.

Floor covering, seats, windows, liners, and other such exposed components, shall meet the following requirements:

- Flammability, smoke emission, and toxicity shall be in accordance with the specified requirements of Section 4.6.14.
- Surfaces shall be free from distortions, gaps, tooling marks, scratches, gouges, or visible defects.
- Surfaces shall be vandal and graffiti-resistant.
- The vehicle interior shall be designed to actively prevent the concealment of weapons or illegal paraphernalia.
- Surfaces shall be supported to prevent sagging, drumming, squeaking, rattling or vibration.
- The surfaces shall be free from sharp corners or edges.
- Interior surfaces shall not require painting where exposed to passenger contact.

- Passenger area or underseat mounted equipment shall be avoided whenever possible.
- The vehicle interior shall be of a harmonious, attractive design that presents a clean, neat surface with a minimum of visible fasteners and a maximum of surface continuity.
- The vehicle interior shall be finished with high durability, low-maintenance materials. Color shall extend all the way through all materials, except fiberglass reinforced plastic (FRP) and melamine where specified.

Interior linings shall be mechanically fastened to their supporting surfaces. The mounting shall accommodate the dynamics of vehicle movement without transmitting stress to the liners.

- The number of seams or joins shall be minimized.
- Linings or panels and any structure to which attachment or contact is made shall have "Anti-squeak" tape installed.
- Linings which cover apparatus or areas requiring maintenance access shall be fastened in a manner allowing ready removal and replacement.
- Any exposed stainless steel, shall be given a brushed finish.
- Gaps between non-rigid apparatus shall be wide enough to prevent injury when the apparatus moves, or rigid spacers shall be provided to prevent the gap from closing.
- Exposed fasteners shall not be used. Where equipment panel removal or maintenance access is required, quarter turn locking mechanisms opened by use of a Maintenance Key shall be used.

TP-4.7.4.1 Colors and Finishes

The vehicle interior shall be finished in accordance with the color scheme and materials to be provided by the City.

TP-4.7.4.2 Interior Graphics

Suitable graphics shall be provided throughout the vehicle to provide passengers with information. All graphics shall meet or exceed ADA requirements.

All controls, devices, and equipment intended for System operations personnel or passenger use shall be clearly labeled both with text and graphical figures or icons.

The following text and graphics shall be provided at a minimum:

- Vehicle Numbers - in the interior of the vehicle.
- Supplier's name plate - two builder's plates may be applied to the interior of each vehicle.
- Control Station switches, all pushbuttons, switches, circuit breakers and other operating devices.
- Ownership nameplate, where applicable.
- Graphics for passenger and safety information, including door emergency releases, emergency evacuation ladder location and instructions, T-TEL station locations and instructions, information for persons with disabilities, bicycle storage information, and other information as appropriate.
- High-voltage safety warnings on equipment boxes containing wiring or components operating at 150 volts or above.

- System maps and other information as appropriate.

TP-4.7.4.3 Insulation

Thermal

The roof, sides, and ends of the vehicles, including the inside faces of posts and structural members, shall be fully insulated with high efficiency insulation with no thermal shorts.

The density, thickness, and type insulation shall be determined by U value requirements established by the HVAC calculations and sustainability considerations.

Insulation separated by a vapor barrier shall be used under the floor. The underfloor insulation shall be protected by stainless steel sheathing, which shall seal the underside of the vehicle against water, dust and debris.

Floor insulation material shall be compatible with the material used at locations in the vehicle structure and shall not mold, rot, or sustain vermin.

Acoustic

Attenuation for noise and vibration shall be incorporated into enclosures, baffles, seals, and body panels for acoustical absorption.

Inner surfaces of areas of the structural shell shall have vibration and sound damping abatement material applied.

Abatement material shall be resistant to dilute acids, alkalis, greases, gasoline, aliphatic oils, and vermin.

Primer shall be applied prior to application of the damping material.

Sound deadening compound shall be sprayed onto the vehicle interior surfaces and underfloor surfaces where practical.

Acoustical insulation shall then be applied to the following:

- The inner surfaces of the vehicle structural shell
- The end underframe weldments
- The inside surfaces of structural members
- The outside surfaces of the main air duct and all ventilation cross ducts
- Duct splitters on one side only.

TP-4.7.4.4 Windows and Glazing

Bodyside Windows

Single-glazed, fixed windows shall be bonded to the structure so as to present a flat outside side appearance. Other methods of attaching the windows to the structure may be proposed.

Window replacement time (return to service) shall not exceed 8 hours including any drying time.

The side windows in the passenger sections shall be laminated safety glass to ANSI Z26.1.

Passenger windows shall be interchangeable, and the number of different sizes shall be kept to a minimum.

Anti-vandal film shall be applied to the inside surface of each window.

All bodyside window glass and door glazing shall be low-e, thermal reflective and provided with tints, screens, or other solar/thermal limiting measures as required by the HVAC design. The tints shall not preclude passengers from being seen from outside the vehicle or limit their vision when looking out the bodyside windows.

Passenger Door Glazing

The door glazing in the passenger sections shall be laminated safety glass to ANSI Z26.1 using a similar bonded application to the passenger side windows to present a coordinated side design.

Anti-vandal film shall be applied to the inside surface of each door glazing panel.

All door glazing shall match the bodyside window characteristics.

Windshields

The windshields fitted to the non-gangway ends of the end vehicles shall be constructed to meet the impact and ballistics requirements as specified in Section 4.6.4.8. They shall be laminated, clear safety glass, bonded in place. Alternatively they may retained in an endless glazing section or frame, and shall be watertight without the use of any sealants or gaskets, except between the frame and the vehicle body. The windshield shall be replaceable from outside the vehicle.

The windshield shall minimize external glare and reflections from inside the vehicle when the vehicle is operated at night with all interior illumination on.

The Core Systems Contractor may propose a windshield with an integral electric demister element for demisting equipment requirements.

The upper portion of the windshield may cover the end destination display, provided the glare from sunlight, etc. does not obscure visibility from outside the vehicle.

TP-4.7.4.5 Draft Screens

Draft screens shall not be required.

TP-4.7.4.6 Walls

All areas below the window mask on side and end linings shall be covered. One joint per wainscot shall be permitted per section between side entrance doors and in each passenger compartment level. Where appropriate, joints in the wainscot panel shall be hidden from view by the seats.

Window masks shall be sloped to eliminate dirt collecting areas and shall be provided at all vehicle body windows, including windshields.

TP-4.7.4.7 Ceilings

Panels shall provide transition from the ceiling to the side walls. The panels shall be individually removable.

A minimum number of panels shall be provided, and shall be consistent with the need for access to equipment.

Longitudinal joints are permissible only at light fixtures.

Ceiling panels may be supported by or integrated with the air diffuser/light fixture assembly installation or by hinges fastened to the roof structure.

TP-4.7.4.8 Moldings

Ceiling and wall joints shall be covered with molding mechanically attached to the vehicle structure without having fasteners exposed.

The color of the molding shall be compatible with the colors of the other materials on all exposed surfaces of the vehicle.

TP-4.7.4.9 Universal Areas

Two universal areas shall be provided in each vehicle to accommodate wheelchairs, bicycles, surfboards and luggage as specified in Section 4.4.4. Tip-up seats shall also be provided in these areas to maximize area usage.

Interior graphics shall be provided at each universal area to indicate that the primary use of the area is for wheelchairs, persons with disabilities, and the elderly.

Suitable handrails shall also be provided to assist wheelchair users in positioning themselves and maintaining stability when vehicle is underway. No wheelchair tie-downs or other securing devices are required.

To accommodate bicycle users, special attention shall be given to the ease with which bicycles can be hung in the bicycle racks. It is expected that the final design shall include guide rails to help steer the bicycle into the correct position with a minimum of effort. Bicycles shall be hung as low as possible and designs requiring the lifting of bicycles over fixed objects shall be avoided.

Suitable racks shall also be provided to safely accommodate a wide variety of surfboards and sizes of luggage.

TP-4.7.4.10 Seats

Standard passenger fixed seats shall be oriented as illustrated in Figure 4-1. Transverse knee to knee seats are not allowed in any location.

Standard Passenger

Transverse passenger seats shall be cantilevered off the side wall of the vehicle. Equipment under seats shall be kept to an absolute minimum.

Each seat frame and its support shall be constructed as an integrated standard unit, providing for easy replacement of the complete seat and shall meet the structural strength requirements of Section 4.6.4.6.

A resilient grab handle shall extend across the top of the entire seat back and down the aisle side of all transverse seats. The handle shall be firmly attached to the seat frame. The resilient grab handles shall be designed to reduce possible injury to passengers in the event of a sudden stop, as well making it easier to maintain a good grip on the handle, while being easily cleaned and resistant to vandalism.

Fabric covered, cushioned inserts shall be provided for back and bottom installation on all passenger seats. The cushion thickness shall be 19 mm to 25 mm [0.75 inch to 1.0 inch], but with sufficient density to prevent a 92 kg [203 lb] passenger from coming into contact with the seat base.

The inserts shall be removable, contoured for maximum comfort, vandal resistant, graffiti resistant and constructed of inherently fire-retardant materials. Vandal resistant materials may include a stainless steel mesh or para-aramid fiber (such as Kevlar, Twaron, or Technora) woven in to the seat fabric so as to be resistant to slashing, as well as fire-resistant.

Fabric and seat base/back colors shall be in accordance with the approved interior color scheme.

All seat inserts of a given type shall be completely interchangeable. Installation and replacement shall be performed by a simple release mechanism.

Should it not be possible to accommodate equipment elsewhere, seats providing access to underseat equipment boxes shall be mounted to allow easy and frequent removal without wear or damage to any part. All underseat equipment areas shall only be accessible by authorized staff using a Crew Key.

Tip-Up

The tip-up seat backs shall be designed to be similar in width, shape and contour to the standard seat back, complete with fabric covered inserts and shall be suitable for use by a US 5^{th} percentile female and 95^{th} percentile male.

The tip-up seats shall be supported by the seat mounting/side impact rails in the vehicle body structure.

The seat bottom assembly shall be hinged and spring-loaded, to allow it to fold up to provide space for the wheelchair. The seat shall normally return and remain in the up or folded position when not in use. A spring or functionally equivalent mechanism shall be utilized to maintain the tip-up seat in the up position.

The seat bottom shall be as comfortable as a standard fixed seat and shall use the same inserts. The seat bottom shall also be fitted with a padded posterior rest on the underside that will provide support to standing passengers when the seat is folded up.

TP-4.7.4.11 Stanchions and Handrails

All stanchions, handrails and grabrails shall meet the applicable ADA requirements, ergonomic design criterion and universal design criterion. They shall also be of a color and finish in accordance with the approved interior color scheme.

Generally stanchions and handrails shall be located as indicated in Figure 6-4.

Full height vertical stanchions shall be avoided wherever practical and ceiling suspended, seat back or wall mounted handrails used instead. Vertical stanchions shall not be fastened to the floor.

Longitudinal grab rails or an equivalent shall be provided along each edge of the center aisle in all passenger areas a minimum of 1830 mm [6 ft] from the floor to assist standees in the aisles.

The position and general design of the stanchions and handrails shall be reviewed by the City.

TP-4.7.4.12 System Maps and Display Panels

Space shall be reserved for the application of at least four system route maps per vehicle in locations easily visible to both seated and standing passengers.

Space shall be reserved for the future installation of flat screen LCD or plasma displays in the passenger areas. Electrical power and video cabling provisions for these screens shall also be provided, including trainlined connections between vehicles. The location, number and size of future advertising displays will depend on the physical interior configuration of the vehicle being supplied. It is expected that the displays will be sited where most visible, generally above the windows in the passenger areas. For a good viewing coverage there are likely to be approximately 6 to 8 displays total per vehicle and each display will probably be 15 to 17 inches diagonally.

TP-4.7.4.13 Emergency Equipment

The following emergency equipment shall be provided in each vehicle:

- Fire extinguisher, 4.5 kilograms [10 pounds] capacity, minimum rating 4A-300:C, marine-type, mounted in a clearly visible location, and with clear instructions for its use. Removal of an extinguisher from its mounting location shall activate an audible alarm on the vehicle and send an alarm to the OCC as per Section 4.7.20.2.

- At least two ladders shall be provided per vehicle, stored separately near either end to minimize the likelihood of one incident rendering both inaccessible. Ladders shall be capable of reaching from vehicle floor level to walkways in both at-grade and elevated sections. Transfer planks, if provided, shall be accessible only to system operations and maintenance personnel.

- The Core System Contractor shall perform a Hazard Analysis for conditions associated with evacuation with assistance, and for conditions associated with evacuation without assistance. The Core System Contractor shall provide vehicle equipment that enables passenger evacuation with and without assistance. For evacuation with assistance, the Core System Contractor shall ensure supervised and orderly evacuation of all passengers in a safe and timely manner, including passengers unable to evacuate themselves, from vehicles located anywhere along the system. For evacuation without assistance, the Core System Contractor shall provide equipment and instructions to ensure safe self evacuation in conditions where supervised evacuation cannot take place (this does not include passengers unable to self-evacuate, i.e., passengers requiring assistance).

TP-4.7.5 Exterior Fittings and Finishing

TP-4.7.5.1 Exterior Equipment

Underfloor equipment shall be protected from water splash, vehicle water drains, flying rock ballast, or other objects thrown by wheels that are in a direct line of sight for any possible truck orientation. Underfloor equipment shall allow access from the side of the vehicle, from maintenance pits, and when the vehicle is on lifts.

All exterior-mounted equipment enclosures shall be watertight when subjected to train washing, hose cleaning and driving rain. Removable or openable covers shall have edge seals to prevent ingress of water. Drain-clearing mechanisms shall be provided.

Equipment installation shall allow for the maximum ventilation of parts and minimum restriction to cooling air. Air exhausted from one piece of equipment shall not be directed into the air intake of another piece of equipment.

Equipment cover latches shall not violate the vehicle dynamic clearance outline when not engaged, and shall hold the cover firmly to the box without rattling in the engaged condition.

Safety catches shall be provided for each equipment box cover. The catches shall be designed to retain the cover within the vehicle dynamic clearance envelope at all operating speeds, and without the cover latches engaged.

Enclosure covers shall have an internal "Hold Open" feature that shall not create electrical safety hazards.

All covers shall open at least 90 degrees, and shall be readily removable without the use of tools.

Underfloor equipment attachment shall meet the requirements of APTA C&S-SS-034-99, Section 5.7. All underfloor equipment shall be secured with mounting brackets in shear or supported safely from beneath. The design shall be sufficiently strong to support indefinitely any piece of equipment having one failed support. Bolting of mounting brackets shall be done in such a manner that the bolts do not carry the load in shear or tension. Bolts and associated nuts shall be accessible for equipment removal.

TP-4.7.5.2 Finishing

Colors and Finishes

The vehicle exterior shall be painted in accordance with the color scheme to be provided by the City.

Exterior Graphics

Suitable graphics shall be provided throughout the vehicle to provide passengers and System operations personnel with information.

All controls, devices, and equipment intended for Operations and Maintenance personnel or passenger use shall be clearly labeled both with text and graphical figures or icons.

Graphics shall be applied in accordance with the manufacturer's instructions on a clean, dry surface.

The following text and graphics shall be provided at a minimum:

- Vehicle Numbers - on the end, bodyside and rooftop.
- System Logo - on the exterior of the vehicle.
- Graphics for passenger and safety information, including external door emergency releases, wheelchair/bicycle accessible doors, crew access, and other information as appropriate.
- High-voltage safety warnings on equipment boxes containing wiring or components operating at 150 volts or above.

TP-4.7.5.3 Truck Lifeguards

Truck lifeguards are not required. However, stone guards shall be mounted in front of the lead axle of each power truck as per Section 4.7.17.21.

TP-4.7.5.4 Replaceable Front End Skirts

Skirts shall be provided along the lower perimeter of the vehicle at the front end, and shall be quickly replaceable in the event of accident damage.

Hinged access panels shall also be provided below the windshield above the anticlimber elements to provide maintenance access to windshield wiper/washer units, etc.

Louvers or grills are allowable for ventilation purposes provided they are sympathetic to the vehicle exterior aesthetic design.

Skirts shall be visually integrated with the anticlimber bumper assembly to provide clean visual lines.

All skirts shall be manufactured of a durable material such as steel, FRP, or aluminum and mounted in such a way as to be easily and quickly replaceable in event of an accident using commonly available hand tools.

Skirt sections should be small and light enough to be easily carried by one person, i.e. not exceed 11.3 kg [24.86 lb] in weight. Skirts shall not be load-bearing members.

TP-4.7.5.5 Exterior Warning Devices

The exterior warning device sounds all may be electronically generated and integrated into a single unit.

Warning Bell

Electronic or bell type warning devices shall be provided at the ends of the vehicle as specified in Section 4.6.19.1. The bell shall produce a repeating sound and be activated on the leading and trailing end of each trainset.

Warning Horn

Electronic or air horn warning devices shall be provided at the ends of the vehicle as specified in Section 4.6.19.2. The horn shall produce a repetitive sound and be activated only on the lead end of the lead vehicle.

Backup Alarm

A standard industrial type electronic reverse warning alarm device shall be provided to indicate when a vehicle is reversing. This alarm shall be activated on the rear end of the rear vehicle in a trainset only when it is being backed using the lead vehicle.

TP-4.7.5.6 Windshield Washer and Wiper Unit

A windshield wiper and washer assembly shall be provided for each windshield. Windshield wiper drive units shall be electrically operated with three-speed progressive intermittent control. All mechanisms shall be enclosed, but shall be readily accessible for repair and replacement. The wiper mechanism shall be mounted at the top or bottom of the windshield glass.

The washer fluid reservoir shall be located to permit easy refilling from the exterior of the vehicle. Any filler caps shall be permanently retained to prevent loss.

The normal off or parked position of the wiper blade shall not impede an operator’s line of sight.

TP-4.7.5.7 Flange Lubrication System

An intelligent wheel flange and top of rail lubrication system shall be provided on each vehicle to automatically dispense an environmentally friendly liquid lubricant on both sides of the wheel flanges of the leading powered axle on the leading vehicle in a consist only

when passing through specific short radius curves unless an alternative wayside system has been agreed as per Section 4.5.2.2.

The system shall also be capable of automatically dispensing this lubricant to the wheel tread of the same wheels for top of rail lubrication in the same locations when enabled by the OCC. The wheel tread lubrication part of the system will be active for one complete system round trip journey and shall deactivate automatically upon completion of the first round trip. (Wheel tread lubrication will be required only once or twice a day using a single vehicle).

The lubricant reservoir shall have sufficient capacity for a minimum of two weeks or 2000 miles of vehicle operation without refilling. Lubricator pumps shall be disabled and an alarm shall be provided to the ATC system when reservoirs are low.

Reservoirs shall be equipped with sight glasses and refilled from outside the vehicle via an easily accessible quick refill connection from either side of the vehicle. Any filler caps shall be permanently retained to prevent loss.

TP-4.7.6 Keys and Locks

Different keys and locks shall be provided for controls and for access to vehicles and equipment. As appropriate, the locks shall be operable by:

- Control Key
- Crew Key
- Maintenance Key
- Video Recorder Key
- Event Recorder Key

Preference is for all such keys to be of the seven pin tumbler type (barrel key), cut to unique key codes assigned to the System, utilizing non-standard key blanks to prevent unauthorized duplication.

Due to the number of personnel who will be issued these keys, 200 of each of these keys (except the Video Recorder Key and Event Recorder Key) shall be provided by the Core Systems Contractor.

TP-4.7.6.1 Control Key

A unique, specially-shaped sturdy key shall be provided to allow operation of the vehicle by the Operations and Maintenance staff.

TP-4.7.6.2 Crew Key

A Crew Key will be used to lock controls, doors, and access panels as required for daily train operation.

TP-4.7.6.3 Maintenance Key

A Maintenance Key shall be used to open all access panels and interior equipment lockers, including those that can be opened with a Crew Key. This key will primarily be used by maintenance personnel.

TP-4.7.6.4 Video Recorder Key

A special, non-standard, not readily-duplicated key shall be provided for the removal of the memory units from all video recorders. Twenty (20) each of these shall be provided by the Core Systems Contractor.

TP-4.7.6.5 Event Recorder Key

A special, non-standard, not readily-duplicated key shall be provided for the removal of the memory card from all event recorders (if removable storage medium provided). Twenty (20) each of these shall be provided by the Core Systems Contractor.

TP-4.7.7 Control Station and Trainlines

TP-4.7.7.1 Control Station

A Control Station (hostler panel) shall be provided at the non-gangway end of each end (E-type) vehicle and shall contain all necessary controls, equipment and devices for manual operation of a single trainset of up to four vehicles in normal operation and a coupled train of up to eight vehicles under emergency conditions.

See also Section 4.7.19 for further Control Station details.

The Control Station shall be inconspicuous, and shall blend in with the vehicle's interior design behind a locked cover when not in use. The Control Station design shall employ sound ergonomic design principles to accommodate a wide variety of potential operators (5^{th} percentile U.S. female to 95^{th} percentile U.S. male) so that the operator's views are not obstructed and the arrangement of all controls, instruments, displays, gauges, switches, and other indicators and devices, required for safe manual train operation are easily accessible, easily removed for maintenance, and within reach of a seated operator whenever manual operation is desired.

All controls shall be arranged so that controls used most frequently, or that are most important to the safe operation of the vehicle, are closest to the operator. Graphic symbols (icons) shall be provided for each switch, pushbutton or indicator clearly identifying it's function and visible in either the energized or the de-energized state. Illuminated pushbuttons shall utilize LEDs. Illuminated pushbuttons shall also incorporate suitable pictograms in accordance with ISO 7000 and IEC 60417 on the button tops to indicate function, in addition to permanent labels. The operator's controls shall be simple and their functioning intrinsically understood without need for extensive training.

Manual operation shall be possible with an operator in either a standing or a sitting position. A simple folding operator's seat or perch shall also be integrated into the Control Station overall design and stored behind a locked panel when not in use.

The following functions shall be incorporated within the Control Station area:

- Annunciators - Overspeed alarms, faults, and subsystem status indication;
- Displays - Speed limit, actual speed and door status indicators;
- Communications - Microphone and controls for manual PA, auto-announcer audio/information display text message selection, route selection and voice radio;
- Master Controller - Controlling end selector switch; combined braking and propulsion controls;
- Misc. controls – Emergency stop button to disable propulsion power and operate the emergency brakes; door open/close, interior/exterior lighting, HVAC, windshield wiper, and coupling/uncoupling controls; and all other controls unique to the specific vehicle design necessary for effective operation and control.

The controls shall be so interlocked that only one Control Station in a trainset has control, and all others are locked out.

TP-4.7.7.2 Bypass / Isolation Controls

To maintain a vehicle in service or allow it to return to the MSF under its own power in event of a failure in service, the following controls shall also be provided, individually sealed and located behind a locked cover accessible only to maintenance personnel having a Maintenance Key. These controls shall also be capable of being bypassed by remote control via the ATC equipment to allow a disabled train to reach the next station and unload passengers or other take actions as appropriate:

Door Interlock Bypass

This switch shall bypass the consist door interlock circuit. Activation of the Door Interlock Bypass shall allow motoring in the event of an open door within the train.

Speed Restriction Bypass

This switch bypasses the circuit which limits train speed due to propulsion or friction brake failure on all vehicles of the train.

Local Vehicle Power Down

This switch initiates a power down of the vehicle

Local No-motion Detection Bypass

This switch shall bypass the local no-motion circuit which prevents door operation at non-zero speed. No other No-Motion interlock functions on coupled vehicle shall be bypassed.

Local Friction Brake Cutout – Truck A

This switch cuts out the Truck A friction brake system

Local Friction Brake Cutout – Truck B

This switch cuts out the Truck B friction brake system

Local Propulsion Cutout – Truck A

This switch isolates the Truck A propulsion equipment

Local Propulsion Cutout – Truck B

This switch isolates the Truck B propulsion equipment

Dynamic Brake Cutout

This switch cuts out local dynamic brake

Regenerative Brake Cutout

This switch cuts out local regenerative brake

Brake Inhibit Bypass

This switch bypasses local brake inhibit circuits

HVAC Units Cutout

This switch cuts out local HVAC units

Audible Alert Bypass

Operation of any bypass/isolation switch, either manually or via the ATC equipment, shall illuminate the local blue exterior vehicle fault/bypass indicator on that vehicle (except for the Audible Alert Bypass), cause the action to be logged by the Maintenance and Diagnostic system, an alert message to be transmitted to the OCC, and where appropriate, automatically reduce the vehicle maximum operating speed.

TP-4.7.7.3 Master Controller with Deadman Protection

Manual control of propulsion and braking shall be accomplished through a single-handle master controller provided in each Control Station.

This controller shall operate to provide infinitely variable control of propulsion and braking rate requests, and shall produce tractive effort linearly proportional to the handle position as indicated in the following table.

The transition point between B3 full-service braking and B MAX maximum braking shall be indicated by a hard detent so as to prevent inadvertent movement into the maximum braking zone. The transition points for the Coast or neutral position shall be indicated by soft detents as a driving aid. The ends of the acceleration and braking zones shall be limited by mechanical stops.

The Master Controller shall move forward and rearward in a longitudinal vertical plane. Power positions shall be activated by a rearward motion of the controller handle, with progressively increasing values of acceleration. The coast (neutral) position shall be in the middle sector between the power and brake commands. Moving the controller forward from the middle position shall command braking with progressively increasing values.

Table 7-1.Master Controller Positions

Position
P3 Maximum Power
P MIN to P3
P MIN Minimum Power
COAST Neutral
B MIN Minimum Braking
B MIN to B3
B3 Full Service Brake
B MAX Maximum Braking

The Master Controller shall have a time-delayed “deadman” feature incorporated, which, if released, shall command a retrievable B3 brake application at the end of a preset time delay, adjustable between 0 and 2 seconds. The time delay shall reset if the “deadman” feature is re-activated prior to the expiration of the two-second time period, and no brake application shall occur. The “deadman” feature shall be de-activated at any time when the Master Controller is in the B3 full-service braking, B MAX maximum braking or emergency braking modes. It shall also be deactivated when the Select Switch is in the OFF position.

The “deadman” feature on the master controller shall be designed to prevent bypassing this safety feature by an operator.

For lay-up storage, the Master Controller handle shall be in the B3 full service braking position, mechanically interlocked with the Select switch and the Direction Switch. It shall be possible to return the Master Controller handle to this position regardless of the position of the Direction Switch or when the Select Switch is in the OFF position.

An alternate proposal for a joystick or other type master controller and associated dead man protection will also be considered.

TP-4.7.7.4 Select Switch

A Select Switch shall be provided in each Control Station that can only be moved from the "Off" position by use of a special and unique Control Key.

The switch shall have two positions: "Off" and "On." The switch shall be so interlocked with the Direction Switch that the lock cannot be moved to the "Off" position unless the Direction Switch is in the neutral position, and the Direction Switch cannot be moved with the Select Switch in the "Off" position. In the "On" position of the Select Switch, that Control Station shall become the control position for operation and shall isolate all other control stations in the consist, including ATC equipment. It shall not be possible to activate automatic operation or any control station unless all other Select Switches are in the "Off" position. If both Select switches in a train are in the "Off" position, the train shall respond to ATC control and/or all trainline commands upon coupling with another train. The status and functions for the two positions of the control switch are as follows:

- **OFF**: When the Select Switch in the "OFF," position, all appropriate propulsion and braking control circuits in the consist shall be under the complete control of the ATC equipment. The Select switch Crew Key shall be removable in this position.
- **ON**: Turning the Select Switch in a Control Station to the "On" position shall establish that vehicle as the lead vehicle for the consist, and shall energize all control circuits necessary for activating all systems in the consist, by activating the appropriate trainlines. Actions shall include energizing of the auxiliary and low voltage power supplies, illumination of the headlights and the end vehicle amber marker lights on the controlling end, and illuminating all amber side marker lights and the red taillights and rear end red marker lights on the rear vehicle of the consist. No lights on intermediate vehicle ends shall be illuminated. The Crew Key shall not be removable in this switch position.

TP-4.7.7.5 Direction Switch

A Direction Switch shall be provided on each Control Station. The switch shall have three positions as follows:

- Forward
- Neutral
- Reverse

The switch shall be interlocked with the master controller so that it cannot be moved from the neutral position or between the forward and reverse position unless the Master Controller is in the B3 full-service braking position. The switch shall also prevent movement into the neutral position unless the Master Controller is in the B3 full service brake position. Conversely, interlocking shall prevent movement of the Master Controller unless the Direction Switch is in either the forward or reverse position.

When all the Direction Switches within a train and ATC controls are in the neutral position, the parking brakes shall be applied automatically.

Whenever the Direction Switch in a train is placed in the reverse position, the reverse warning device shall be activated on the trailing end of the train and the hazard lights on all vehicles in the train shall flash.

TP-4.7.7.6 Vehicle Wash Mode Control

A pushbutton switch identified as "Vehicle Wash" shall be located on the Control Station. When in the on position, it shall prevent any propulsion trainline command higher than 0.134 m/s^2 [0.3 mphps] from being issued by the master controller regardless of power position. This function shall be used to limit the vehicle speed through the train wash equipment to 3.2 km/hr [2.0 mph]. All other master controller functions shall operate normally. The switch shall be illuminated steady yellow when in the on position. This switch shall function only on an active Control Station.

The vehicle shall be powered from the contact rail system for this operation.

TP-4.7.7.7 Monitoring and Diagnostic Display

An Operator Monitoring and Diagnostic display panel shall be provided in each Control Station. This panel shall provide illuminated display of the speed, time, date, and system status as the default display.

TP-4.7.7.8 Odometer

An electronic odometer with a permanent non-volatile memory and an LED display or non-resettable electromechanical odometer shall be provided in each vehicle for the accumulation of vehicle mileage. The odometer shall register the total number of miles traveled. It shall not be possible to reset the counter display to zero.

The odometer shall register miles to the nearest mile and shall have a minimum of eight digits.

Replacement of any other system component shall not impact the recorded mileage or require replacement of the odometer. The odometer design shall provide allowance for wheel diameter correction.

TP-4.7.7.9 Running Hour Meter

The Core Systems Contractor shall propose methods to record accumulation of actual hours of operation of each vehicle to assist maintenance personnel in scheduling preventive maintenance on vehicle systems that must be maintained on a running time-based schedule. The hour meter shall be electrically or electronically controlled, but shall have a mechanical step-counter for indicating total hours. It shall not be possible to reset Running Hour meters.

TP-4.7.7.10 Trainlines and Interlocks

The vehicle and all coupled vehicles shall be controlled through a combination of LVPS-level digital and analog train lines. Minimal use shall be made of electro-mechanical relays in vehicle control circuits. Control of systems not described below shall be determined by the Core Systems Contractor.

Digital Train Lines

All digital train lines shall conform to the requirements of IEEE 1475-1999 - Functioning of and Interfaces Among Propulsion, Friction Brake, and Train-borne Master Control on Rail Rapid Transit Vehicles, Type I requirements.

Analog Train Lines

All analog train lines shall be PWM signals, conforming to IEEE 1475-1999 - Functioning of and Interfaces Among Propulsion, Friction Brake, and Train-borne Master Control on Rail Rapid Transit Vehicles, Type II requirements. Network implementation of analog trainlines may be proposed if compliant with IEEE 1475-1999, Type III requirements and service-proven.

Trainline and Interconnecting Wiring

The wire harnesses or groups of wires between equipment enclosures shall have a minimum of 10 percent spares (not less than two spare conductors for each wire size).

The trainline wire harnesses shall have a minimum of 6 spare train wires running the full length of the vehicle to the coupler heads.

Where possible, the wiring shall be pre-fabricated into standard harnesses, wrapped and tied with a high strength tie designed not to invade the wire insulation, and shall include spare wires within unit compartments

Generally, wires shall be installed and marked with the same arrangement and location, with all identifications visible in each vehicle having similar apparatus.

Spare wires shall be so marked on each end.

Propulsion and Braking Trainlines

The Master Controller shall generate the appropriate discrete trainline signals to confirm master controller analog commands:

- Power (High Above Coast)
- Full Service Brake (High Above B3)
- Emergency Brake (High when not in Emergency Braking)

The power and brake rate trainline shall provide the active Master Controller Handle Position to all propulsion/brake logic units on a train.

Emergency Brake Loop

The Emergency Brake shall be controlled by a four wire trainline emergency loop. The controlling vehicle shall provide the positive and negative feeds to the trainlines through the console Emergency Stop pushbutton, regardless of the switch location in the train. The emergency brake loop trainlines shall be treated as vital trainlines, with maximum isolation maintained from possible sources of false energization.

All emergency brake loop circuits shall be arranged in a fail-safe manner, requiring that trainlines be energized to allow a permissive condition. The emergency brake trainline circuit shall require both energization and continuity throughout the train to allow a permissive state.

The emergency brake circuit shall be interlocked with the no-motion detection system such that, once emergency brake is commanded, the emergency brake circuit cannot be reset to the normal state until no-motion is indicated.

Automatically Initiated Emergencies

In multiple trainset operation, unintended separation of the coupler electric portions shall cause an automatic emergency brake application on all vehicles in the train. Normal

uncoupling that is preceded by a successful isolation shall not apply emergency brakes on the section of the train with the active Control Station or ATC equipment.

Track Brake Control

Track brakes shall be controlled by a trainline that is energized to apply the track brakes in B MAX or Emergency Braking modes. The track brakes shall be controlled locally by the emergency brake relay in each vehicle. All track brakes in a train shall be applied when commanded by the ATC system or by use of an active Control Station Emergency Stop pushbutton.

Door Closed Interlock

A trainline electrical loop circuit shall be provided to monitor all door panel positions in a consist. Position sensing switches shall be provided for each door panel to positively and directly detect that each panel is fully closed and locked, prior to the application of propulsion. Breaking of the door closed interlock circuit shall cause the removal of traction power and the initiation of full service braking (B3) on all vehicles of the consist.

TP-4.7.8 Passenger Doors

The passenger door system shall be a service-proven, power-operated design with electrical controls and operators, and shall be considered a vital train safety system.

Vehicles shall have four to six full-width door openings, with two to three openings on each side. Doors shall be located directly across from those on the opposite side. At least one door opening on each side shall allow for crew access with recessed handrails and steps in the lower bodyside to enable access by maintenance personnel into the vehicle from ground level.

All passenger doors shall be two-panel, sliding-plug type. Alternative designs with outside sliding leaf doors will also be acceptable.

All door panels shall be flush with the vehicle body when closed. The closed door panels shall seal to prevent the ingress of water during the train wash operation or proceeding at maximum speed in revenue service under the worst-case climatic conditions.

The door tracks shall not be visible on the vehicle exterior. The door controls and operating mechanisms shall be protected from inclement weather when the door panels are in the open position and shall not present a safety hazard to boarding or alighting passengers.

The door control system shall be trainlined so that either the ATC system or a manual operator can open or close all left side, all right side or all passenger doors in the consist. All door control circuits for one side of the vehicle shall be separate and distinct from those for the other side of the vehicle.

All door panels, controls, and operating mechanisms shall be interchangeable throughout the fleet.

Left and right door panels shall be interchangeable with any other corresponding left or right mounting door panels delivered under this Contract.

TP-4.7.8.1 Door Leaf

All door leafs shall meet the structural strength requirements of Section 4.6.4.7.

Glazing details on the vehicle doors shall be submitted to the City for review and approval as part of the vehicle design review. The door leaf glazing shall be of laminated safety glass that meets the requirements of Section 4.7.4.4.

Door frames shall be free of dimples and warping, and shall be reinforced at the mounting points of all hardware. The size of the door frame, door operators and mounting components shall be selected to provide strength and rigidity.

The door panels shall be fitted with long-life, neoprene weather strip or equivalent material to meet the HVAC pressurization requirements, be vibration and rattle-free, not produce whistling and other objectionable noises at all vehicle operating speeds, and to prevent ingress of moisture and dust at all operating speeds under the worst-case possible combination of climatic conditions or when the vehicle is being washed.

TP-4.7.8.2 Door Operator and Controller

One electrically actuated door operator shall control both door panels that shall move simultaneously during each opening and closing cycle. The door operator shall have sufficient power to open and close the two-door panels under the most unfavorable wind, and vehicle pressurization conditions.

The door operator and its controller shall be powered from the low voltage dc supply system and shall operate over the full battery voltage range.

The door motion shall be smooth and free of shock and impact. Damping shall be provided at the end of travel of the door in both the opening and closing directions. With the loss of the battery supply, the doors shall remain in the last commanded position.

An automatic door lock function shall positively retain the doors in the closed position.

A door operator controller shall be provided near each doorway opening, preferably integrated with the door operator. The controller shall be located on the inside of the vehicle behind a hinged door panel accessible only by authorized personnel using a Crew or Maintenance Key.

Each door controller panel shall be capable of responding to trainline door control commands and shall be interlocked with the no-motion circuit.

All items shall be accessible for maintenance without having to remove any obstructing components.

Door system faults shall be reported to the Monitoring and Diagnostic System.

Local door status indicators and test points shall also be provided at each door position to assist in local troubleshooting activities.

Door opening times shall be as required by Section 4.6.20.

Door panels shall remain open for an adjustable period of time (between 5 seconds and 30 seconds) when manually operated or until closed by a door close signal from the ATC system,

TP-4.7.8.3 Obstruction Detection

A door obstruction detection device, of a service-proven design, shall be incorporated to monitor closing and plugging of the door panels. Preference is for independent detection of obstructions by sensing both door operator motor current and door panel speed/position/time as well as pressure sensitive door edges.

Upon detection of an obstruction, the door panels in the affected doorway shall immediately open, and remain open for a preset period of time prior to attempting to close again. The preset period shall be adjustable from 0 to 10 seconds. If the obstruction is still detected after the third closing attempt, the motion shall reverse and the door panels shall fully open and remain in that position until the cause is investigated and cleared.

- The sensitivity of the obstruction detection system with both door leafs closing simultaneously shall be as specified in Section 4.6.20.4.

TP-4.7.8.4 No Motion Detection Interlock

All door controls and pushbutton illumination circuits shall be electrically interlocked with the no-motion circuit, which shall permit the doors to be electrically opened only when vehicle no-motion is detected.

TP-4.7.8.5 Door Closed Interlock

A trainline electrical loop circuit shall be provided to monitor all door panel positions in a consist. Position sensing switches shall be provided for each door panel to positively and directly detect that each panel is fully closed and locked, prior to the application of propulsion. In addition, door interlock status shall be transmitted to the ATC system.

TP-4.7.8.6 Emergency Manual Door Opening Facilities

Interior and exterior emergency manual door release mechanisms shall be provided to permit doors to be opened locally without the use of electrical power. The force to activate the manual release mechanisms shall not exceed that specified in Section 4.6.20.1.

TP-4.7.8.7 Interior Manual Door Release

A lever or pull knob to operate the combination manual door release mechanism shall be provided on the interior of the vehicle at each doorway.

Upon operation of the release mechanism an automatic mechanical trip device shall lock the release handle in a visibly tripped position. A frangible cover shall keep the passengers from actuating the manual release unnecessarily. Since the frangible cover must be broken or removed to activate the manual release, service personnel can determine the door location where the manual release occurred.

When the manual release mechanism is initially activated the following shall occur:

- The door interlock circuit shall be interrupted, causing propulsion power to be removed and full Service Brake to be applied to all vehicles in the train.
- The alarm “PASSENGER DOOR EMERGENCY RELEASE” shall be illuminated on the Control Station when in manual mode and sound an audible alarm.
- The T-TEL passenger to OCC Intercom shall be enabled and the two best video cameras for that location shall be displayed in the OCC.

The final motion of the manual release knob or lever shall then cause the mechanism to unlock the adjacent door panels and open them approximately 25 mm [1 in] to allow the door panels to be manually pushed fully open. Electrical power to the door operator shall also be removed from the door operator by this action.

TP-4.7.8.8 Exterior Manual Door Release

Two manual door releases shall be provided on each vehicle just above floor level, one per side located diagonally opposite, for crew, maintenance and emergency personnel use for entry into the vehicle when no power is available. This mechanism shall have no lock, but an emergency service symbol on the exterior and a security seal to discourage unauthorized use. The cover shall be flush with the vehicle bodyside and self closing, preferably with a spring loaded hinge. Operation instructions shall be provided on the inside so as to only be visible when the cover is opened.

TP-4.7.8.9 Door Closing Warning Chime

A pleasing audible warning chime shall be provided two seconds prior to door closings for each doorway. A set of yellow door closing indicators, visible from both inside and outside the vehicle, shall flash with the audible warning indication for the duration of the closing sequence.

The sound level of the warning chime shall be adjusted so that with constant use at all stops, it does not cause annoyance to passengers on the train.

TP-4.7.8.10 Interlock Bypass Facility

A sealed door interlock bypass feature shall be provided in each vehicle as specified in Section 4.7.7.2.

TP-4.7.8.11 Door Lockout Facility

A door cut-out device shall be provided inside the vehicle at each door position activated by a Crew Key, and shall perform the following functions:

- Disconnect power to the door operator.
- Mechanically restrains door leafs in closed and locked position.
- Bypass the door interlock switch for that door.
- Indicate the door is out of service on the vehicle Control Panel when manually operated.

Deactivate the local pushbutton lights and activate a red door out-of-service indicator light located over the interior and exterior doorway for that door or towards the top of the door leaf.

TP-4.7.8.12 Crew Access Switches

One passenger door on each side of the vehicle (2 per vehicle), shall be provided with electrical, weatherproof, rotary crew access switches located inside and outside the vehicle just above floor level adjacent to the door. These three-position switches (close/off/open) shall operate by use of a Crew Key or Maintenance Key. These switches shall perform the following functions:

- Provide the City or emergency services personnel access to or from the vehicle regardless of whether the vehicle systems are energized or not.
- Provide means of verifying vehicles are empty at the end of a run and close the doors one vehicle at a time

The switches shall function as follows:

- OPEN: Turning a switch to the open position shall open the door adjacent to that switch for an indefinite period and activate emergency lighting in the passenger areas for a period of 15 minutes.
- OFF (default position): Turning a switch to the neutral position shall allow normal door control operation and insertion/withdrawal of Crew Key or Maintenance Key.
- CLOSE: Turning a switch to the close position shall close all doors on that side of the vehicle and cancel any existing 'enable doors' signal on that vehicle.

TP-4.7.8.13 Passenger Counters

Passenger counters shall be provided at all passenger doorways as specified in Section 4.7.21.

TP-4.7.9 Heating, Ventilation, and Air Conditioning

The HVAC system design shall make every effort to reduce the requirement for air conditioning capacity through utilization of vehicle passive and active measures that will reduce solar and radiated heat load, while minimizing cool air loss.

HVAC equipment shall be of robust, heavy duty construction and proven in rail transit applications. "Recreational" or "static commercial"-type units will not be acceptable.

TP-4.7.9.1 Passenger Area Main HVAC Units

Each vehicle shall have two self contained, modular roof mounted HVAC units to provide all vehicle heating, ventilation and air conditioning requirements. Split systems shall not be acceptable. Each HVAC unit shall provide all necessary equipment for the control of vehicle air temperature, relative humidity, cleanliness and distribution to meet the specified performance requirements of Section 4.6.3.

HVAC units shall be identical and interchangeable between ends and be individually controlled by a thermostat located to monitor the relevant passenger area. Overhead heaters shall be incorporated within the HVAC unit to provide reheat to maintain humidity control under partial cooling operation of the air conditioning apparatus, and for general passenger area heating.

Adequate provisions shall be made for collection and drainage of condensate, as well as to prevent water carryover into the ductwork. The outside of the evaporator coil casings shall be insulated to prevent condensation.

HVAC units shall utilize only ac-powered blower, fan and compressor motors.

The failure of one or both cooling circuits in an HVAC unit shall not cause failure of the ventilation fans.

Each HVAC unit shall have local diagnostic indicators to aid troubleshooting faults on the unit. HVAC system faults shall be reported to the vehicle Monitoring and Diagnostic System.

TP-4.7.9.2 Fresh Air

Fresh air as per the requirements of Section 4.6.3.2 shall be drawn into the vehicle, filtered, suitably conditioned and delivered to the vehicle interior.

TP-4.7.9.3 Temperature Regulation

The system shall automatically maintain the comfort zone requirements of temperature and humidity as specified in Section 4.6.3.1. These settings shall not be capable of adjustment by Operations personnel or passengers.

TP-4.7.9.4 Air Filtration

Fresh and recirculated air shall be filtered by use of high efficiency disposable, pleated media filters of the cardboard frame type, in a commercially-available standard size, as per the requirements of Section 4.6.3.3.

Return air filters shall be readily accessible for replacement from inside the vehicle without use of special tools.

Fresh air filters shall be readily accessible from inside the vehicle without the use of special tools.

TP-4.7.9.5 Refrigerant

The HVAC units shall be designed for and initially charged with refrigerant R-407C or other environmentally friendly refrigerant conforming to Department of Transportation 40 CFR 82 – Protection of Stratospheric Ozone.

TP-4.7.9.6 Floor Heating

Not required.

TP-4.7.9.7 Air Distribution

Ductwork

All air distribution ducts shall be concealed above the ceiling. The overhead ducts shall be supplied with conditioned air from the HVAC units, and shall discharge the air through air diffusers into the passenger compartment. These ducts shall supply conditioned air to all areas of the vehicle without objectionable drafts on standing or seated passengers.

All air ducts shall be designed so that the average air velocity does not cause excessive noise.

All ducts shall be constructed of rustproof materials and be fully thermally and acoustically insulated.

Diffusers and Grilles

Air shall be distributed evenly through adjustable diffusers throughout the vehicle interior. Following the initial balancing of diffuser air flows, the diffuser positions shall be fixed. All diffusers shall be incorporated into the design of the ceiling lighting installation.

The diffusers shall not blow air directly on the passengers and shall discharge the air parallel to the ceiling.

Recirculated/return air shall be drawn in through return grilles in the ceiling.

Smoke Detectors

Each passenger compartment shall have smoke detectors which, when activated, shall be annunciated by a discrete alarm in the OCC via the ATC system as per section 4.7.20.2. The detectors shall be appropriate for transit vehicle applications.

At least one shall be mounted on the ceiling at the center of the passenger compartment, and not directly in the discharge air flow from the HVAC system.

Smoke detectors shall also be located in the return air stream of each air conditioner. There shall be means to test the smoke detectors.

TP-4.7.10 Interior and Exterior Lighting

All lighting fixtures shall provide for easy installation and removal or replacement, as well as diffuser, lamp and ballast change-out and cleaning.

All fixtures shall be dustproof to minimize the accumulation of airborne dirt and dust within the fixture.

The lighting fixture housing or socket shall not be used as a ground return for any other electrical circuits.

Fixtures installed on the vehicle exterior, and in the interior within 610 mm [2 ft] of a doorway, shall be watertight, except for interior ceiling lights.

Ground isolation shall be provided for both electrical feeds to the lamp.

All lamps and ballasts shall be a US standard type and be readily commercially available.

All interior, exterior and indicator lights shall be long life LED type wherever this is practical.

Illumination levels shall be as specified in Section 4.6.8.

TP-4.7.10.1 Normal Interior Lighting

Overhead

The passenger area shall be illuminated by two continuous rows of fluorescent or LED equivalent fixtures mounted in the ceiling. The interior overhead lighting shall be of a harmonious, attractive design that presents a clean, neat surface with a minimum of visible fasteners and a maximum of surface continuity. The light fixtures shall be dust-proof and moisture-proof, and may be combined with the air diffusers and ceiling panels. Fixtures shall be arranged on circuits with adjacent lamps or pairs of lamps connected to different ballasts.

Passenger compartment lighting shall utilize fluorescent cool white tubes or LED equivalents with a minimum life of 20,000 hours, with rapid-start ballasts. All fluorescent tubes shall be of the same length wherever possible. Some shorter tubes may be utilized to achieve continuous lighting coverage.

All ballasts shall have an over-temperature protection feature that automatically resets when the temperature drops to an acceptable level.

Inverter ballasts shall not be damaged by application of reverse-polarity, direct-current power.

Overhead fixtures shall be finished to match the interior color scheme.

Door Entry

LED type down lighters shall be provided at the side of each doorway for door threshold/local platform area illumination to assist passengers in clearly delineating the entrance to the vehicle.

The lights shall be illuminated when the passenger doors start to open, and shall be extinguished when the doors are closed.

Door entry lights shall be finished to match the interior color scheme.

TP-4.7.10.2 Emergency Lighting

The following lights shall remain operative after the loss of primary high-voltage power or the ac auxiliary inverter:

- 20 percent overhead LED or fluorescent lights (fitted with inverter ballasts)
- Overhead lights in the doorways
- Doorway floor lights
- Head lights
- Tail lights and stop lights
- Exterior marker and indicator lights.

Emergency lights shall be powered from the battery low-voltage power supply. In case of vehicle power failure, the emergency lighting shall remain illuminated for at least one hour.

TP-4.7.10.3 Exterior Lighting

Exterior lighting assemblies shall be mounted in waterproof enclosures, and shall operate from the low-voltage battery power supply.

Head lights, tail lights, stop lights, clearance lights, and marker lights shall conform to 49CFR571.108/FMVSS108- Federal Safety Standard - Lamps, Reflective Devices and Associated Equipment, Table 1, as applicable to multipurpose passenger vehicles 2032 mm [80 in] or more in overall width. Service-proven alternative designs will also be considered by the City. However given that these standards do not as yet reflect the latest related SAE standards associated with these widths, the following standards shall apply:

Table 7-2. Lighting Standards

[head]	[head]	[head]
Headlights	SAE J1383	Performance Requirements for Motor Vehicle Headlamps
Tail Lamps	SAE J2020	Tail Lamps (Rear Position Lamps) for Use on Vehicles 2032 mm or More in Overall Width
Clearance, Sidemarker and Identification Lamps	SAE J2042	Clearance, Sidemarker and Identification Lamps for Use on Motor Vehicles 2032 mm or More in Overall Width
Stop Lamps and Front- and Rear-Turn Signal Lamps	SAE J2261	Stop Lamps and Front- and Rear-Turn Signal Lamps for Use on Motor Vehicles 2032 mm or More in Overall Width
LED Lighting Devices	SAE J1889	L.E.D. Lighting Devices
Testing	SAE J2139	Tests for Signal and Marking Devices Used on Vehicles 2032 mm or More in Width

Exterior lights shall be illuminated as follows.

- Red tail/stop lights only when the train is in layover.
- Red tail/stop lights and red marker lights, at both ends of the train, when a leading end has been selected, but no direction selected.
- Headlights and amber marker lights on the leading vehicle and red tail/stop lights and red marker lights on the trailing end of the train, when a leading end and a direction has been selected.

TP-4.7.10.4 Headlights

Standard, heavy duty commercial bus or truck halogen low beam head light units of a pleasing appearance in accordance with the vehicle external aesthetic design shall be provided at each the non-gangway end of each E-type vehicle. M-type vehicles shall not require headlights.

TP-4.7.10.5 Tail/Stop Lights

Two red tail lights shall be provided at each non-gangway end of each E-type vehicle suitably integrated into the headlight assembly.

Red stop lights shall also be provided as part of the tail light assemblies. The stop lights shall be illuminated, on the trailing end of a train only, whenever the brakes are applied.

M-type vehicles shall not require tail lights or stop lights.

TP-4.7.10.6 Marker Lights

One amber and one red marker light shall be provided at the non-gangway end of each E-type vehicle. M-type vehicles shall not require end marker lights. Four amber marker lights shall also be provided equally spaced along the side of each vehicle.

TP-4.7.10.7 Destination Displays

Exterior destination and interior information displays shall be normally illuminated when the auxiliary power is energized. All such displays shall have an independent, local circuit breaker.

TP-4.7.10.8 Vehicle Fault Indicator

A blue fault indicator light shall be provided on each side of the vehicle at both ends.

The external fault indicator shall be illuminated when the associated vehicle detects a fault or when a bypass/cutout switch on that vehicle is used.

TP-4.7.11 High Voltage Power Collection and Distribution

TP-4.7.11.1 Shoegear

The vehicle power shall be collected from the contact rail supply as specified in Section 4.5.3.

Each vehicle shall be supplied with four contact rail current collectors (shoegear) that shall be compatible with the contact rail location and surface material, together with an associated fuse, one mounted on each side of each truck. The collector shoes shall have a life of at least 25,000 miles and shall be sacrificial to, and resist welding to the contact rail.

If possible, the collectors shall be attached to a part of the truck frame cushioned by the primary suspension, provided that reliable contact will be maintained with the contact rail under the worst conditions of dynamic motion, wear and tolerance conditions, and with the vehicle on the maximum super-elevation at any speed. If such is not the case, the current collector shall be mounted on an un-sprung part of the truck. The truck attachment point shall be selected to minimize any vibration transmitted to or from the current collectors.

The current collectors shall be service-proven and capable of stable, bi-directional operation at all vehicle speeds up to the maximum design speed and external contact rail system characteristics as specified in Section 4.5.3, with satisfactory tracking and minimum wear, including expansion joints and end approaches, without excessive arcing, wear or other defects.

The current collectors shall be designed and manufactured for interchangeability of components and provide for vertical adjustment due to wheel wear.

The contact paddle shall have a stop to prevent possible under-ride of the contact rail, and shall have a built-in shear point to cause it to break off without damage to the current collector mounting assembly or the contact rail in the event of contacting an obstruction. The paddle shall include a wear indicator to permit quick easy visual indication for shoe replacement.

The contact rail current collectors and fuses shall be arranged to prevent any arcing to grounded metal parts of the vehicle body and the truck.

The current collectors shall be mounted to an approved fiberglass or other dielectric bracket, with sufficient insulation and arc interruption capacity to allow mounting directly to a grounded portion of the truck. No wood or shoe beams shall be used. Suitable arc shields of an approved material shall be used.

All vehicle wiring downstream of each contact paddle shall be protected by a single, current-limiting, arc-confining cartridge fuse capable of carrying the current for the entire vehicle indefinitely. The fuse shall be easily accessible and have a blown fuse indicator. The fuse characteristics shall be coordinated with the propulsion system.

The collector head assembly shall contain renewable contact pads capable of conducting the total vehicle peak and rms currents for the worst-case time duration, assuming that they occur repetitively. Shoe contact force shall be adjustable and shall provide optimum current collection, with minimum wear over the entire operating range. . Power cables from the collector shoegear on each truck shall be connected to the vehicle body via a quick disconnect device.

TP-4.7.11.2 **750 Vdc Shop Power Control / Receptacle**

Contact rail power shall be routed via an easily accessible, side under-vehicle transfer switch (or contactor set), housed in a weather-resistant enclosure constructed of fiberglass-reinforced plastic or similar approved material located near the middle of the vehicle. The transfer switch shall provide a means of automatically and positively disconnecting all 750 Vdc supplied power circuits from the shoegear when powering vehicle circuits using a shop power supply as detailed in Section 4.5.8.6. and will contain a suitable 750 Vdc shop power receptacle.

The receptacle shall be designed to prevent ingress of dirt and water, have adequate clearance for plugging in a shop power cable, be adequately sized for the application, be located so as

to be readily reached by a shop power cable from the side of the vehicle, and be equipped with a spring load protective cover to automatically seal it when not in use.

TP-4.7.11.3 Primary Protection

Overvoltage protection, current sensing, ground fault sensing, fault clearing devices, and other circuit protection shall be provided to protect high voltage primary, auxiliary and propulsion system components from damage due to lightning, circuit faults and ground faults.

Fault-clearing devices shall be vented or shielded in order to prevent damage to adjacent equipment and the vehicle structure.

Contact rail system voltage loss, high-speed circuit breaker open and main fuse open incidents shall be reported to the Monitoring and Diagnostic System as required in Section 4.7.23.

TP-4.7.11.4 Line Filters

Line filters shall be provided as required to suppress high-frequency voltage transients. Capacitive-type filters shall be provided with a "Bleeder Resistor" circuit to reduce the voltage potential to less than 50 Vdc within three (3) minutes of primary power removal. Alternative service-proven line filter discharge schemes may be provided.

Detection of line filter failure shall automatically inhibit propulsion and annunciate the failure and other related primary voltage faults.

TP-4.7.11.5 High Voltage Circuit Breaker

A high-speed circuit breaker (HSCB) shall be provided to protect the propulsion primary power circuits.

- The HSCB shall be operated by the battery low-voltage power supply, and shall not require special action for vehicle startup.
- Means shall be provided to reset the breaker when the battery is discharged below the minimum pick-up voltage.
- The HSCB operating and fault-clearing time shall prevent secondary damage without substation breaker tripping.

Alternative means of providing protection for the propulsion primary power circuits will be considered.

TP-4.7.11.6 High Voltage Main Fuse

A separate high-speed high voltage fuse shall be provided to protect the auxiliary power supply (APS) and any other high voltage circuits.

The use of an auxiliary high-speed circuit breaker is also permitted for this application provided it is also operated by the battery low-voltage power supply, and it shall automatically restart the vehicle auxiliary circuits when primary power is restored, including during low battery voltage situations.

TP-4.7.11.7 Ground Fault Protection

Ground fault protection shall be provided to protect auxiliary and propulsion primary circuits against the return of primary current through abnormal paths to the primary return buses. Design of the ground fault protection shall be service-proven.

TP-4.7.12 Grounding

The following section details the requirements of the vehicle grounding scheme. Alternative service-proven ground brush arrangements and ground connections due to different hardware or EMC control schemes may be proposed.

TP-4.7.12.1 Primary Power Return Circuit

All negative returns shall be connected to a common negative bus on the vehicle, consisting of two negative bus bars, one mounted adjacent to each of the truck locations and connected together by cables. Negative bus bars shall be returned to ground via axle-mounted ground brush assemblies that have sufficient capacity for circuit rms current.

TP-4.7.12.2 Ground Brush Assemblies

Axle-mounted ground brushes may be either radially or axially mounted. The brush and contact surface design shall be service-proven.

TP-4.7.12.3 Safety Grounding

All equipment, components, and resiliently mounted apparatus, including all truck-frame and truck-mounted equipment, shall be electrically connected to the adjacent vehicle structure using grounding pads and cables. Ground pads shall be copper with appropriate studs continuous welded directly to the vehicle body structure. An anti-oxidant compound shall be applied to all pads and connections. All sections of the vehicle shall be connected together by cables. The vehicle body ground plate on one section shall be connected to ground via axle-mounted safety ground brush assemblies.

TP-4.7.12.4 Return Circuits

The vehicle structure shall not be used as a normal circuit return path for any electrical equipment. Each system or circuit shall have its own return wiring. The low-voltage dc system shall have a single point connection from the low-voltage, negative bus to the vehicle body.

TP-4.7.13 Auxiliary Power and Distribution

TP-4.7.13.1 Auxiliary Inverters

A minimum of two static inverters per trainset, shall be used to convert the 750 Vdc contact rail voltage to a regulated three phase ac supply, which shall power the major auxiliary equipment located on their respective vehicles. Appropriate circuitry shall be provided so as to allow vehicle limp-home capability in the event of inverter failure, which may include load shedding of non-essential loads, reduction of HVAC performance, and failure mode cross connection to supply essential loads. The inverters shall be sized for continuous operation with all their normal loads simultaneously and short time rated for the starting of the largest individual load with all other loads applied.

Alternative auxiliary power schemes may be proposed, including provision of separate inverters for the HVAC units, air compressors (if used), propulsion blowers (if used), etc. or a single, proven reliable full duty inverter provided vehicle limp-home capability or 3 plus 2 capability (4 phase inverters with automatic changeover) is maintained.

The inverters shall be capable of operating satisfactorily with input primary voltages as specified in Section 4.5.3. The inverter output supply shall not be affected by normal rail

operation interruptions of the primary power supply caused by third section breaks, discontinuities or instantaneous loss of contact (shoegear bounce). The inverters and connected loads shall not be damaged under these conditions.

Auxiliary inverters shall be provided with an AUX OFF timer or equivalent to automatically shut down auxiliary systems after a set time of between 20 and 60 minutes when the vehicle is not in service to reduce unnecessary power consumption.

TP-4.7.13.2 Load Management

A load management system shall be provided capable of maintaining essential vehicle operating systems on-line for as long as possible during primary power interruptions, and shall prevent prolonged delays when restarting equipment after a momentary power interruption. The ac auxiliary power system shall meet the load-shedding requirements and provide the required reapplication system.

TP-4.7.13.3 Voltage and Frequency Regulation

The nominal, steady state output of the inverter shall be an industry standard three phase, 60 Hz, voltage, to include 208 Vac, 230 Vac, or 460 Vac, with a steady state output controlled with a tolerance of ± 5 percent for voltage level and ±1 percent for frequency over the full range of input voltages and load conditions. The inverter output shall be appropriate for the ac-powered equipment it shall power so that the design life, performance, maintenance and operation of this equipment is not adversely affected.

The inverter shall be protected against prolonged delays when restarting equipment after normal rail operation interruptions to the primary power.

The controls for the inverter shall be designed to prevent damage both to auxiliary equipment, and the inverter.

The inverter output shall be electrically isolated from the primary high voltage supply so as to prevent damage to connected loads in the event of an inverter failure.

The inverter output voltage shall also be stepped down to 120 Vac rms, 60 Hz for lighting loads, small motors, and convenience outlets.

Auxiliary inverter system faults shall be reported to the Monitoring and Diagnostic System as required per Section 4.7.23.

Local status indicators and test points shall be provided to assist in local troubleshooting.

TP-4.7.13.4 Auxiliary Shop Power Control / Receptacle

Suitable auxiliary shop power control circuits and a receptacle shall be provided mounted under-vehicle in the middle of each vehicle on both sides to energize the vehicle auxiliary ac bus and low voltage power supply using auxiliary shop power in accordance with Section 4.5.8.6 during intervals of routine maintenance The vehicle auxiliary inverter(s) shall be automatically protected from any damage when auxiliary shop power is utilized.

The receptacle shall be designed to prevent ingress of dirt and water, have adequate clearance for plugging in a shop power cable, be adequately sized for the application, be located so as to be readily reached by a shop power cable from the side of the vehicle, and be equipped with a spring load protective cover to automatically seal it when not in use.

TP-4.7.13.5 Auxiliary AC Circuits

The auxiliary distribution circuits shall be individually protected by circuit breakers.

TP-4.7.13.6 Convenience Outlets

Two 120 Vac, 60Hz, 20A duplex, heavy duty convenience outlets with ground fault protection shall be provided per vehicle, located at opposite ends of the vehicle and mounted with tamper resistant screws.

TP-4.7.14 Low Voltage (DC) Power and Distribution

All vehicle control circuits and auxiliary control systems shall be powered from the Low-Voltage (dc) Power Supply (LVPS) system, consisting of a battery, battery charger, and associated circuitry.

All equipment operating on the battery power system bus shall function normally within the ranges of +5 percent and -25 percent from the nominal rated battery charging voltage, and shall function without failure or degradation in serviceable life. The equipment shall not be damaged by continuous application of voltages between 0 and +5 percent above the nominal charging voltage.

Emergency loads shall be transferred to the battery with the loss of the primary power, ac auxiliary supply or the battery charger.

TP-4.7.14.1 Battery Charger

The battery charger shall be a solid state device, and shall be capable of operating with input primary voltages as specified in Section 4.5.3.

A nominal battery charging output voltage of 28.5 Vdc is required. Ripple in the battery charger output shall not exceed 5 percent and regulation shall not exceed ±1.5 percent for the full range of input voltage and output loads. The battery charger output voltage shall be limited to +5 percent maximum of the nominal rated battery charging voltage.

Alternative battery charger/battery combinations such as 42 Vdc charging voltage with a 37 Vdc battery may also be proposed.

The battery charger shall constantly monitor the output state of the battery and automatically adjust the charging rates.

Battery charging system faults shall be reported to the Monitoring and Diagnostic System as required per Section 4.7.23.

The battery charger shall start automatically when primary power is applied.

Battery power shall not be required for closing circuit breakers or contactors needed for vehicle operation.

Local status indicators and test points shall be provided to assist in local troubleshooting.

TP-4.7.14.2 Battery

Emergency power shall be provided through the main 24 Vdc storage battery, which shall be rated for emergency duty cycle service in the operating environment specified. The battery shall be of long life, minimal maintenance design, nickel cadmium or equivalent. It shall have sufficient capacity to supply the required emergency low-voltage loads for a half-hour period

of normal vehicle operation without use of track brakes. The emergency loads shall include lighting, communications and train control.

The battery shall be installed within an under-vehicle battery box capable of being opened to provide full accessibility to all cells for inspection and servicing. The battery box shall contain a temperature sensor, which shall trip the battery circuit breaker upon detection of an over-temperature condition. The battery box shall be of high grade stainless steel construction with seal welded seams. The box shall be equipped with a drain pipe fitted with a valve and plug to facilitate the controlled removal of any spilled fluids or cleaning solutions. A vent shall be provided at the top of the box to allow the escape of any gas generated during battery charging while preventing the entry of storm water or train washing fluids.

TP-4.7.14.3 Battery Isolation Switch

Battery isolation shall be provided by a battery isolation switch.

TP-4.7.14.4 Auxiliary DC Circuits

The auxiliary dc distribution circuits shall be individually protected by circuit breakers.

TP-4.7.15 Propulsion System

The microprocessor-based propulsion system shall utilize solid-state control devices, ac traction motors, gear drives and other accessories to meet the performance requirements of propulsion and dynamic braking specified herein and in Section 4.6.2.

The propulsion equipment proposed shall be service-proven for at least three years in revenue service on at least one similarly sized fleet with a similar vehicle operation. Proposals offering new technologies or implementing design changes to existing systems may be considered, provided that the supplier can supply sufficient data to indicate that the system is capable of meeting all requirements specified.

The propulsion system shall be configured so that trains operate successfully and reliably on a contact rail system.

The propulsion system shall provide the specified performance continuously at the nominal voltage of 750 Vdc, within the duty cycle requirements, over the range of the system voltages specified in Section 4.5.3, without damage, reduction in life, or exceeding the manufacturer's allowable device temperatures within the duty cycle requirements specified in Section 4.3.2.

On-board braking resistors shall be sized for duty cycles and shall be sized to dissipate all dynamic braking energy. Alternatively, lineside braking resistors may be proposed provided the interfaces are identified and agreed with the Core Systems Contractor.

The abnormal duty cycle shall be based on an operating condition of a train with half of its inverters inoperative, or an operative train towing a dead train of equal mass. There shall be no equipment damage, heating above design limits, or activation of any protective devices when operated over one complete round trip of the route profile with such a duty cycle.

Each major component shall be independently cooled by natural convection, forced air, or liquid cooling, and shall be protected from damage due to cooling failure.

Liquid cooling systems shall be sealed, all components shall be rated for continuous exposure to the liquid, and the system shall not require maintenance at intervals of less than five years. Use of chlorofluorocarbons (CFCs) shall be prohibited.

All propulsion system components including, but not limited to traction motors, gear units, couplings, inverter units, dynamic braking resistor, logic assemblies and printer circuit boards shall be directly interchangeable with each device of the same design without modification.

Propulsion system faults shall be reported to the Monitoring and Diagnostic System as per Section 4.7.23.

Local status indicators and test points shall be provided to assist in local troubleshooting.

TP-4.7.15.1 System Requirements

The vehicle shall have, as a minimum, the following equipment supporting each motor truck or powered axle:

- AC, three-phase traction motors, each driving a gear unit.
- Propulsion and dynamic braking control, accomplished by microprocessor- based, solid state, inverter equipment. The inverters shall use insulated gate bipolar transistor (IGBT) technology or other proven advanced technologies.
- One fully independent inverter, powering two parallel-connected traction motors or two fully independent inverters, each powering one traction motor.
- Inverters that operate independently of each other, providing independent interpretation of trainline command signals.
- Wheel spin/slide correction system for each inverter identified above, for parallel-connected motors or independently powered motor.
- Interchangeable traction motors, couplings and gear units.
- Independent load weigh systems on each truck and set of running gear.

All electrical and electronic control shall be operated from the battery dc power supply.

TP-4.7.15.2 Overspeed Protection and Top Speed Regulation

The propulsion control system shall include an internal overspeed protection and top speed regulation logic, which shall limit motor speed and train speed to set values by means of tractive effort control and brake control.

When the speed exceeds the overspeed protection set point, the propulsion tractive effort shall be reduced to zero in the train.and the overspeed protection logic shall apply a full-service brake (B3) to the entire train.

Overspeed set points shall be as follows:

- 109 km/hr [68 mph] ± 1.6 km/hr [1 mph] during normal operation or when the Speed Restriction Bypass switch is in the Bypass position.
- 51 km/hr [32 mph] ± 1.6 km/hr [1 mph] when any propulsion or brake equipment has been cut out or when any propulsion or brake fault has been detected.
- The top speed regulation protection logic shall be configured to reduce tractive effort as the vehicle speed approaches its top speed. Speed reductions shall be as follows:
- During normal operation or when the Speed Restriction Bypass switch is in the Bypass position, as the vehicle speed reaches 100 km/hr [62 mph], tractive effort shall be linearly reduced to a rate of 0.02 m/s² [0.5 mphps] by the time it reaches 105 km/hr [65 mph]. The tractive effort shall continue to be reduced until it is zero at the set point of 109 km/hr [68 mph] ± 1.6 km/hr [1 mph].

- The speed shall be automatically restricted to 48 km/hr [30 mph] when any propulsion or brake equipment has been cut out or when any propulsion or brake fault has been detected unless the speed bypass switch is in the bypass position. Tractive effort reduction shall begin at 43 km/hr [27 mph], reducing to zero at the set point of 48 km/hr [30 mph] ± 1.6 km/hr [1 mph].

The speed information shall be from a source corrected for wheel wear.

A vehicle speed output signal shall also be provided for the Control Panel speedometer display.

TP-4.7.15.3 Blended Brake Control

The propulsion control logic shall provide signals to the friction brake control logic for blending of friction braking effort with dynamic braking.

TP-4.7.15.4 Spin-Slide Control

A wheel spin-slide detection and correction circuit shall be provided as an integral part of the propulsion control system and shall meet the performance requirements of Section 4.6.2.

The propulsion system shall provide the spin and slide control signals and shall provide slide signals for the friction brake control systems. An independent correction signal for each of the trucks or running gear sets shall be provided and shall be interfaced with the sanding trainlines, if provided. The system shall detect changes in wheel velocity above a threshold value in relation to the other wheels. The system shall also detect wheel acceleration above a threshold value.

TP-4.7.15.5 Load Compensation

Sensing devices on each truck shall provide each independent braking system (dynamic and friction, but not track brakes) with passenger loading variations which will in turn provide a signal to the propulsion system to enable compensating tractive efforts to provide specified accelerating and decelerating requirements with changing passenger loading. Load weigh measurement on an individual truck shall result in a default value of AWO weight being assumed. The actual driving/braking load weigh effort on the affected truck shall be a percentage of the default value and the adjacent truck(s) weight.

Alternative service-proven load weigh compensation schemes may be proposed.

TP-4.7.15.6 Direction, Mode, and Rate Selection

The propulsion system shall directly utilize the trainlined rate, brake, and power mode selection signals generated by the ATC system (or Master Controller in the selected Control Station when in manual operation). The propulsion motoring mode shall be inhibited by any brake request or brake application, or any equipment fault, bypass, cut-out, overspeed or other abnormal operation that would initiate a speed restriction trainline condition.

The propulsion system shall directly utilize the trainlined direction selection signals generated by the ATC system (or the Direction Switch in the selected Control Station when in manual operation). A change of direction shall be possible only when no-motion is detected.

TP-4.7.15.7 Degraded Running

Reduced performance under reduced voltage shall be provided as specified in Section 4.5.3.

When the propulsion system is isolated for a single truck, the empty (AW0) vehicle shall be capable of safely returning to the MSF at reduced speed as specified in Section 4.6.2, for repair.

TP-4.7.15.8 Rollback Protection

The traction control shall coordinate the release of the brakes and the application of tractive effort to preclude the rollback of the vehicle on any gradient up to and including 7 percent. (The ATC system (or an operator when in manual operation) can be assumed to be increasing the tractive effort demand until the vehicle is moving.)

If rollback occurs, it shall be detected within 0.5 seconds and the holding brake shall be automatically reapplied. In no case shall the rollback distance exceed 762mm [30 in].

TP-4.7.15.9 System Faults

All critical, safety-related propulsion system faults shall be reported to the Monitoring and Diagnostic System as described in Section 4.7.23.

Local fault logs, along with troubleshooting/system status indicators and test points shall also be provided to aid troubleshooting activities.

A fault signal to drive the blue external fault indicator shall also be provided.

Each propulsion system fault shall be capable of being reset for the specified fault to a maximum number of times allowable, as determined by the supplier, without degrading or over-stressing the system. Lockout or cutout of individual propulsion inverter(s) shall result in proportionately reduced performance including a reduced setting for tractive effort, maximum speed, and overspeed for the consist as per Section 4.6.2. Consists may run at reduced performance with up to 50 percent of the inverters cut-out or locked out for one round trip. Loss of inverter(s) shall be automatically detected by all functioning inverter controllers in the consist and appropriate performance adjustments shall be implemented for the entire consist.

Provisions shall be made for automatic detection of failures resulting in excessive EMI, particularly at signal system operating frequencies. Detection of these failures shall automatically inhibit propulsion, annunciate a propulsion failure to the local and trainlined fault indicators, and store the data in the propulsion failure log.

TP-4.7.16 Dynamic Braking

The dynamic brake shall supply the primary braking effort. It shall be a combination of regenerative and rheostatic braking and shall be continuously available from maximum speed to less than 9.65 km/hr [6.0 mph].

Regenerative braking shall primarily be via regeneration back into the contact rail traction power system, followed by dissipation in the braking resistors only when the contact rail is not receptive or the equivalent if braking resistors are located lineside

Dynamic braking shall be available independent of the presence of line voltage, once initiated. The regeneration feature shall be manually disabled on a per inverter basis.

Dynamic brake failure detection circuits shall be provided for each powered truck or axle. Detection of failed dynamic braking on a power truck will cause a signal to be sent to the friction braking system on all trucks commanding them to assist in sharing the braking effort.

Whenever dynamic braking is commanded, the circuits shall verify that dynamic braking effort of the correct level is produced.

TP-4.7.16.1 Traction Motors

ac traction motors shall be provided with the following basic design features:

- Three-phase AC, squirrel cage induction motor, with copper alloy cage, and formed stator coils.
- Totally enclosed, self-ventilated; and weather-protected motor enclosure. Open frame, self ventilated designs will also be acceptable provided they are service-proven and meet the requirements of these Technical Provisions.
- Designed in accordance with IEC Standard 349/2 - Electric Traction – Rotating Electrical Machines for Rail and Road Vehicles – Part 2: Electronic Converter-Fed Alternating Current Motors or IEEE 11-2000 – Standard for Rotating Electrical Machinery for Rail and Road Vehicles.
- Lowest possible unsprung mass.
- Bearings with an L10 rating life equivalent to $1.61X10^6$ km [$1.0X10^6$ miles] of service or greater.
- Motors that are all identical and completely interchangeable.
- Motor characteristics that allow all performance characteristics to be met with wheel diameter differences that may vary between 0.0 mm and 6.35 mm [0 in and 0.25 in] between axles on a truck.
- Traction motor over-temperature protection.
- Highly effective seals so that they will not drop oil or grease between scheduled overhauls.
- Lifting lugs or with means for attaching lifting devices.
- Cables from traction motors on each truck connected to the vehicle body via a quick disconnect device.

TP-4.7.16.2 Gearboxes

Each powered axle shall be driven by a gear unit of the type appropriate for the application. The gear drive shall be service-proven. The gear units shall have the following characteristics:

- Lowest possible unsprung mass.
- Gearboxes that are identical and completely interchangeable.
- Lifting lugs or with means for attaching lifting devices.
- Bearings and gears with an L10 rating life equivalent to $1.61X10^6$ km [$1.0X10^6$ miles] of service or greater.
- Drain plugs with magnetic particle collectors.
- Oil filler/breather
- Highly effective seals so that they will not drop oil or grease between scheduled overhauls.
- Removable and accessible oil-tight and airtight inspection covers on the gear housing for visual inspection of the gears.
- Resilient attachment to the truck frame and traction motors.

TP-4.7.17 Trucks and Running Gear

This section specifies the functional requirements for truck assemblies or running gear, including the frame, wheel and axles, traction motors, gearboxes, shoegear, bolster components (if used) and associated components from the running rail, to and including the first components rigidly fastened to the vehicle body.

All trucks or running gear shall be service-proven for a minimum of three years and require a minimum of maintenance under stop-and-go transit, light metro service operations, and shall provide a comfortable ride at all operating speeds.

All trucks, traction motors, gearboxes, and running gear shall be as light as possible, with the lowest possible unsprung weight, consistent with the requirements for strength, performance, and ride quality.

For the general arrangement of the vehicles, there shall be two trucks. Each truck shall have both axles powered and installed with flexibility to rotate.

All truck frames, running gear, and components shall be capable of withstanding, with factors of safety, the maximum stresses imposed by the forces acting on the frame.

The minimum service life of the truck and running gear frames shall be 30 years.

TP-4.7.17.1 Lifting and Jacking Points

Slip-resistant pads shall be mounted on the underside of the truck frame to lift the trucks so that wheels may be rotated. These pads shall also be suitable for jacking the truck during emergencies.

The truck frame shall incorporate four lifting eyes that will be used to lift the entire truck assembly during routine maintenance actions.

TP-4.7.17.2 Truck Attachment

A positive mechanical connection shall be provided between the vehicle body and trucks, such that the trucks will be raised with the vehicle body, without disengaging any part of the suspension system. These connections shall be detachable by conventional hand tools to permit removal of the trucks.

The attachment shall fulfill the specified structural strength requirements and be capable of supporting the full weight of the truck without damage when the vehicle is suspended on its jacking points.

TP-4.7.17.3 Wheel Truing

All trucks and running gear shall be compatible with the underfloor wheel profiling equipment located in the MSF. The design of the truck shall enable truing of wheels without the removal of any components, except end-of-axle ground brush equipment or protection elements.

Wheel and axle assemblies shall be capable of being trued either on or off the vehicle, and as individual assemblies.

TP-4.7.17.4 Speed Sensors

Identical speed sensing devices shall be provided to measure all axle and separate wheel speeds. They shall be installed on the axles or wheel assemblies, or incorporated as integral with traction motor or gearbox. Use of axle end speed sensors is not preferred.

TP-4.7.17.5 Truck Frame

Truck frames and bolsters shall be of a service-proven design fabricated by welding, casting, or a combination of the two.

The structural strength shall be as specified in Section 4.6.4.5.

Each truck frame shall be provided with a permanently attached serial number plate located on the right hand side of the truck in a conspicuous place.

TP-4.7.17.6 Suspension

The vehicle suspension system shall include primary and secondary suspension elements to obtain the ride quality specified in Section 4.6.9, to minimize the effect of vibration and shock loads on passengers and vehicle equipment. The suspension system shall be capable of manual adjustment and shall automatically adjust the height of the vehicle to within the ADA height limits specified in Section 4.6.7. Alternate systems utilizing service-proven flexible frame trucks and a load leveling primary suspension may also be proposed.

The system shall also automatically provide varying passenger load signals to the propulsion and brake control systems.

Suspension components shall not drip oil, grease or fluids, even when worn.

Secondary suspension system faults shall be reported to the Monitoring and Diagnostic System as per Section 4.7.23.

Primary

Each motored truck shall have primary suspension to partially or fully equalize any track irregularity, and to reduce vibration levels in the truck to an acceptable level suitable for trouble-free operation of traction motors, gear units, friction brake and associated truck frame-mounted equipment. Design of suspension elements shall be service-proven.

Secondary

The secondary suspension shall support the vehicle body, using service-proven methods and may be either hydraulic (preferred) or pneumatic. Sliding surfaces, where utilized, shall be suitable non-metallic, renewable wearing elements that do not require lubrication.

Load Leveling

The secondary suspension shall be capable of manual adjustment and automatically maintaining the vehicle floor height at the door thresholds as specified in Section 4.6.7 under vehicle loads from AW0 through AW3. The vehicle leveling system shall be capable of establishing the floor height so specified, excluding wheel wear adjustment, and shall be capable of maintaining this height within ±6 millimeters [±0.250 inch] throughout normal routine revenue service. Oscillation dampening shall be provided if required.

Load leveling system faults shall be reported to the Monitoring and Diagnostic System as per Section 4.7.23. Local status indicators and test points shall be provided to assist in local troubleshooting.

TP-4.7.17.7 Shock Absorbers

Lateral shock absorbers shall be of the hydraulic type.

Vertical shock absorbers may be either hydraulic or friction type as required by the truck design.

The Core Systems Contractor shall be responsible for determining the proper parameters for the shock absorbers to meet the specified performance requirements.

TP-4.7.17.8 Suspension Stops

Where lateral and vertical suspension stops are required, they shall have a progressive rate that shall increase as the stop is compressed.

TP-4.7.17.9 Wheel Wear Adjustment

Positive means shall be provided as a method of adjustment to compensate for wheel wear, and wear or settlement of other truck components. The adjustment method shall be within a maximum of 6.0 mm [0.250 in] increments.

TP-4.7.17.10 Equalization

Lifting or lowering any wheel on a truck 38.0 mm [1.5 in] shall not cause the load to change on any wheel of that truck by more than 60 percent with the vehicle on level tangent track and under an AW0 load. Loss of contact shall not result between any of the wheels and the rail when raising or lowering any one wheel on a truck, up to 50.0 mm [2 in].

TP-4.7.17.11 Tram and Axle Parallelism

The motor truck when loaded to its share of the AW2 vehicle weight, shall maintain the axles parallel to each other within 2.0 mm [0.080 in] on each side at the journal centers. It shall also limit the difference between diagonally opposed bearing locations to 10.0 mm [0.40 in] when measured on the truck alone and when installed on a stationary, complete AW2 loaded vehicle on level tangent track.

Motor truck frame tram marks shall be provided located within 0.75 mm [0.03 in] of their true position.

TP-4.7.17.12 Traction Motors

Traction motors shall be supplied for fitting onto the vehicle trucks. Refer to Section 4.7.16.1 for further details.

TP-4.7.17.13 Gearboxes

Gearboxes shall be provided for the final drive between the traction motors and the truck axles. Refer to Section 4.7.16.2 for further details.

TP-4.7.17.14 Axle / Wheel Interchangeability

Complete interchangeability shall be required for all powered axles and components between axles, on either end of each vehicle and among all vehicles.

Wheel tires shall have the same inside diameter on all trucks and be fully interchangeable.

TP-4.7.17.15 Wheels

The wheel profile, as shown in these Technical Provisions is provided as a preliminary concept. The Core Systems Contractor shall submit wheel profile recommendations to meet all specified requirements as required in Section 4.5.2.

Wheels shall be capable of having repeated, controlled reprofiling, and shall provide a minimum service life of 250,000 km [150,000 miles].

Minimum allowable tread wear shall be 50 mm [2 in] of the new wheel diameter.

Resilient Wheels

Wheels shall be resilient-type to reduce shock forces between the wheel and the rail and may be equipped with noise vibration dampeners if required. The wheels shall utilize rubber in compression and shear for structural integrity and safe operation through AW4 loadings.

Multiple electrical shunts shall be provided between the hub and the tire. Design for the shunts shall have a proven successful record on similar vehicles. Shunts shall be easily visible from the outside of the vehicle. The shunting resistance of each assembled wheelset with traditional axles (including tires) shall not exceed 0.01 ohms when measured across the axle from tire tread to tire tread.

Replacement of steel tires shall be accomplished primarily through use of common hand tools. Any special jigging or special tools required for this activity shall be included in the Core Systems Contractors supply of special tools and equipment as required in Section 8.12.

Tires shall meet the Class DHT requirements of ASTM A-551-94(1999) – Standard Specification for Steel Tires or approved equivalent.

Lightweight hubs of aluminum or composite materials will be considered by the City provided they are rail proven and the Core Systems Contractor can demonstrate they will be trouble free based on a 30 year vehicle life.

Identification

Both tires and wheel hubs shall be serialized.

Tire marking and hub marking shall be in accordance with ASTM A-551, Class DHT.

TP-4.7.17.16 Axles

Full length axles shall have a fatigue life of not less than 30 years.

Both ends of each full-length axle shall be chamfered and furnished with standard 60° lathe centers.

Each axle shall be permanently marked with the information required by AAR M-101.

TP-4.7.17.17 Bearings

Wheel and/or bearings shall have an L-10 life rating of 1,600,000 km [1,000,000 miles] based on an AW4 vehicle weight with shock and vibration loads typical of light metro operation. The bearings shall be fully enclosed, permanently grease lubricated, and shall not require inspection more than once every 250,000 km [150,000 miles].

Bearings shall be fitted with highly effective seals so as to not drip oil or grease between scheduled overhauls.

TP-4.7.17.18 Flange Lubrication

The lead axle of the lead power truck of each E-type vehicle shall be equipped with all the equipment necessary for wheel flange and railhead lubrication as per Section 4.5.2.

TP-4.7.17.19 Track Brake

The electromagnetic track brakes (if required) shall be supported from the journal bearing housings or similar unsprung element of the truck. The track-brake support arrangement shall maintain positive lateral alignment of the track brake with the running rail. Track brake forces shall be transmitted to the truck frame as near to the top of rail as practical to minimize the moment on the track brake unit.

Please refer to Section 4.7.18.11 for further track brake details.

TP-4.7.17.20 Friction Brakes and Actuators

Please refer to Section 4.7.18.9 for friction disk brake details.

TP-4.7.17.21 Obstacle Deflectors and Safety Hangers

Each end truck shall be provided with safety bars at its outer or lead end, to deflect debris and to prevent such material from getting under the truck.

Stone guards and splash guards or equivalent shall be provided.

Trucks shall be equipped with safety hangers to retain traction motors and gear units in place in the event of support failure.

TP-4.7.17.22 Sanding Pipework

Sanding nozzles shall be fastened to the truck frame and connected to the sand traps by flexible hoses. Sanding nozzles shall be positioned so as to deposit sand immediately in front of the leading wheels on all of the powered trucks as per Section 4.7.18.13.

TP-4.7.17.23 Ground Brush Assembly

Ground return circuits and devices shall be provided as specified in Section 4.7.12.

Methods shall be employed so that all ground paths are not interrupted by paint, corrosion, and other obstructions. Fasteners utilized to mount components or assemblies to the vehicle structure shall not be used for ground paths. All grounding straps or devices shall be provided with dedicated fasteners.

TP-4.7.18 Friction Braking System

Design for the friction brake control system shall be service-proven and inherently fail-safe in operation. The system operating medium shall be either hydraulic (preferred) or pneumatic.

The friction brake control system shall include the parking brake and track brake functions, and shall control the application of sand, if required.

The friction brake control system shall supply retarding forces by means of axle-mounted or outboard wheel-mounted disc brakes, and shall provide the required holding force for the parking brake application.

The propulsion control logic shall provide signals to the friction brake control logic for control of disc braking effort during blended dynamic braking and under wheelslide conditions as detailed in Section 4.6.2.5.

The system shall also respond to all brake efforts requested from the ATC system (or Master Controller or emergency stop pushbutton when in manual operation), trainlines, and shall satisfy all required braking rates for all loading conditions with or without the availability of dynamic braking, and from any operating speed as specified in Section 4.6.2.

The friction brake system shall supply supplemental braking effort to the dynamic brake during normal service brake applications and add track brakes during emergency brake applications.

The friction brake system shall provide local brake control units on a per truck or axle basis. Each control unit shall be independently controlled from the other trucks or axles on the vehicle.

A local brake cut-out shall be provided for each truck.

The friction brake electrical system shall operate from the battery low-voltage power supply.

Brake system faults shall be reported to the Monitoring and Diagnostic System as required in Section 4.7.23. Local status indicators and test points shall be provided to assist in local troubleshooting.

The components of the friction braking system shall not drip oils or fluids at any time between scheduled maintenance intervals.

Hydraulic reservoirs (if used) shall be equipped with sight glasses and refilled from outside the vehicle. Any filler caps shall be permanently retained to prevent loss.

TP-4.7.18.1 Service Braking

Normal service braking is provided by a blended combination of dynamic and friction disc braking as required to achieve the requested braking effort controlled by a signal from the propulsion equipment and in accordance with the performance requirements of Section 4.6.2.

TP-4.7.18.2 B MAX / Emergency Braking

Either a B MAX or Emergency brake request shall initiate a combined application of dynamic, disc friction, and track brakes, to achieve the specified braking rate, and shall be continuous until the vehicle comes to a complete stop as required by Section 4.6.2.

Sanding, if provided, shall be automatically activated during Emergency braking and shall only be applied during B MAX braking as required by the spin/slide system to prevent slide.

The spin/slide system, load weigh compensation and jerk limitation shall be active when B MAX is selected by the ATC system (or active Master Controller when manually operated).

The spin/slide system, load weigh compensation and jerk limitation shall be inactive when Emergency braking is activated by the Emergency Stop pushbutton.

B Max and Emergency brake applications shall be interlocked with the propulsion system to inhibit power as per Section 4.6.2.

TP-4.7.18.3 Parking Brake Application

The parking brake shall be automatically applied when the vehicle direction ‘neutral’ is selected.

A parking brake activation shall apply all parking brakes on the vehicle or train, and shall illuminate a parking brake "ON" indication on all associated Control Stations.

A parking brake release command shall cause the release of all parking brakes on the vehicle or train.

An applied parking brake actuator anywhere on the vehicle or train shall inhibit propulsion and brake release.

TP-4.7.18.4 Blended Brake Control

A constant blending arrangement shall be provided for the interface between dynamic and friction braking.

The propulsion system shall provide a fail safe signal based on the vehicle braking rate requested by the ATC system (or Master Controller when manually operated) to the friction brake control system for each truck requesting supplemental application of friction brakes as required to achieve the requested braking effort.

The friction disc brake equipment for each powered truck or axle shall respond to the propulsion brake rate request signal, and shall adjust the disc brake effort, suitably modified by inputs from the load weigh system, spin slide control system and jerk control limitation circuitry, to provide the braking rate requested.

TP-4.7.18.5 Slide Control

The vehicle shall be provided with slide protection during braking, to maintain the maximum available adhesion and to limit wheel tread damage utilizing a signal from the propulsion equipment. Wheel slide signals generated during braking shall modify friction braking effort on the affected wheel pair or truck until the slide is corrected.

Sanding, if provided, shall be automatically activated upon detection of severe spin or slide conditions.

TP-4.7.18.6 Load Compensation

The load weighing system shall be operational in all braking modes except Emergency Braking and shall produce a signal to permit constant braking effort for varying passenger loadings.

TP-4.7.18.7 Jerk Limiting

Jerk rate control shall be applicable to vehicle friction braking as specified in Section 4.6.2 3. The design of jerk limiting circuitry shall be fail-safe so that any failure shall not produce excessive jerk or reduce the braking rate during any brake application. Jerk rate control shall not be active for Emergency Brake applications.

TP-4.7.18.8 Degraded Running

When the friction brakes are isolated on a single truck, with dynamic brake functional, the empty (AW0) vehicle shall be capable of safely returning to the MSF, at reduced speed as specified in Section 4.6.2, for repair.

TP-4.7.18.9 Friction Disc Brakes

All axles or wheels shall be provided with friction braking capability.

Brake discs and their associated calipers, shall be either axle-mounted or outboard wheel-mounted. Brake discs shall be of the split type to allow easy replacement.

Motor truck brake controllers, discs, actuators and calipers shall be interchangeable among all motor truck axles.

The brake pads and holders shall be designed for quick pad replacement without disassembly of the caliper unit. Brake pads shall be interchangeable between all axles of the same type.

TP-4.7.18.10 Friction Brake Isolation

A manual cutout valve shall be provided on each truck, which will prevent subsequent application of the service brake on that truck only, as well as allow movement of the truck when disconnected from the vehicle for maintenance. Cut-out valve handles shall be of a locking design, and shall have provisions for a lock wire and seal. Service brake cutout shall not affect parking brake operation. Service-proven electrically operated cutout valve schemes may also be proposed.

TP-4.7.18.11 Track Brake

Each truck shall be equipped with two electro-magnetic track brakes, with no less than four provided per vehicle (if required).

Track brakes shall function at any speed and over all normal track conditions, grades, and special works.

The Core Systems Contractor may propose, as an alternative to electro-magnetic track brakes, permanent magnet track brakes, in order to reduce battery capacity, and weight.

All track brake assemblies shall be interchangeable without modification to the position mounting arrangement.

The track brakes shall be fully watertight.

Connection to vehicle wiring shall be via flexible cable(s) with waterproof connectors at both ends.

TP-4.7.18.12 Parking Brake

The friction disc brake system shall also perform the parking brake function.

It shall be possible to manually release the parking brake on a per truck basis in the event of a failure of the normal parking brake controls.

TP-4.7.18.13 Sanding Equipment

If required for operations or safety, each vehicle shall be provided with a service-proven sanding system consisting of sandboxes, pneumatic sand traps, and truck mounted sanding nozzles arranged to deposit sand on both rails immediately in front of the leading wheels on all of the powered trucks on each vehicle of a train when commanded by the braking (emergency braking command) or spin – slide system.

The sanding system detailed design and operational requirements shall be determined by the performance and reliability of the vehicle propulsion and braking systems during marginal adhesion conditions, particularly on significant grades.

Sand boxes shall be provided with sufficient capacity for a minimum of two weeks or 3218 km [2000 miles] of vehicle operation without refilling. Sandboxes shall be equipped with sight glasses and refilled from outside the vehicle via an easily accessible quick refill connection from either side of the vehicle. Any filler caps shall be permanently retained to prevent loss.

TP-4.7.19 Automatic Train Control

TP-4.7.19.1 Automated Mode

The vehicles shall be designed for automatic operation to satisfy the requirements of the ATC system further defined in Section 4.5.6.

TP-4.7.19.2 Manual Mode

Vehicles shall be equipped with a manual Control Station at each end to enable vehicles or trains to be driven manually. The manual driving controls shall be interlocked with the vehicle propulsion control system so that only the manual control equipment at the forward (direction of travel) end of the train may be used to drive a train manually. It shall not be possible to reverse a train under power, or coast unpowered in the reverse direction. It shall, however, be possible to apply minimum power, for up to 5 seconds, to reverse a train from another following uncoupling.

Manual Control Station

Controls for manual operation of vehicles shall be located in a special, locked Control Station at each end of the vehicle. An operator at this position shall have a field of view necessary to perform manual operations anywhere in the System and during all weather conditions.

See also Section 4.7.7 for further Control Station details.

The Control Station shall be inconspicuous, and shall blend in with the vehicle's interior design when not in use. When in use, the layout of the controls shall be ergonomically designed for operation and shall satisfy both the 95th percentile adult male and the 5th percentile adult female requirements. Panels that need to be opened for operation shall not interfere with an operator's view of the right-of-way, or with access to the necessary controls. Manual operation shall be implemented with an operator in a seated position.

TP-4.7.20 Video Monitoring and Communications Systems

TP-4.7.20.1 Video Monitoring / Recording

Internal Video Cameras

Internally mounted color video cameras with a resolution of at least 400 lines horizontal by 350 lines vertical shall be provided in each vehicle to allow full monitoring of all passengers inside the vehicle. The internal video cameras and associated recording system shall have a minimum frame rate of 15 fps. This facility is specifically designed to record anti-social behavior of passengers, as well as allow real time visual communication with all vehicles in the train by the OCC to reduce vandalism and criminal activities, particularly late at night or on lightly loaded journeys.

Internal cameras shall be integrated into the ceiling so as to present a clean, neat, but vandal resistant installation. The internal camera housings shall be finished to match the interior color. Integration into other ceiling level equipment, such as passenger information displays, is preferred.

Cameras shall be vandal-resistant, yet easily accessible, modular and replaceable by maintenance personnel within 15 minutes in case of failure.

The Core Systems Contractor shall place the cameras so there are no blind spots in camera coverage and that at least two cameras cover all Passenger to OCC Intercommunication System station and passenger emergency manual door release areas. This coverage shall be confirmed by use of a three dimensional interior model of the vehicle, followed by validation using actually equipment during Mock-up Evaluation. This coverage is expected to require the use of at least 4 cameras per vehicle.

In the event of the activation of a T-TEL station or the passenger emergency manual door release handle, the system shall automatically select the two internal cameras that best cover this area and transmit it to an OCC video display (in addition to onboard recording) until the OCC deactivates the connection or System operations personnel reset the emergency handle.

External Forward-Facing Video Camera

An externally mounted, forward-facing color video camera with a resolution of at least 400 lines horizontal by 350 lines vertical shall be provided at the non-gangway end of each end (E – type) vehicle to allow full monitoring of the right of way in front of the vehicle. The external video camera and associated recording system shall have a minimum frame rate of 15 fps. This facility is specifically designed to monitor and record the condition of the right of way each morning during system start-up and record any incident which may occur in the right of way during daily operation, particularly at station platforms. The external video camera/recording shall only be active when the vehicle is the lead vehicle in a train.

External cameras shall be equipped with a wide angle lens and located in the center of the non-gangway end of each end (E-type) vehicle. It shall be flush mounted and fully integrated into the vehicle end so as to present a clean, neat, but vandal resistant installation which is resistant to dirt build-up.

Cameras shall be easily accessible, modular and replaceable by maintenance personnel within 15 minutes in case of failure.

Contact rail / Right of Way External Monitoring Cameras

Two E-type vehicles shall be equipped with two additional externally mounted, angled color video camera with a resolution of at least 400 lines horizontal by 350 lines vertical. to allow full monitoring of the condition of the contact rail and shoegear operation on both sides of the vehicle. These external video cameras and associated recording system shall have a minimum frame rate of 15 fps. The contact rail external video cameras/recording shall only be active when this capability is specifically selected.

These external cameras shall be located at underframe level and rearwards of the lead truck so as to have a clear view of the shoegear/contact rail interface, while not inteferring with vehicle clearances. They shall be fully integrated into the vehicle so as to present a clean, neat, but vandal resistant installation which is resistant to dirt build-up.

Cameras shall be easily accessible, modular and replaceable by maintenance personnel within 15 minutes in case of failure.

On-board Video Recorders

A digital video recorder shall be provided in each vehicle to continuously record at a minimum frame rate of 15 frames per second, each of the camera inputs in that vehicle whenever the vehicle is in operating service. Note that the two vehicles equipped with contact

rail cameras, higher capacity video recorders will be required to accommodate the two additional cameras.

Efficient video compression techniques, such as MPEG-4, shall be utilized to reduce data storage and transmission bandwidth requirements.

The video recorder shall also include audio tracks to continuously capture all audio transmitted via any Passenger to OCC Intercommunication System station.

The video recorder shall have a robust, secure, removable memory module with a storage capacity of at least 7 days (140 hours) of vehicle operation.

The recording system shall include digital watermarking or equivalent means of preventing subsequent unauthorized editing or other modification of the recorded images.

Suitable video control equipment shall also be provided to enable the video stream from any video camera on a vehicle to be individually selected and transmitted live to the OCC upon request from the OCC.

The Core Systems Contractor shall also supply a fixed base video work station for location within the MSF to securely download and process stored video images, including any furniture, monitors, printers, custom docking stations necessary for removable memory modules, connecting cables, ethernet card and operating system/custom software. Downloading of vehicle video files shall be manual using removable memory modules or functional equivalent.

Local status indicators and test points shall be provided to assist in local troubleshooting.

TP-4.7.20.2 Communications System Overview

The design of the communication system shall be service-proven for transit rail, or shall be documented to have provided all the necessary functions detailed within these specifications on other types of large transportation systems.

Each vehicle shall be provided with an integrated Communications Control System that includes the following elements:

- GPS/AVL or other vehicle location equipment
- Communications Controller
- Communications Handset
- Wireless LAN and/or other high-speed data links
- AGC sensing interior covert microphone
- Any associated low voltage power supplies and protection circuit breakers, etc.

Control and monitoring of the Communications System shall only be available from one vehicle in a train, as selected by the ATC system or manual Control Panel.

The core requirement is for a totally integrated communications control system that will control all the sub-systems listed below and provide the functionality identified. Details of exactly how this shall be accomplished shall be established by the contractor.

Controlled Communications Sub-Systems

The Communications Controller shall directly control the following sub-systems:

- PA System

- T-TEL System
- Auto-Announcer
- Interior Passenger Information Displays
- Exterior Destination Displays
- Flange Lubrication System

All controlled communications sub-systems shall be trainlined to allow control by the active Communications Controller in all vehicles of the train. Passenger information displays, destination displays and the flange lubrication system shall utilize Lon-Works, 10/100 Base-T, RS-232, J1708 or other suitable local data busses.

Provisions shall also be made for the future installation of a multi-media LCD flat panel display and advertising system such as AGATE e-Media or similar.

Communications System Functionality

OCC to Vehicle

The following information will be transmitted from the OCC to the vehicle via whatever communications link the contractor deems appropriate for the function:

- Text messages to the passenger information system of individual consists
- Text messages to the passenger information systems of all consists
- Confirmation of Train ID, routes, etc. after vehicle automatic ATC or operator manual log-on
- Automatic vehicle location query (automatic polling)
- Voice messages to the public address system of individual consists
- Voice messages to the public address system of all consist
- Two way voice communications with an active T-TEL station

Voice messages may be live or pre-recorded. Pre-recorded voice messages that will be originated from the Operations Control Center will be in English or English and Hawaiian and may be linked with specific text messages for simultaneous play on board the vehicle.

Vehicle to OCC

The following information shall be transmitted from the vehicle to the OCC via whatever communications link the contractor deems appropriate for the function:

- Consist fault summary status
- Consist bypass summary status
- Lead vehicle location (when polled by the OCC/ATC system)
- Consist log on
- Smoke alarm (see section 4.7.9.7)
- Fire extinguisher removal (see section 4.7.4.13)
- Two way voice communications with an active T-TEL station

TP-4.7.20.3 Voice Radio Link

Standard voice communications by System operations personnel is expected to be via hand held portable radios utilizing the existing EDACS 800 MHz trunked radio system operated

and maintained by the City and County of Honolulu. No voice radio equipment shall be installed on any vehicle.

TP-4.7.20.4 Wireless LAN / High Speed Data Links

Utilizing an IEEE 802.11n or IEEE 802.16 wireless LAN (or other suitable high-speed data links), the following information shall be transmitted from the vehicle to wayside communications equipment for subsequent routing to the appropriate destination:

Mobile

- Video camera feeds from an active T-TEL station or manual door release
- Audio feed from an active T_TEL station or manual door release
- On demand video streams from individual vehicle cameras to OCC
- Real-time Maintenance and Diagnostic data from the vehicle
- Basic vehicle travel log data such as vehicle ID, location, mileage, time, etc.

Fixed / MSF Yard

- All raw automatic passenger counter data
- Logged Maintenance and Diagnostic data since last download
- Any changes to the messages to be displayed on the vehicle destination or passenger information displays
- Any new audio messages to announced on the vehicle auto-announcer
- Any new advertising messages to be displayed on the vehicle advertising displays (future)
- Any changes to the operating points for the intelligent flange lubrication system

RF spectrum for this system is preferred to be licensed using 2.3, 2.5 or 4.9 GHz bands. Alternatively unlicensed 2.4, 5.8 or 5.9 GHz bands may be considered.

TP-4.7.20.5 Vehicle Trainline Communications Link

Within a train, the system shall provide the following functions in all vehicles via the trainline:

- Automatic setting of all vehicle exterior destination displays
- One-way communication from the active cab to the passenger interior and/or vehicle exterior PA speakers (when train manually operated).
- Automatic dynamic setting of interior passenger information displays and auto-announcer messages for upcoming stops, this station, etc.
- Display of advertising on multi-media displays (future)
- Automatic activation of the flange lubrication system in pre-determined locations

TP-4.7.20.6 Communications Controller (CC)

The Communication Controller is a microcomputer-controlled device that manages all the communications and control functions of the on-board equipment. The primary functions of the controller are:

Provide a communications interface with the ATC equipment and the Control Station display.

Interface with and control of the vehicle radios for voice and data transmission.(where not controlled by ATC equipment)

To continuously determine vehicle location from differential GPS inputs (and route-matching algorithms for fixed-route vehicles) or other sources, such as ATC equipment, for use in triggering associated communications equipment/flange lubricators.

To provide both manual and automatic control of the interior passenger information displays, auto-announcer, exterior destination displays, multi-media advertising (when fitted) and the public address system.

To collect and log train diagnostic and mileage data

To control the operation of the vehicle T-TEL system

To control uploading /downloading of data via the wireless LAN/high-speed data link.

To activate the rail/flange lubrication system.

To select interior/exterior speakers

One Communications Controller shall be provided in each end vehicle. No communications controllers are required on middle vehicles.

The Communications Controller shall be able to store at least ten different route profiles, with all associated text and audio messages, including stopping at all stations and other City specified Express runs.

In normal operation, route selection signals shall be automatically provided to the Communications Controller by the ATC system. During manual operation, route selection may be made via the Control Panel.

The controller shall be capable of activating passenger information (displays and auto-announcer) in English and Hawaiian with a provision for at least three additional languages, i.e., Spanish, French, German, and Japanese.

The controller shall also be capable of displaying up to twenty advertising messages.

The CC shall have the capacity for storing the following:

- Up to 99 text messages for use by the Destination Displays
- Up to 5000 text messages for use by the Passenger Information Displays
- Up to 5000 audio messages for use by the Auto-Announcer

TP-4.7.20.7 GPS/AVL System

The components for a Global Positioning System (GPS) based Automatic Vehicle Location (AVL) System (or approved functional equal, such as an ATC vehicle location signal) shall be provided and installed by the Core Systems Contractor on each end vehicle. These shall include:

- GPS antenna/receiver unit (roof mounted)
- Suitable low voltage dc power supplies with associated circuit protection and wiring.
- Interconnecting cables and connectors

TP-4.7.20.8 Public Address System

A Public Address System (amplifier, local controls and speakers) shall be provided in each vehicle, controlled by the active train Communications controller via trainline. All PA

trainline wires shall be provided with adequate shielding and shall be balanced to keep noise interference and cross-talk to a minimum. Digital transmission is preferred.

The public address (PA) system shall permit announcements to be made to all passengers inside and outside the train. The PA system shall permit the OCC (and an operator during manual operation) to make non-prerecorded announcements to the passengers on all vehicles of the train.

The PA system shall be designed to provide a uniformly distributed minimum sound pressure of 12 dB above vehicle ambient noise level of +5dB at a height of 1,525 mm [60 in] above the floor. All messages shall be intelligible and acoustically pleasing under all operating conditions.

Preceding any OCC- or operator-initiated public announcement, an alert tone shall be sounded to advise passengers that an announcement is forthcoming.

Speech and tone peaks shall be limited to approximately 3 dB above the average input level.

The PA amplifier shall be muted until the announcement is made and shall not emit noise when the amplifier is turned on or off.

Interior speakers shall be flush-mounted in the ceiling panels in a suitable acoustical enclosure lined with sound-absorbent material. These speakers shall be arranged in a pattern so that every point at the height of 1,525 mm [60 in] above the floor is within the horizontal and vertical 6 dB audio throw projection cone of at least one speaker. Interior speakers shall be finished to match the interior color.

Weatherproof exterior speakers shall be required on each side near the middle of the vehicle. The speakers shall be recessed into the vehicle body and protected by suitable grilles so as to be flush with the bodyside. These speakers shall be rated weatherproof, for exterior, rough duty use and of a service-proven design. All mounting hardware shall be stainless steel. Exterior speaker grilles shall be finished to match the exterior color.

Exterior speaker volume shall be provided with automatic volume reduction for quieter operation during sensitive periods such as early mornings and at night.

TP-4.7.20.9 Train Emergency Speakerphone (T-TEL)

The Train Emergency Speakerphone (T-TEL) system shall allow passengers to communicate directly with the OCC. See also TP-7, Section 27 30 01 – Telephone Systems, for a system overview.

T-TEL stations shall be located at each of the two universal areas to enable wheelchair-borne passenger access to the T-TEL station. This may be integrated into the local door surround. The T-Tel stations shall be finished to match the interior color.

T-TEL stations shall also be provided in at least one further location near the middle of the vehicle and integrated into the door surround of one the passenger doors at standing passenger height.

The T-TEL stations shall incorporate a push-to-call feature and a visual indicator for the hearing-impaired to indicate that the call has been acknowledged. Upon acknowledgement, normal two-way voice communications shall be enabled.

Activation of this station shall also cause the video signal from the two internal CCTV cameras which best cover that area to be transmitted to the OCC.

TP-4.7.20.10 Passenger Information

Each vehicle shall be supplied with equipment providing audible and visible announcement of a train's destination, and other variable information as specified by the City and compatible with the requirements of TP-7, Section 27 80 00 – Passenger Information System.

The equipment shall meet the requirements of the ADA regulations in effect at the time of contract award.

All vehicle consist destination and passenger information displays shall be remotely controlled via the trainline by the active Communications Controller. Suitable message storage and sign control shall be provided locally at each display.

Destination Displays

Exterior destination displays shall be provided on each vehicle for the display of selected route, final destination and special messages.

For end vehicles, one at the non-gangway end and two side displays, one per side located in the middle of the vehicle, shall be provided. For middle vehicles, two side displays, one per side located in the middle of the vehicle, shall be provided.

Special destination display messages shall include but not be limited to:

- Special
- Test Train
- Express
- Training
- Out of Service

End vehicle destination displays shall be mounted so as to be visible in all lighting conditions and in particular not be obscured by glare. These displays shall be visible at a distance of no less than 46 m [150 ft] in bright sunlight. End vehicle destination displays shall display as a minimum 150 mm [6 in] high uppercase characters.

All side destination displays shall be mounted at the top of the bodyside window and shall display as a minimum 100 mm [4 in] high uppercase characters through the glass to the outside of the vehicle.

A minimum of 14 characters per line shall be displayed on both display types. Characters shall be a light color against a dark background, typically amber, yellow or orange against a black background.

Messages shall be capable of being displayed in a variety of formats, including scrolling, flashing and alternating message segments.

Passenger Information Displays

Four interior passenger information displays shall be provided per vehicle for the automatic display of current station, next station, stopping at the next station, doors enabled/opening on the left/right side and doors closing text messages in conjunction with audio messages from the auto announcer. ATC-, OCC- or manually-selected special operational and emergency messages shall also be displayed and announced on this system. Selective advertising messages may also be displayed on this system.

Each display shall be mounted transversely from the ceiling and located so as to permit all passengers on board the vehicle to have a clear view of at least one of the displays, regardless of passenger loading.

Interior passenger information displays shall display as a minimum 25.4 mm [1.0 in] high characters in red, yellow and green. As a minimum, the display shall display a single line of at least 18 characters. Messages of at least 48 characters in length shall be capable of being stored and displayed in a variety of display formats including scrolling, flashing and alternating message segments.

The displays shall display in English and shall also have the capability of displaying the special characters used in Hawaiian.

TP-4.7.20.11 Auto-Announcer

An automatic announcement system shall automatically provide audio announcements of the current station, next station, doors enabled/opening on left/right side and doors closing, etc. in conjunction with text messages being displayed on the passenger information displays. ATC-, OCC- or manually-selected special operational and emergency messages shall also be displayed and announced on this system when desired. The auto-announcer functionality may be combined with the Communications Controller or other functional equivalent.

Special announcements shall include, but not be limited to:

- End of line – please exit at this station
- Express
- Special
- Temporary Delay
- Vehicle failure – please exit at this station
- Please evacuate the vehicle immediately
- Help is on the way, do not evacuate the vehicle

TP-4.7.21 Automatic Passenger Counters

Automatic Passenger Counting (APC) equipment utilizing infrared motion detection (or the functional equivalent) shall be provided at each passenger door. The sensors shall be installed in the door header panels and suitably integrated into the vehicle interior aesthetic design so as to be as unobtrusive as possible. All sensors shall be robust, vandal resistant and protected against intrusion of water.

The APC equipment shall also be equipped with fault indication and test facilities.

The installation shall provide a sufficient number of sensors to guarantee a per door raw data passenger count accuracy of at least 95 percent.

Statistical processing of the raw passenger count shall be performed either directly by the onboard system, or by subsequent off-vehicle processing, to produce a corrected passenger count with at least 98.5-percent accuracy coupled with precise stop locations provided by the onboard GPS/AVL subsystem.

Each door on each vehicle shall be assigned a unique address and count records shall be maintained for each door, grouped by vehicle. Trip reports shall be available in a variety of formats, including total passengers per day, total passengers per trip, passengers loaded/discharged per each station, passenger load, passenger miles, seat miles, passenger change time, etc.

Raw data files shall be downloaded from the vehicle daily via the wireless LAN.

The vehicle Core Systems Contractor shall also provide APC system data analysis/reporting and associated operating system software, along with an SQL database/web/ftp workstation/server for raw data processing and report generation.

TP-4.7.22 Events Recorder

An events recorder shall be provided on each E-type vehicle (or a minimum of one per train) to record operational and fault data, primarily to support accident investigations. These data shall include:

- Date
- Time
- Vehicle number
- Train number
- Vehicle speed
- Accumulated mileage
- Direction of movement
- Active end
- Traction demand/application
- Dynamic brake demand/application
- Service brake demand/application
- Emergency brake demand/application
- Track brake demand/application
- Sanding application
- Bypass/cutout active
- Smoke Alarm initiated
- ATP/ATS trip
- Warning bell application
- Warning horn application
- Door status (open/close)

As a provision for future needs, at least two spare digital and one spare analog channels shall also be provided.

The events recorder shall be in accordance with IEEE 1482.1 – Standard for Rail Transit Event Recorders and be based on service-proven designs with at least 5 years successful operating history in revenue service on rail vehicles. Alternative standards for this device may be proposed.

Data sampling rates shall be user adjustable, provided with sampling rates adjustable between 50 milliseconds through 1 second. Each individual sampling per function shall include time, date, fault, and operational system configuration data.

The recorder shall be able to store a minimum of 48 hours of data, including signals from the spare channels, in a removable non-volatile memory card (or functional equivalent). This memory card shall not require any battery backup for data retention and the data shall remain intact for a period at least one year after removal from the vehicle. A special, non-standard, not readily duplicated key shall be provided for the removal of the memory card so that access to this card will be by authorized

System management personnel only. Maintenance and Operations personnel shall not be permitted access.

The recorded data shall be capable of transfer to an off vehicle computer for evaluation by the following means:

Data copied on to a PCMCIA Type II flash memory card or flash drive (for download to a desktop or other computer not supplied by the Core Systems Contractor).

Data copied to a laptop computer (supplied by the Core Systems Contractor as a part of the vehicle special tools and equipment) via an RS-232C port/cable.

It shall not be possible to erase the data in the data recorder by either of these processes. The Core Systems Contractor shall provide all necessary software and interconnecting cabling required. Recorded data shall be capable of being presented using graphs, event sequences, flow charts, tables, etc. that allow easy interpretation of events.

The events recorder shall be secured within a sealed, tamper proof, and vandal resistant unit in a position protected from possible collision damage.

The system shall be capable of automatically adjusting or updating for yearly time/date changes.

TP-4.7.23 Monitoring and Diagnostic System

A comprehensive vehicle Monitoring and Diagnostics system (MDS) compatible with the requirements of TP-7, Section 27 90 03 – Maintenance Management Information System, shall be provided to offer maintenance personnel a clear, unambiguous indication of the systems availability on the train at all times. The MDS shall make it possible for the maintainer to immediately determine the status of individual items of equipment on each vehicle in the train without using any external test equipment and guide him in taking corrective or preventive action if required.

The MDS shall utilize existing subsystem control sensors whenever possible, and independent sensors only where absolutely essential.

The MDS shall interface with the vehicle communications system to allow real-time downloading of vehicle fault information over the wireless LAN (See Section TP-4.5.7), as well as the cumulative fault log whenever the vehicle comes out of revenue service.

A detailed technical description of the MDS, including all screen displays, shall be submitted for approval.

TP-4.7.23.1 Control Station Display

A display shall be located in the Control Station at the non-gangway end of each E-type vehicle.

In normal manual operation, whenever the vehicle is in motion, the display shall show the following information:

- Vehicle speed (digital and analog)
- Time and date
- Route
- Train vehicle numbers, orientation, and lead vehicle
- Overall systems status

Whenever the vehicle is stopped, the display shall show the following information:

- Door status (graphical representation showing status of each door in train)
- Time and date
- Route
- Vehicle numbers, orientation, and lead vehicle
- Overall systems status
- Menu button (for access to system set-up and diagnostic screens)

Upon detection of a fault condition by the MDS, a fault alarm tone shall be sounded, and the Control Station display shall present a systems fault indication only when that Control Station is active. Access to a fault screen that identifies the failure and its location shall be available when the vehicle is stopped via the Menu button. Acknowledgement of the fault shall cancel the alarm tone.

TP-4.7.23.2 Monitored Fault Conditions

As a minimum, the following fault conditions shall be monitored:

- Contact rail power lost
- HSCB tripped: location
- ATC system fault
- Door interlock bypass active
- No-motion detection bypass active
- Speed restriction bypass active
- Local friction brake cutout: location
- Local propulsion cutout: location
- Network fault: location
- Auxiliary ac power fault: location
- Auxiliary dc power fault: location
- Battery over-temperature trip: location
- Manual door release activated: location
- T-TEL station activated: location
- Door not closed: location
- Door cut out: location
- Air compressor fault (if used): location
- Stuck brake: location - vehicle, truck, side
- Brake in emergency: location
- Insufficient propulsion: location
- HVAC unit fault: location
- Suspension fault: location
- Flange Lubricator level low: location

If a corrective action can be taken by the Control Station user, this action shall be clearly stated.

The system shall be capable of automatically adjusting or updating for yearly time/date changes.

TP-4.7.23.3 Maintenance Troubleshooting Screens

Troubleshooting screens shall be available on the Control Station Display to maintenance personnel to assist in further defining the fault area and diagnosing the fault. These screens shall not be available to an operator and shall only be accessed by use of the Maintenance Key or by entering the appropriate password.

Subsystem troubleshooting screens shall display real time status information systems, subsystems and sensors at the train and vehicle level. Subsystem status information shall, as a minimum, display the following subsystem states:

- Subsystem Off or Inactive but Ready.
- Subsystem Operating Normally.
- Subsystem Activated but no High Voltage available (where applicable)
- Subsystem Shutdown due to fault but automatic reset expected.
- Subsystem Shutdown and Locked Out. Maintenance required.
- MDS communication to Subsystem unavailable.

Subsystem diagnostics shall be provided for each major subsystem and shall meet the following requirements:

- All failures during operation or self-test shall be recorded.
- All parameters associated with failure indications and exception reporting shall be clearly documented.
- All subsystem reports shall be stored in a non-volatile memory for diagnostic use. Records shall include time stamp, condition and associated data. Identical log formats shall be used for all vehicle systems.
- All the above data shall be accessible locally at the subsystem, using Portable Test Equipment or personal computer.

TP-4.7.24 Scale Model

A scale 1:20 model of the exterior of the vehicle, comprising of 1 E-type and 1 M type car with associated gangways, shall be provided. This model shall be used to display the exterior vehicle styling and decorative treatment. The interior layout and the trucks are not required to be fully detailed. The model shall be attractively mounted on a wood base suitable for exhibit with a removable clear plastic cover, which can be secured in place when desired. The roof-mounted equipment, doors, couplers, signs, lettering, handholds, lights and all other external features, shall be included to be an accurate exterior representation of the vehicle. All windows shall be delineated with either glass or clear plastic with the appropriate tint, and shall be backed up with an appropriately colored recessed area so that the interior from the exterior shall appear as realistic as possible.

This model shall become the property of the City, and shall be provided prior to the completion of the first vehicle to allow it to be used for publicity displays. The model shall be supplied along with two or more foam-rubber-lined, permanent shipping containers of metal construction to allow the model to be shipped as commercial air cargo without damage.

The weight of the model in its shipping containers shall not exceed 50 kg [110 lb] total or more than 25 kg [55 lb] for any individual model section in its container.

TP-4.8 *Configuration Control*

TP-4.8.1.1 Vehicle Configuration Control

For the duration of the Contract, including the Warranty period, the Core Systems Contractor shall maintain a fleetwide vehicle configuration control system.

All vehicle system equipment and major components shall be permanently identified with the supplier's name, part number, serial number, and revision level. This may be by use of an engraved metal label riveted in plate or other approved permanent method. Provision shall be made for updating the revision level when upgrades are implemented. This identification shall be supplemented by identification using bar codes, RFID tags or other suitable machine readable method.

As a minimum, the following equipment shall have serial numbers applied:

HVAC units	Brake control unit
Defroster fan unit	Brake discs
Gangway bellows	Brake caliper units
Propulsion inverter/control units	Door operators
Dynamic resistor unit	Door control units
Traction motors	Master controller
Gearboxes	Direction switch
Truck frames	Fire extinguishers
Journal bearings	Standard and inverter ballasts
Axles	Events recorder
Wheel hubs	Radios
Tires	ATC equipment
Ground brush units	Any AVL equipment
Speed, etc. probes	Communications controllers
Primary and secondary suspension elements	Video displays, cameras, and recorders
Truck shock absorbers	PA equipment
Brake control units	Destination and passenger info displays
Brake / suspension hydraulic units (if used)	Coupler units
Hydraulic reservoirs (if used)	Warning bell, horn and back-up alarm units
Air compressors (if used)	Windshield wash/wipe unit
Air reservoirs (if used)	Flange lubrication controllers and pumps
Third rail shoegear	Monitoring and Diagnostic System equipt
Line filter	Printed circuit boards
Lightning arrestor	Data Acquisition Units
HSCB	Battery unit
Main power switch	Low voltage dc power supply
Auxiliary inverter units	

TP-4.9 *Vehicle Verification Testing and Acceptance*

The vehicle and its components shall be tested to verify compliance with design, performance, reliability, and maintainability requirements in accordance with the requirements of TP-2: Verification, Test and Acceptance.

The City reserves the right to witness all or any portion of the required tests.