SECTION 6: TECHNICAL SPECIFICATIONS

GENERAL

Scope

Technical specifications state requirements for heavy-duty transit buses and commuter coaches, which, by the selection of specifically identified alternative configurations, may be used for both suburban express service and general service on urban arterial streets. Buses shall have a minimum expected life of twelve (12) years or 500,000 miles, whichever comes first, and are intended for the widest possible spectrum of passengers, including children, adults, the elderly and people with disabilities.

Definitions

Ackerman Design: A geometric arrangement of linkages in the steering of a vehicle designed to solve the problem of wheels on the inside and outside of a turn needing to trace out circles of different radii.

Agency Operating Profile: The operational requirements under Agency-specific operating conditions that the bus must be able to achieve.

Alternative: An alternative specification condition to the default bus configuration. The Agency may define alternatives to the default configuration to satisfy local operating requirements. Alternatives for the default configuration will be clearly identified.

Ambient Temperature: The temperature of the surrounding air. For testing purposes, ambient temperature must be between 16 and 38 °C (50 and 100 °F).

Analog Signal: A continuously variable signal that is solely dependent upon magnitude to express information content.

NOTE: Analog signals are used to represent the state of variable devices such as rheostats, potentiometers, temperature probes, etc.

Audible Discrete Frequency: An audible discrete frequency is determined to exist if the sound power level in any 1/3-octave band exceeds the average of the sound power levels of the two adjacent 1/3-octave bands by 4 decibels (dB) or more.

Battery Compartment: Low-voltage energy storage, i.e., 12/24 VDC batteries.

Battery Management System (BMS): Monitors energy, as well as temperature, cell or module voltages, and total pack voltage. The BMS adjusts the control strategy algorithms to maintain the batteries at uniform state of charge and optimal temperatures.

Battery Pack: An electrical equivalent of a collection of cells or modules or physical sub-packs forming the highest-level energy storage system. Often multiple physical sub-packs are connected in series, and these may also be connected in parallel.

Braking Resistor: Device that converts electrical energy into heat, typically used as a retarder to supplement or replace the regenerative braking.

Burst Pressure: The highest pressure reached in a container during a burst test.

Capacity (fuel container): The water volume of a container in gallons (liters).

Capacitor: A device that stores electrical energy in an electric field. It is a passive electronic component with two terminals.

Cell: Simplest discrete component of the energy storage system, such as a battery or a capacitor.

Charging Equipment: The equipment that encompasses all the components needed to convert, control and transfer electricity from the grid to the vehicle for the purpose of charging batteries. May include chargers, controllers, couplers, transformers, ventilation, etc. See *Electric Vehicle Supply Equipment (EVSE)*.

Charging Interface: The equipment and/or coupler used to create a connection between the charging equipment and the vehicle for the purpose of recharging a vehicle’s batteries.

Charging Station: The location that houses the charging equipment connected to a utility’s electric service to provide electricity to a vehicle’s battery system through a charging interface.

Class A Voltage: Electric component or circuit with a maximum working voltage of less than 30 VAC (rms) or 60 VDC (ISO 6469-3), also referred to as “low voltage” (LV).

Class B Voltage: Electric component or circuit with a working voltage greater than 30 VAC (rms) and 60 VDC (ISO 6469-3), also referred to as “high voltage” (HV).

Code: A legal requirement.

Composite Container for CNG: A container fabricated of two or more materials that interact to facilitate the container design criteria.

Compressed Natural Gas (CNG): Mixtures of hydrocarbon gases and vapors consisting principally of methane in gaseous form that has been compressed for use as a vehicular fuel.

Curb Weight: Weight of vehicle, including maximum fuel, oil and coolant; and all equipment required for operation and required by this Specification, but without passengers or driver.

dBA: Decibels with reference to 0.0002 microbar as measured on the “A” scale.

DC to DC Converter: A device that converts a source of direct current from one voltage level to another.

Diesel Exhaust Fluid (DEF): A solution of urea in water, used to reduce engine emissions of nitrogen oxides (NOx) in conjunction with a selective catalytic reduction system (SCR).

Default Configuration Bus: The bus described if no alternatives are selected. Signing, colors, the destination sign reading list and other information must be provided by the Agency.

Defueling: The process of removing fuel from a tank.

Defueling Port: A device that allows for vehicle defueling, or the point at which this occurs.

Design Operating Profile: The operational requirements under standard operating conditions that the bus must be able to achieve.

Destroyed: Physically made permanently unusable.

Discrete Signal: A signal that can take only predefined values, usually of a binary 0 or 1 nature, where 0 is battery ground potential and 1 is a defined battery positive potential.

DPF: Diesel particulate filter.

Driver’s Eye Range: The 95th-percentile ellipse defined in SAE J941, except that the height of the ellipse shall be determined from the seat at its reference height.

Electrical Pack: See *Battery Pack*.

Electric Vehicle Supply Equipment (EVSE): The conductors, including the ungrounded, grounded and equipment grounding conductors, the electric vehicle connectors, the attachment plugs, and all other fittings, devices, power outlets or apparatuses installed specifically for the purpose of delivering energy from the premise’s wiring to the electric vehicle.

End of Life: A condition reached when an energy storage system fails to meet specified capacity, power or function in specified use conditions.

Energy Density: The relationship between the weight of an energy storage device and its power output in units of watt-hours per kilogram (Wh/kg).

Energy Storage System (ESS): A component or system of components that stores energy and for which its supply of energy is rechargeable by the on-vehicle system (engine/regenerative braking/generator) or an off-vehicle energy source.

Fill Pressure for CNG: The pressure attained at the actual time of filling. Fill pressure varies according to the gas temperatures in the container, which are dependent on the charging parameters and the ambient conditions. The maximum dispensed pressure shall not exceed 125% of service pressure.

Fire-Resistant: Materials that have a flame spread index less than 150 as measured in a radiant panel flame test per ASTM-E 162-90.

Fireproof: Materials that will not burn or melt at temperatures less than 2000 °F.

Flow Capacity: For natural gas flow, this is the capacity in volume per unit time (normal cubic meters/minute or standard cubic feet per minute) discharged at the required flow rating pressure.

Free Floor Space: Floor area available to standees, excluding the area under seats, the area occupied by the feet of seated passengers, the vestibule area forward of the standee line, and any floor space indicated by the manufacturer as non-standee areas, such as the floor space “swept” by passenger doors during operation. Floor area of 1.5 ft2 shall be allocated for the feet of each seated passenger protruding into the standee area.

Fuel Line: The pipe, tubing or hose on a vehicle, including all related fittings, through which natural gas passes.

Fusible Material: A metal, alloy or other material capable of being melted by heat.

Fuel Management System: Natural gas fuel system components that control or contribute to engine air fuel mixing and metering, and the ignition and combustion of a given air-fuel mixture. The fuel management system would include, but is not limited to, reducer/regulator valves, fuel metering equipment (e.g. carburetor, injectors), sensors (e.g., main throttle, waste gate).

Generator (Electric): A device that converts mechanical energy into electrical energy.

Gross Axle Weight Rated (GAWR): The maximum total weight as determined by the axle manufacturer, at which the axle can be safely and reliably operated for its intended purpose.

Gross Load: 150 lb for every designed passenger seating position, for the driver, and for each 1.5 ft2 of free floor space.

Gross Vehicle Weight (GVW): Curb weight plus gross load.

Gross Vehicle Weight Rated (GVWR): The maximum total weight as determined by the vehicle manufacturer, at which the vehicle can be safely and reliably operated for its intended purpose.

High Pressure: Those portions of the CNG fuel system that see full container or cylinder pressure.

High Voltage (HV): Electric component or circuit with a working voltage greater than 30 VAC (rms) and 60 VDC (ISO 6469-3), also referred to as “Class B voltage.”

Hose: A flexible line.

Hybrid: A vehicle that uses two or more distinct power sources to propel the vehicle.

Hybrid System Controller (HSC): Regulates energy flow throughout hybrid system components in order to provide motive performance and accessory loads, as applicable, while maintaining critical system parameters (voltages, currents, temperatures, etc.) within specified operating ranges.

Hybrid Drive System: The mechanical and/or electromechanical components, including the engine, traction motors and energy storage system, that comprise the traction drive portion of the hybrid propulsion system.

Intermediate Pressure: The portion of a CNG system after the first pressure regulator, but before the engine pressure regulator. Intermediate pressure on a CNG vehicle is generally from 3.5 to 0.5 MPa (510 to 70 psi).

Inverter: A module that converts DC to and from AC.

Labeled: Equipment or materials to which has been attached a label, symbol or other identifying mark of an organization, which is acceptable to the authority having jurisdiction and concerned with product evaluation, which maintains periodic inspection of production labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

Leakage: Release of contents through a defect or a crack. See *Rupture*.

Line: Any tube, flexible and hard, that carries fluids.

Liner: Inner gas-tight container or gas container to which the overwrap is applied.

Local Regulations: Regulations below the state level.

Low-Floor Bus: A bus that, between at least the front (entrance) and rear (exit) doors, has a floor sufficiently low and level so as to remove the need for any steps.

Low Voltage (LV): Electric component or circuit with a maximum working voltage of less than 30 VAC (rms) or 60 VDC (ISO 6469-3), also referred to as “Class A voltage.”

Lower Explosive Limit: The lowest concentration of gas where, given an ignition source, combustion is possible.

Maximum Service Temperature: The maximum temperature to which a container/cylinder will be subjected in normal service.

Metallic Hose: A hose whose strength depends primarily on the strength of its metallic parts; it can have metallic liners or covers, or both.

Metering Valve: A valve intended to control the rate of flow of natural gas.

Module: A collection of cells forming a physical and electrical subassembly contained within an enclosure.

Motor (Electric): A device that converts electrical energy into mechanical energy.

Motor (Traction): An electric motor used to power the driving wheels of the bus.

Nameplate Capacity (or Nominal Capacity): The total amount of energy available between 0% state of charge (SoC) and 100% SoC.

Non-Drive Axle: a drive axle without the drive gear with a load rating sufficient for the load to GVWR.

Operating Pressure: The varying pressure developed in a container during service.

Pack: A collection of cells or modules described on the basis of electrical or physical attributes, to include *Battery* *Pack* and *Physical Pack*.

Physical Layer: The first layer of the seven-layer International Standards Organization (ISO) Open Systems Interconnect reference model. This provides the mechanical, electrical, functional and procedural characteristics required to gain access to the transmission medium (e.g., cable) and is responsible for transporting binary information between computerized systems.

Physical Pack: An enclosure consisting of a collection of cells or modules at a location or multiple locations. Physical packs differ from battery packs, as they are defined by layout rather than electrical equivalent.

Pipe: Nonflexible line.

Pressure Relief Device (PRD): A pressure and/or temperature activated device used to vent the container/cylinder contents and thereby prevent rupture of a natural gas vehicle (NGV) fuel container/cylinder, when subjected to a standard fire test as required by fuel container/cylinder standards.

NOTE: Since this is a pressure-activated device, it may not protect against rupture of the container when the application of heat weakens the container to the point where its rupture pressure is less than the rated burst pressure of the relief device, particularly if the container is partially full.

Power: Work or energy divided by time.

Power Density: Power divided by mass, volume or area.

Propulsion System: System that provides propulsion for the vehicle proportional to operator commands. Includes, as applicable, engine, transmission, traction motors, the hybrid drive system, energy storage system (ESS), and system controllers including all wiring and converter/inverter.

Ramp: A device deployed by the bus operator to enable riders with disabilities, including wheeled mobility device users, to board and alight at a 1:6 maximum slope.

Real-Time Clock: Computer clock that keeps track of the current time.

Regenerative Braking: Deceleration of the bus by switching motors to act as generators, which return vehicle kinetic energy to the energy storage system.

Rejectable Damage: In terms of NGV fuel containers/cylinders, this is damage as outlined in CGA C-6.4, “Methods for External Visual Inspection of Natural Gas Vehicle Fuel Containers and Their Installations,” and in agreement with the manufacturer’s recommendations.

Retarder: Device used to augment or replace some of the functions of primary friction-based braking systems of the bus.

Rupture: Sudden and unstable damage propagation in the structural components of the container resulting in a loss of contents. See *Leakage*.

Seated Load: 150 lb for every designed passenger seating position and for the driver.

Seated Load Weight (SLW): Curb weight plus seated load.

Serial Data Signals: A current loop-based representation of ASCII or alphanumeric data used for transferring information between devices by transmitting a sequence of individual bits in a prearranged order of significance.

NOTE: An example is the communication that takes place between two or more electronic components with the ability to process and store information.

Service Pressure: The settled pressure at a uniform gas temperature of 21 °C (70 °F) and full gas content. It is the pressure for which the equipment has been constructed, under normal conditions. Also referred to as the nominal service pressure or working pressure.

Settled Pressure: The gas pressure when a given settled temperature, usually 21 °C (70 °F), is reached.

Settled Temperature: The uniform gas temperature after any change in temperature caused by filling has dissipated.

Sources of Ignition: Devices or equipment that because of their modes of use or operation, are capable of providing sufficient thermal energy to ignite flammable compressed natural gas–air mixtures when introduced into such a mixture, or when such a mixture comes into contact with them.

Special Tools: Tools manufactured or customized for a specific purpose applicable to work associated with the vehicle and not commercially available off the shelf from sources such as a hand tool vendor.

Specification: A particular or detailed statement, account or listing of the various elements, materials, dimensions, etc. involved in the manufacturing and construction of a product.

Square Cubic Foot: A standard cubic foot defines an amount of gas contained in a volume of 1 ft3 at standard temperature and pressure.

Standard: A firm guideline from a consensus group. Standards referenced in Section 6, “Technical Specifications” are the latest revisions unless otherwise stated.

Standee Line: A line marked across the bus aisle to designate the forward area that passengers may not occupy when the bus is moving.

State of Charge (SoC): Quantity of electric energy remaining in the battery relative to the maximum rated amp-hour (Ah) capacity of the battery expressed in a percentage. This is a dynamic measurement used for the energy storage system. A full SoC indicates that the energy storage system cannot accept further charging.

Stress Loops: The “pigtails” commonly used to absorb flexing in piping.

Structure: The basic body, including floor deck material and installation, loadbearing external panels, structural components, axle mounting provisions, suspension beams and attachment points.

Thermally Activated Gas Relief Device: A relief device that is activated by high temperatures and generally contains a fusible material.

NOTE: Since this is a thermally activated device, it does not protect against overpressure from improper charging practices.

Traction Control System (TCS): Typically (but not necessarily) a secondary function of the electronic stability control (ESC) designed to prevent loss of traction (i.e., wheel spin) of the driven road wheels. TCS is activated when throttle input and engine power and torque transfer are mismatched to the road surface conditions.

Transit Vehicle Manufacturer: As defined by the FTA, any manufacturer whose primary business purpose is to build vehicles specifically for public mass transportation.

Useable Capacity: Nameplate Capacity × Allowable Depth of Discharge (for example, 95%).

Valve: A device or natural object that regulates, directs or controls the flow of a fluid (gases, liquids, fluidized solids or slurries) by opening, closing or partially obstructing various passageways.

Warrantable End of Life (WEOL): A measure of battery degradation determined as the point at which the batteries can no longer provide the energy or power required to meet the design operating profile. It is expressed as a percentage of remaining battery capacity as compared with gross capacity at the beginning of useful life. For purposes of this specification, WEOL shall be a measure of the useful and intended life of the energy storage device.

Wheeled Mobility Device: A mobility aid belonging to any class of three- or four-wheeled devices, usable indoors or outdoors, designed for and used by individuals with mobility impairments, whether operated manually or powered. A “common wheeled mobility device” is such a device that does not exceed 30 in width and 48 in length measured 2 in above the ground, and does not weigh more than 600 lb when occupied.

Zero-Emission Vehicle: A vehicle that emits no tailpipe emissions from the onboard source of power.

Referenced Publications

The documents or portions thereof referenced within this specification shall be considered part of the requirements of the specification. The edition indicated for each referenced document is the current edition, as of the date of the issuance of this specification. The Contractor is responsible for complying with current referenced documents.

Any inconsistency in compliance with this Technical Specification and its referenced documents shall be resolved by giving precedence in the following order:

1. Federal requirements (Title 49 CFR, FMVSS, etc.)
2. State requirements (in California, for example, it would be Title 13 Vehicle Code)
3. Local requirements
4. Technical content of this Technical Specification section
5. Referenced standards, practices and codes (APTA, SAE, ASTM, UL, ISO, etc.)

As an attachment to this RFP, CER 9.3 identifies the specifications, standards, regulations and references used within the RFP. The form must be returned with a proposal and requires an indication of the state of compliance and an opportunity for listing other pertinent references. Please indicate “compliance” as full, partial or N/A (not applicable). If “partial” or “N/A,” please describe.

Legal Requirements

The Contractor shall comply with all applicable federal, state and local regulations. These shall include but not be limited to the Americans with Disabilities Act (ADA), as well as state and local accessibility, safety and security requirements. Local regulations are defined as those below the state level.

Buses shall meet all applicable Federal Motor Vehicle Safety Standards (FMVSS) regulations and shall accommodate all applicable Federal Motor Carrier Safety Administration (FMCSA) regulations in effect at the location of the Agency and the date of manufacture. Unless stated otherwise, any forecasted regulatory changes are not to be considered for this procurement.

Note: In the event of any conflict between the requirements of these specifications and any applicable legal requirement, the legal requirement shall prevail. Technical requirements that exceed the legal requirements are not considered to conflict.

Overall Requirements

The Contractor shall ensure that the application and installation of major bus subcomponents and systems are compliant with all such subcomponent vendors’ requirements and recommendations. Contractor and Agency shall identify subcomponent vendors that shall submit installation/application approval documents with the completion of a pilot or lead bus. Components used in the vehicle shall be of heavy-duty design and proven in transit service.

Weight

It shall be a design goal to construct each bus as light in weight as possible without degradation of safety, appearance, comfort, traction, longevity or performance.

Buses at gross vehicle weight (GVW) shall not exceed the tire factor limits, brake test criteria, structural design criteria or the gross vehicle weight rating (GVWR).

Capacity

The vehicle shall be designed to operate at gross load, which shall not exceed the bus GVWR nor any individual GAWR.

Service Life

«service\_life»

Maintenance and Inspection

Scheduled maintenance tasks for buses shall be related and shall be in accordance with the manufacturer’s recommended preventive maintenance schedule (along with routine daily service performed during the servicing). The overall PM schedule for buses shall be based upon a minimum of a 6000 mi interval and/or multiples of same.

The manufacturer is responsible for providing a written comprehensive 52-week and long-term rehab/replacement maintenance plan encompassing buses for their entire useful life. The plan should include times (in hours) to complete the jobs.

Test ports or connectors, as required, shall be provided for commonly checked functions on the bus, such as hydraulic, pneumatic, cooling, temperature, voltage, current and state of charge (SoC).

The Offeror shall give prime consideration to the routine problems of maintaining the vehicle. All vehicle components and systems, both mechanical and electrical, that will require periodic physical work or inspection processes, shall be installed so that a minimum of time is consumed in gaining access to the critical repair areas. It shall not be necessary to disassemble portions of the bus structure and/or equipment, such as seats and flooring under seats, in order to gain access to these areas. Each bus shall be designed to facilitate disassembly, reassembly, servicing or maintenance, using tools and equipment normally available as standard commercial items.

Requirements for the use of unique or specialized tools shall be minimized. The body and structure of the bus shall be designed for ease of maintenance and repair. Individual panels or other equipment that may be damaged in normal service shall be repairable or replaceable. Ease of repair shall be related to the vulnerability of the item to damage in service.

The Contractor shall provide an itemized list of all special tools and pricing for maintaining this equipment as a supplement to the Pricing Schedule.

NOTE: Tools such as compartment door keys, bellows gauges, and other tools required for daily maintenance and inspection shall not be included in the special tools list and shall be furnished for each bus.

Interchangeability

Unless otherwise agreed, to the maximum extent possible, all units and components procured under this Contract, whether provided by Suppliers or manufactured by the Contractor, shall be duplicates in design, manufacture and installation to ensure interchangeability among buses in each order group or production run in this procurement. This interchangeability shall extend to the individual components, as well as to their locations in the buses. These components shall include, but are not limited to, passenger window hardware, interior trim, lamps, lamp lenses and seat assemblies. Components with non-identical functions shall not be, or appear to be, interchangeable.

Any one component or unit used in the construction of these buses shall be an exact duplicate in design, manufacture and assembly for each bus in each order group in this Contract. Contractor shall identify and secure approval for any changes in components or unit construction provided within a Contract that has a different fit, form or function.

In the event that the Contractor is unable to comply with the interchangeability requirement, the Contractor must notify the Agency and obtain the Agency’s prior written approval, including any changes in pricing.

Regulatory changes may impact Manufacturer’s ability to maintain interchangeability for a production run or order, including options, and are outside the control of the Manufacturer. Manufacturer will inform the customer of any impacts of regulatory changes.

Training

«training\_requirements»

* + 1. **Technical/Service Representatives**

«technical\_service\_representatives\_»

Operating Environment

«operating\_environment»

Noise

The Contractor is expected to meet the interior and exterior noise requirements specified in TS 5.8.1 and TS 5.8.2. Furthermore, it shall be a design goal to minimize noise. Component layout and packaging, material selection and build quality shall reflect that goal.

* + 1. **Interior Noise**

The combination of inner and outer panels and any material used between them shall provide sufficient sound insulation so that a sound source with a level of 80 dBA measured at the outside skin of the bus shall have a sound level of 65 dBA or lower at any point inside the bus, except in proximity to passenger door brush seals. These conditions shall prevail with all openings, including doors and windows, closed and with the propulsion/drive system and accessories switched off.

Maximum internal noise level shall not exceed 75 dBA in the operator’s area near normal operator ear level and 80 dBA in all other areas in the interior of the vehicles under all normal operating conditions at locations inside the bus in adherence with the standards of ISO 5128.

* + 1. **Exterior Noise**

Airborne noise generated by the bus and measured from either side shall not exceed 80 dBA under full-power acceleration when operated at 0 to 35 mph at curb weight. The Contractor shall comply with the exterior noise requirements defined in local laws and ordinances identified by the Agency and SAE J366.

«exterior\_noise»

* + 1. **Fire Safety**

The bus shall be designed and manufactured in accordance with all applicable fire safety and smoke emission regulations.

«fire\_safety»

* + 1. Materials

«materials»

Fire Suppression

«fire\_suppression»

Respect for the Environment

In the design and manufacture of the bus, the Contractor shall make every effort to reduce the amount of potentially hazardous waste. In accordance with Section 6002 of the Resource Conservation and Recovery Act, the Contractor shall use, whenever possible and allowed by the specifications, recycled materials in the manufacture of the bus.

The Contractor shall provide a plan for reuse or recycling of replaced battery cells, modules and/or physical packs.

DIMENSIONS

Physical Size

With exceptions such as exterior mirrors, marker and signal lights, fender skirts, washers, wipers, ad frames, cameras, object detection systems, bicycle racks, feelers, and rubrails, the bus shall have the overall dimensions specified in the following sections, using Figure 1 as a reference, at static conditions and design height.

Bus Length

For ease of use, the following tolerances will be allowable for each given bus length. Bus length is determined as the measurement from bumper to bumper.

* 30 ft bus: less than or equal to 30 ft
* 35 ft bus: 30 ft 1 in. to 39 ft, 11 in.
* 40 ft bus: 40 ft to 44 ft, 11 in.
* 45 ft bus: 45 to 47 ft
* 60 ft (articulated) bus: 59 to 65 ft

Bus Width

Note: Body width measurements are without mirrors.

|  |  |
| --- | --- |
| FIGURE 1  Transit Bus Exterior Dimensions  Diagram  Description automatically generated  Diagram  Description automatically generatedDiagram, engineering drawing  Description automatically generated | |
| cid:_1_081EABAC081EA930005F868D86257AB9 | |
| cid:_1_081EABAC081EA930005F868D86257AB9 | cid:_1_081EABAC081EA930005F868D86257AB9 |

* + 1. Transit Coach

«transit\_coach\_header»

«transit\_coach»

* + 1. Commuter Coach

“Reserved”

Bus Height

**Maximum Height**

«bus\_height»

Underbody Clearance

The bus shall maintain the minimum clearance dimensions as defined and shown in Figure 22 of SAE J1100, regardless of load up to the gross vehicle weight rating.

Ramp Clearances

The approach angle is the angle measured between a line tangent to the front tire static loaded radius arc and the initial point of structural interference forward of the front tire to the ground.

The departure angle is the angle measured between a line tangent to the rear tire static loaded radius arc and the initial point of structural interference rearward of the rear tire to the ground.

The breakover angle (see Table 2) is the angle measured between two lines tangent to the front and rear tire static loaded radius and intersecting at a point on the underside of the vehicle that defines the largest ramp over which the vehicle can roll.

TABLE 2

Breakover Angle – Approach and Departure

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Agency to Select** | | |
| **Angle** | **30 to 45 ft Bus (Default)** | **30 to 45 ft Bus (Alternative)** | **60 ft Bus** |
| Approach | 8.6 deg (min.) | 8.6 deg (min.) | 8.6 deg (min.) |
| Front breakover | 8 deg (min.) | 7.5 deg (min.) | 10.2 deg (min.) |
| Rear breakover (articulated only) | N/A | N/A | 8.7 deg (min.) |
| Departure | 8.6 deg (min.) | 7.5 deg (min.) | 8.6 deg (min.) |

Ground Clearance

Ground clearance shall be no less than 9 in., (8 in. at jacking pad) except within the axle zone and wheel area.

Axle zone clearance, which is the projected area between tires and wheels on the same axial centerline, shall be no less than 5.4 in.

Wheel area clearance shall be no less than 8 in. for parts fixed to the bus body and 6 in. for parts that move vertically with the axles. See Figure 2.

**Figure 2**Transit Bus Minimum Road Clearance

|  |
| --- |
|  |
|  |

Floor Height

* + 1. Transit Coach

Height of the step above the street shall be no more than 16 in. measured at the centerline of the front and rear doorway. All floor measurements shall be with the bus at the design running height and on a level surface and with the specified installed tires.

A maximum of two steps are allowed to accommodate a raised aisle floor in the rear of the bus.

* + 1. Commuter Coach

“Reserved”

Interior Headroom

Headroom above the aisle and at the centerline of the aisle seats shall be no less than 76.75 in. in the forward half of the bus, tapering to no less than 74 in. forward of the rear settee. At the centerline of the window seats, headroom shall be no lower than 65 in., except for parcel racks and reading lights, if specified. Headroom at the back of the rear bench seat may be reduced to a minimum of 56 in., but it shall increase to the ceiling height at the front of the seat cushion. In any area of the bus directly over the head of a seated passenger and positioned where a passenger entering or leaving the seat is prone to strike their head, padding shall be provided on the overhead paneling.

VEHICLE PERFORMANCE

Power Requirements

The system shall be sized to provide sufficient power to enable the bus to meet the defined acceleration, top speed, route, mileage, GVWR and gradeability requirements, while operating all accessories. This shall be verified using actual road test results and/or simulated vehicle performance data.

A loss of power to the bus shall not cause the driver to lose control of the bus or to lose steering or braking. The bus shall be able to be safely brought to a controlled stop.

Top Speed

«top\_speed»

Startability and Gradeability

Startability and gradeability requirements shall be met on grades with a dry commercial asphalt or concrete pavement at GVWR with all accessories operating.

«startability\_and\_gradeability»

Acceleration

The acceleration shall meet the requirements in Table 3, regardless of propulsion type. Acceleration measurement shall commence when the accelerator is depressed. The maximum, instantaneous acceleration rate of the vehicle shall never exceed 0.130g. The rate of change of acceleration (jerk) shall be minimized throughout the acceleration/deceleration range and shall never exceed 0.30 g/s. This requirement shall be achieved regardless of operator action.

«power\_requirements\_acceleration»

TABLE 3

Maximum Start Acceleration Times on a Level Surface1

|  |  |
| --- | --- |
| Speed (mph) | Maximum time (seconds) |
| 10 | 5 |
| 20 | 10 |
| 30 | 18 |
| 40 | 30 |
| 50 | 60 |
| Top speed |  |
| 1. Vehicle weight = GVWR | |

Note: The system shall be programmable to allow optimization of acceleration. Performance may be affected when reprogramming. The manufacturer shall supply the new performance data.

Operating Range

The operating range of the coach shall be designed to meet the operating profile as stated in Section TS 8.

* + 1. Diesel (Transit and Commuter Coach)

“Reserved”

* + 1. CNG

“Reserved”

* + 1. Hybrid

«operating\_range\_hybrid»

Fuel Economy/Range and Design Operating Profile

The bus must be able to achieve operational requirements under standard operating conditions and in Agency-specific conditions. These conditions make up the design operating profile. The standard operating conditions are defined by the Bus Research Testing Center at Altoona, Pennsylvania (“Altoona”), and are used as a benchmark and as a means to compare the performance of various buses across a standard. The Agency-specific conditions are established to ensure that the bus will be able to meet the unique operational requirements of the Agency.

Altoona Fuel Economy Tests

The Altoona Energy Economy and Range Test for buses is an energy consumption and range test for battery electric buses under Altoona’s pass/fail procedures. Buses are tested using the Manhattan cycle (a low average speed, highly transient urban cycle), the Orange County cycle (consists of urban and highway driving segments), and the EPA HD-UDDS cycle test results from the Energy Economy and Range Test or other applicable test procedures. Results shall include vehicle configuration and test environment information. Energy economy data shall be provided for each duty cycle.

Agency Operating Profile: Battery Electric Bus

“Reserved”

POWERPLANT

Engine

Engine (Diesel and CNG)

“Reserved”

Engine (CNG)

“Reserved”

Propulsion System (Hybrid or All Electric)

* + 1. Propulsion System Description (Hybrid)

The bus shall be powered by a hybrid propulsion system. The OEM shall ensure that the bus structure can successfully accept the installation of the propulsion system and be operated on the stated duty cycle for a period of 12 years without a structural failure. At a minimum, the propulsion system shall comply with applicable local, state and/or federal emissions and useful life requirements.

The hybrid drive system shall be rated for the GVWR or greater of the bus.

Labels should be posted on high-voltage devices to identify them as components containing high-voltage potential. These labels shall be applied in such a way that they can be seen when access doors are opened or closed, so as to protect both emergency and maintenance personnel.

A detailed description of the propulsion system shall be provided with the proposal. The description shall include a written narrative, a block diagram showing major propulsion system components, an illustration showing the physical layout of propulsion components and high-voltage wire routing within the vehicle, and a detailed wiring diagram and/or electrical schematic for the high-voltage system. The Proposer is required to provide a list of applicable industry standards that the proposed propulsion system meets.

* + 1. Propulsion System Description (All Electric)

“Reserved”

#### Propulsion System Service

The propulsion system shall be arranged so that accessibility for all routine maintenance is ensured. No special tools, other than dollies and hoists, shall be required to remove the propulsion system or any subsystems. The Agency recognizes that properly rated test equipment and safe electrical work practices are essential when servicing high-voltage components. The Contractor shall identify safe electrical work practices that are essential when servicing high-voltage components. The Contractor shall provide all specialty tools and diagnostic equipment required for maintaining the propulsion system in accordance with the Special Tools List.

#### Energy Storage System

The energy storage system (ESS) shall be of a commercial design capable of operating in the Agency transit environment and design operating profile. The ESS shall use battery technology with a field-proven track record of safe, reliable and durable operation in similar transit applications. The ESS shall be designed, sized and selected to ensure that the vehicle performance specifications, compatibility with charging and other related requirements are met or exceeded, bearing in mind cost/benefit and reliability variables as they relate to the characteristics of the different battery types.

The ESS shall comply with ECE R100 Revision 2, UN/DOT 38.3 and/or SAE J2464 requirements for lithium batteries. For non-lithium batteries, the ESS shall comply with all appropriate applicable standards.

The Contractor shall deliver the bus with an installed, functioning ESS charged with sufficient usable energy for delivery and to be maneuvered around the Agency’s property. The ESS shall be fully formed, installed and tested in accordance with the battery manufacturer’s recommended practices. The ESS design, including containers, module bracing systems, thermal-management systems, battery-management systems, watering/venting systems, interconnections, fusing, and traction-controller and charger interfaces, shall be adequately described in the proposal. The proposal shall include a description of all battery maintenance requirements, including any periodic charge requirements necessary for cell balancing. The proposal shall also include a comprehensive statement of the warranty terms relating to the battery, including explanation of all disclaimers within the warranty. The battery life shall be stated in terms of cyclic life and calendar life in the proposal with a description of all factors that will affect the battery life, including charging, operation and environmental effects. The Agency operating profile shall be considered when making this analysis. A life-cycle cost analysis of the proposed battery system in the specified application shall be provided.

The battery system shall be capable of withstanding the current and voltage profiles necessary to accomplish daily recharge events within the defined operating profile.

Thermal management will be provided as needed to ensure optimal life and performance of the ESS over the environmental operating range. The battery thermal management system shall be adequate to maintain the battery within the battery manufacturer’s recommended temperature range during operation in the specified duty cycle and climatic conditions.

Proposals shall include complete descriptions of all life-cycle testing procedures used to validate the life of batteries used for this application at the proposed charging rates, charge durations, and expected ambient temperatures and operating profiles. Proposers shall include documented results of life-cycle testing. Proposers shall include certification of battery life-cycle testing.

TS 9.3.4.1 Energy Storage System Capacity

The ESS shall have sufficient energy storage to meet the requirements of the intended duty cycle when new and up until the degradation has reached warrantable end of life (WEOL), or other such agreed upon end of life (EOL) capacity, as defined within the warranty terms of this RFP by percent remaining capacity. As an example, if the capacity when new is 300 kWh and the WEOL is at 80%, then the useable capacity range shall be from 300 to 240 kWh.

The Manufacturer shall provide a test procedure and recommended test interval for periodically measuring ESS capacity during the 12-year design life of the bus. The test interval shall not be more than two years. The Manufacturer shall certify that the test procedure provides true and accurate results. Periodic testing will be performed according to the documented procedure. The Agency may engage third parties to perform the bus manufacturer ESS capacity test procedure.

TS 9.3.4.2 Energy Storage System Safety

The ESS shall be placed on the bus to optimize both interior space and vehicle weight distribution. The batteries shall be load-distributed within the bus to equalize weight between the wheels on the same axles and to achieve appropriate weight distribution between axles so as not to adversely affect handling of the bus.

The bus body shall be designed and constructed to ensure that passengers and the operator will not be exposed to hazardous high voltage. This design will also minimize potential exposure to hazardous electrical current in the event of a vehicle accident. Analysis and test data shall be provided to the Agency. The vehicle and energy storage system shall be designed and constructed to prevent gassing or fumes from the energy storage system from entering the interior of the bus, i.e., a vent path to the exterior, preferably at or above the roof, rearward.

Written confirmation from the battery manufacturer attesting to the safety of the proposed battery system in the specified application and charging profile shall be submitted as part of the proposal, and shall include full disclosure and discussion of any and all relevant issues or prior incidents relating to safety.

Proposals shall include complete descriptions of all safety standards followed in the design and manufacture of the battery system, safety testing procedures used to validate the safety of battery operation in this application, and documented results of safety testing to confirm that standards have been met.

All ESS disconnect means shall be compliant with all applicable standards and regulations for HV electric vehicles. The bus manufacturer shall provide documentation listing all standards, recommended practices and other design guidelines the ESS is compliant with.

The HV system and ESS shall include isolation protection between the HV and bus chassis system, to include automatic detection of isolation faults, diagnostic system alerts to the operator, and appropriate action to prevent personnel from HV exposure. Detection, alerting and vehicle control shall occur in accordance with SAE J2910. Detection shall be provided at two levels, as per J2910, and detection at any level shall be alerted to the operator and maintenance personnel.

The system described above may also be an integral part of the overall emergency shutdown system, with functions to include the following:

* Offers a quick, safe and organized means for the operator, maintenance personnel and/or first responders to shut down the HV system.
* Shutting down the system shall include at least:
* “opening” all HV contactors;
* discharging capacitors (if used); and
* disconnecting any devices that could provide HV during normal operation and including during charging.
* Devices used to initiate shutdown shall be located within and outside the bus to satisfy ease of use by the mentioned personnel and shall be clearly marked as to location and use.
* In addition to manual use, this same functionality shall extend to the charging operation in the event of a fault sensed by the ground fault interrupter, to also include termination of charge.

TS 9.3.4.3 Battery Containers

Battery containers shall be constructed to withstand the rigors of transit service for the design life of the bus. Construction shall be of materials compatible with the battery electrolyte. All electrical connections shall be fully shielded and hand-operable. Connector and cabling design shall be such that inappropriate or unsafe connections are prevented. Vent-and-fill system components for individual packs or containers shall not require any disassembly on removal or installation of the battery packs or containers. Pack design must comprehend the protection of battery cabling and vent/watering system components during pack removal and installation. The batteries, when installed, shall be secured to the chassis to prevent any movement that may cause damage or personal harm while the vehicle is in operation.

TS 9.3.4.4 Battery Management System

The battery management system must be designed to ISO 26262, as applicable, safety principles to control state of charge, voltage, current and temperatures on a cell-to-cell level and provide diagnostic output at the lowest field-serviceable element. The diagnostic output must be made available to the maintainer.

As a minimum, the battery management system (BMS) must perform the following functions:

1. The BMS must be capable of monitoring the voltage of cells within each battery pack. The BMS must be able to read individual battery or block voltages at a frequency sufficient to ensure reliable, functional and safe operation.
2. The BMS must be capable of monitoring battery temperatures, mitigating damage to the battery and surroundings, and preventing thermal runaway.
3. The BMS must be capable of communicating when a battery fault (as defined by the battery manufacturer) has occurred and must be able to identify and communicate the location of the faulty battery in order to perform maintenance.
4. The BMS must be capable of engaging prudent safety interlocks when an unsafe battery condition has been detected.
5. The BMS must be able to monitor the battery SoC and provide information to the rest of the vehicle.
6. The BMS must be able to communicate all data to the bus level information system (reference TS 84) for storage and communication.
7. The BMS shall communicate the maximum charge and discharge current that is permitted (e.g., load-shedding).

TS 9.3.4.5 Battery Thermal Management

Thermal management shall be provided to ensure optimal life and performance of the ESS over the environmental operating range.

During operation, battery temperatures must never exceed the manufacturer’s recommended range in the design operating profile and specified ambient conditions. Battery cooling must be sufficient to prevent the temperature from exceeding the battery manufacturer’s recommended maximum temperature.

TS 9.3.4.6 High Voltage Battery Charging

The bus shall support an SAE-approved charging standard (SAE J1772 DC and/or SAE J3068 AC). The Manufacturer shall provide a detailed description of its charging system and specify its compliance with one of the above-listed standards. Proposers shall include a description of the charging infrastructure required to install and operate the charging equipment. All charging systems provided for use with the bus and in conjunction with the battery management system must comply with the battery manufacturer’s electrical and thermal limits.

The bus must be immobilized during all charging operations. Upon successful engagement of the charging interface, the bus shall be interlocked such that propulsion is rendered non-tractive and the brakes applied.

The charging receptacle located on the bus shall be at the «propulsion\_system\_high\_voltage\_battery\_1» and located within a range of height from grade at normal suspension ride height between «propulsion\_system\_high\_voltage\_battery\_2» in.

«propulsion\_system\_high\_voltage\_battery\_c»

* + 1. Propulsion System Controller (PSC)

The PSC regulates energy flow throughout hybrid or electric system components in order to provide motive performance, accessory loads and load-shedding, as applicable, while maintaining critical system parameters (voltages, currents, temperatures, etc.) within specified operating ranges.

The controller shall monitor and process inputs and execute outputs as appropriate to control the operation of all propulsion system components.

Energy storage system SoC correction methods stated in SAE J2711 shall be used (for all-electric or hybrid only.)

«propulsion\_system\_controller\_psc»

* + 1. Engine (Hybrid)

The engine and related emission systems shall meet all applicable emissions and design/durability guidelines and standards.

The Contractor shall provide the Agency with expected durability of the engine and related emission systems.

«engine\_hybrid\_powerplant»

The engine shall be equipped with an electronically controlled management system, compatible with multiplex wiring systems and either 12 or 24 V electrical systems.

The engine shall have onboard diagnostic capabilities, be able to monitor vital functions, store out-of-parameter conditions in memory, and communicate faults and vital conditions to service personnel. Diagnostic reader device connector ports, suitably protected against dirt and moisture, shall be provided in the operator’s area and near or inside the engine compartment. The onboard diagnostic system shall inform the operator via visual and/or audible alarms when out-of-parameter conditions exist for vital engine functions.

The engine starting system shall be protected by an interlock that prevents its engagement when the engine is running. Special equipment or procedures may be employed to start the engine when exposed to temperatures less than 30 °F (−1 °C)for a minimum of four hours without the engine in operation. All cold-weather starting aids, engine heating devices and procedures shall be of the type recommended by the engine manufacturer and approved by the Agency.

«engine\_hybrid\_fastidle»

Charge Air Piping

Charge air piping and fittings shall be designed to minimize air restrictions and leaks. Piping shall be as short as possible, and the number of bends shall be minimized. Bend radii shall be maximized to meet the pressure drop and temperature rise requirements of the engine manufacturer. The cross-section of all charge air piping shall not be less than the cross-section of the intake manifold inlet. Any changes in pipe diameter shall be gradual to ensure a smooth passage of air and to minimize restrictions. Piping shall be routed away from heat sources as practicable and shielded as required to meet the temperature rise requirements of the engine manufacturer.

Charge air piping shall be constructed of stainless steel, aluminized steel, or anodized aluminum rated at minimum 1000 hours of salt spray according to ASTM B117, except between the air filter and turbocharger inlet, where piping may be constructed of flexible, heat-resistant material. Connections between all charge air piping sections shall be sealed with a short section of reinforced hose and secured with stainless steel constant tension clamps that provide a complete 360 deg seal.

Cooling Systems

The capacity of the cooling system shall be adequate to maintain design component temperatures under all operating conditions for the design life of the vehicle in the service area and environment of the Agency. The Contractor shall provide evidence that the cooling system selected has the capability to handle peak heat rejection from the traction motor, energy storage system, propulsion control system, and the intermediate and low-voltage power supply with a partially clogged radiator at maximum ambient temperature plus heat reflected off the pavement. The Contractor shall submit an analysis verifying cooling system capabilities. The entire cooling system shall be equipped with an electronic detection device to indicate overheating on the driver’s control panel.

Operation of required battery thermal management systems shall be automatically controlled under all normally encountered operating and charging conditions and shall be powered by an onboard source at all times during operation. Thermal management shall be continuously monitored during all periods of charge and discharge with appropriate safety interlocks installed to react to adverse conditions.

Air intakes shall be properly positioned and configured to minimize the intake of water, road dust and debris and shall be adequately filtered.

In the event of a failure of the battery thermal management system (BTMS) subsequently resulting in battery temperature outside the allowable limits, the BMS shall limit, in a manner appropriate to the situation, the operation of the bus including charging. A diagnostic indicator shall accompany any BTMS failure.

A complete description of the battery thermal management systems shall accompany the bid package. Written confirmation from the battery manufacturer attesting to the suitability of the battery thermal management system shall be submitted to the Agency concurrent with or prior to delivery of the first bus.

Component Thermal Management

Under the vehicle operating temperature range, the thermal management system shall be designed such that each component will remain in its allowed operating range.

Component temperature sensors may be used for monitoring, control or component/system protection. If equipped and serviceable, component temperature sensors shall be easily accessible. Under typical failure modes or out-of-limit conditions, component temperature sensors shall not disable the bus unless there is an immediate risk of hazardous fault propagation (e.g., temperature levels in the motor area known to start fires). In the event that a component temperature sensor must disable the bus, the component/system must comply with the automatic propulsion system protection/shutdown override feature requirement of TS 9.

Cooling fans shall be of durable, corrosion-resistant construction and designed so a mechanic can gain access. The cooling fan and mounting bracket shall be designed to withstand the thermal fatigue and vibration associated with the installed configuration.

«component\_coolant»

«heat\_exchanger»

* + 1. Radiator Screen

The radiator input shall be protected by an easily cleanable screen designed to collect large debris. The radiator and charge air cooler cores shall be easily cleaned (to include engine side core surface) with standard pressure-washing equipment.

* + 1. Coolant

Coolant shall be compliant with the thermal management system manufacturer’s requirements.

* + 1. Drive Design
* Standard control and drive design: Control and drive of the radiator and charge air cooler fan(s) shall be the Contractor’s standard design.
* Electric fans: The bus shall be equipped with an electric fan drive bus cooling system, including fan reversal (automatic at system start) as well as maintenance switch.
  + 1. Mounting

«mounting\_header»

«mounting»

Charge Air Cooling

«charge\_air\_cooling»

Transmission Cooling

If a transmission is present in the bus, the transmission shall be cooled by a heat exchanger sized to maintain operating fluid within the transmission manufacturer’s recommended parameters of flow, pressure and temperature. Where applicable, the transmission cooling system shall be matched to the retarder and engine cooling systems to ensure that all operating fluids remain within recommended temperature limits established by each component manufacturer. Where applicable, the engine cooling system should provide coolant bypass flow to the transmission cooling system with the engine thermostats closed.

«transmission\_cooling»

Transmission

If multiple-speed transmission is used, the transmission shall be automatic shift with torque converter, retarder and electronic controls. Gross input power, gross input torque and rated input speed shall be compatible with the propulsion system. The transmission shall be designed to operate for not less than 300,000 miles on the design operating profile without replacement or major service. The transmission should be easily removable without disturbing the engine and accessible for service.

The electronic controls shall be capable of transmitting and receiving electronic inputs and data from other drivetrain components and of broadcasting that data to other vehicle systems. Communication between electronic drivetrain components and other vehicle systems shall be made using the communication networks. Electronic controls shall be compatible with either 12 or 24 V power distribution, provide consistent shift quality, and compensate for changing conditions, such as variations in vehicle weight and engine or motor power. At a minimum, drivetrain components consisting of the motor(s), motor inverter(s), engine, transmission, retarder, TCS and anti-lock braking systems shall be powered by a dedicated and isolated ignition supply voltage to ensure that data communication among components exists when the vehicle ignition is switched to the “on” position.

The electronically controlled transmission shall have onboard diagnostic capabilities, be able to monitor functions, store and time-stamp out-of-parameter conditions in memory, and communicate faults and vital conditions to service personnel. The transmission shall contain built-in protection software to guard against severe damage. The onboard diagnostic system shall trigger a visual alarm to the driver when the electronic control unit detects a malfunction.

An electronic transmission fluid level monitoring and protection system shall be provided.

«transmission\_brake\_pedal\_application»

«transmission\_neutral\_function\_»

Hydraulic Retarder (Transit Coach)

The powertrain shall be equipped with a retarder designed to extend brake lining service life. The application of the retarder shall cause a smooth blending of both retarder and service brake function and shall not activate the brake lights.

Actuation of antilock braking system (ABS) and/or automatic traction control (ATC) shall override the operation of the brake retarder.

«brake\_light\_hydraulic\_retarder\_transit\_c»

«retarder\_activation\_transit\_coach»

«retarder\_disable\_switch\_transit\_coach»

Additional Hybrid Acceleration Requirements: Hybrid or Battery Electric

Braking application and performance shall remain consistent across the highest possible range of battery system SoC or other variances related to regenerative braking. At no time should the application and performance of the mechanical friction brakes be affected by these conditions.

Engine Brake (Commuter Coach)

“Reserved”

Additional Hybrid Acceleration Requirements: Hybrid or Battery Electric

“Reserved”

Mounting of Powerplant

All powerplant mounting shall be mechanically isolated to minimize transfer of vibration to the body structure and provide a minimum clearance of 0.75 in. Mounts shall control the movement of the powerplant so as not to affect performance of belt driven accessories or cause strain in piping and wiring connections to the powerplant.

Service

All systems requiring routine maintenance shall be arranged for ease of access and maintenance. The Contractor shall list all special tools, fixtures or facility requirements recommended for servicing. All fillers shall be easily accessible with standard funnels, pour spouts and automatic dispensing equipment.

The propulsion system shall be arranged for ease of access and maintenance. The Contractor shall list all special tools, fixtures or facility requirements recommended for servicing. The muffler, exhaust system, air cleaner, air compressor, starter, alternator, radiator(s), all accessories, and any other component requiring service or replacement shall be easily removable and independent of the engine and transmission removal, or removal of electric traction system components (hybrid and battery electric buses). An engine oil pressure gauge and coolant temperature gauge(s) shall be provided in the engine compartment. These gauges shall be easily read during service and mounted in an area where they shall not be damaged during minor or major repairs.

An air cleaner with a dry filter element and a graduated air filter restriction indicator shall be provided. The location of the air intake system shall be designed to minimize the entry of dust and debris and to maximize the life of the air filter. The engine air duct shall be designed to minimize the entry of water into the air intake system. Drainage provisions shall be included to allow any water/moisture to drain prior to entry into the air filter.

«mounting\_of\_powerplant\_service\_fillers»

«mounting\_of\_powerplant\_service\_filters»

«mounting\_of\_powerplant\_service\_display»

Hydraulic Systems

Hydraulic system service tasks shall be minimized and scheduled no more frequently than those of other major coach systems. All elements of the hydraulic system shall be easily accessible for service or unit replacement. The hydraulic system shall be fitted with service ports so that portable diagnostic equipment may be connected or sensors for an off-board diagnostic system permanently attached to monitor system operation when applicable. A tamperproof priority system shall prevent the loss of power steering during operation of the bus if other devices are also powered by the hydraulic system.

The hydraulic system shall operate within the allowable temperature range as specified by the lubricant manufacturer.

«hydraulic\_systems\_»

Fluid Lines

All lines shall be rigidly supported to prevent chafing damage, fatigue failures, degradation and tension strain. Lines should be sufficiently flexible to minimize mechanical loads on the components. Lines passing through a panel, frame or bulkhead shall be protected by grommets (or similar devices) that fit snugly to both the line and the perimeter of the hole that the line passes through to prevent chafing and wear. Pipes and fluid hoses shall not be bundled with or used to support electrical wire harnesses.

Lines shall be as short as practicable and shall be routed or shielded so that failure of a line shall not allow the contents to spray or drain onto any component operable above the auto-ignition temperature of the fluid.

All hoses, pipes, lines and fittings shall be specified per the vehicle manufacturer’s recommendations. Installation of these fluid lines shall be in accordance with the vehicle manufacturer’s standards. Vehicle manufacturer recommendations and standards must comply with all required USDOT or industry standards.

Fittings and Clamps

All clamps shall maintain a constant tension at all times, expanding and contracting with the line in response to temperature changes and aging of the line material. The lines shall be designed for use in the environment where they are installed (for example, high-temperature resistant in the engine compartment, resistant to road salts near the road surface and so on).

Compression fittings shall be standardized to prevent the intermixing of components. Compression fitting components from more than one manufacturer shall not be mixed, even if the components are known to be interchangeable.

Radiator

If liquid cooling is used, the radiator(s) and/or heat exchanger shall be a heavy-duty metal unit, designed and constructed for transit duty. The Contractor shall demonstrate the reliability and durability of the proposed heat exchanger. The radiator(s) shall be accessible for cleaning. Any radiator shall be easily removable from the bus.

«radiator»

Radiator piping shall be stainless steel, aluminum, brass tubing or painted steel rated at 1000 hours of salt spray according to ASTM B117. Where practicable, hoses shall be eliminated. Necessary hoses shall be impervious to all bus fluids. All hoses shall be secured with stainless steel clamps that provide a complete 360 deg seal. The clamps shall maintain a constant tension at all times, expanding and contracting with the hose in response to temperature changes and aging of the hose material.

Oil and Hydraulic Lines

All systems requiring lubrication shall meet or exceed component manufacturer’s recommendation for installation, operation and maintenance. The fluid transfer lines shall be designed and intended for use in the environment where they are installed (for example, high-temperature resistant in the engine compartment, resistant to road salts near the road surface and so on). No fluid lines shall be below the frame line of the bus.

Fuel

Fuel Lines

Fuel lines shall be securely mounted, braced and supported as designed by the bus manufacturer to minimize vibration and chafing and shall be protected against damage, corrosion or breakage due to strain or wear.

Manifolds connecting fuel containers shall be designed and fabricated to minimize vibration and shall be installed in protected locations to prevent line or manifold damage from unsecured objects or road debris.

Fuel hose and hose connections, where permitted, shall be made from materials resistant to corrosion and fuel and protected from fretting and high heat. Fuel hoses shall be accessible for ease of serviceability.

«fuel\_lines»

* + 1. Fuel Lines, Diesel

“Reserved”

* + 1. Fuel Lines, CNG

“Reserved”

Fuel Tank – Design and Construction

* + 1. Design and Construction, Diesel

Fuel Tank(s)

“Reserved”

* + 1. Design and Construction, CNG

“Reserved”

Emissions and Exhaust

Emissions (All-Electric)

“Reserved”

Exhaust Emissions (All except All-Electric)

The engine and related systems shall meet all applicable emission and engine design guidelines and standards at date of manufacture.

Exhaust System (HFC)

The exhaust pipe shall be of sufficient height to prevent exhaust gases and waste heat from discoloring or causing heat deformation to the bus. The entire exhaust system shall be adequately shielded to prevent heat damage to any bus component, including the exhaust aftertreatment compartment area. The exhaust outlet shall be designed to minimize rain, snow or water generated from high-pressure washing systems from entering into the exhaust pipe.

«emissions\_and\_exhaust\_exhaust\_system\_hfc»

Exhaust Aftertreatment

An exhaust aftertreatment system will be provided to ensure compliance to all applicable EPA regulations in effect at date of manufacture.

* + 1. Diesel Exhaust Fluid (DEF) Injection

If required by the engine manufacturer to meet NOx level requirements specified by the EPA, a DEF injection system will be provided. The DEF system will minimally include a tank, an injector, a pump, an engine control module and a selective catalytic converter. The tanks shall be designed to store DEF in the operating environment described in “Operating Environment.”

«diesel\_exhaust\_fluid\_def\_injection\_fille»

«diesel\_exhaust\_fluid\_def\_injection\_lines»

Particulate Aftertreatment

If required by the engine manufacturer to meet particulate matter (PM) emission limits specified by the EPA, a diesel particulate filter (DPF) will be provided. The DPF system shall be designed to periodically remove accumulated carbonaceous particulate via oxidation (regenerate). Regeneration cycles and conditions will be defined by the engine manufacturer. Vehicle shall be equipped with a manual regeneration inhibit switch for utilization during maintenance operations.

STRUCTURE

General

Design

The structure of the bus shall be designed to withstand the transit service conditions typical of an urban or intercity duty cycle throughout its service life. The vehicle structural frame shall be designed to operate with minimal maintenance throughout the 12-year design operating profile. The design operating profile specified by the Agency shall be considered for this purpose.

FTA Required New Model Bus Testing

Prior to acceptance of the first production bus, the vehicle must have completed the FTA-required New Model Bus Testing. Any items that required repeated repairs or replacement must undergo the corrective action with supporting test and analysis prior to production of series buses. A report clearly describing and explaining the failures and corrective actions taken to ensure that any and all such failures will not occur shall be submitted to the Agency.

Any bus delivered under the Contract is a production bus unless the parties have agreed that it is a pilot bus to be used for preproduction purposes.

«fta\_required\_new\_model\_bus\_testing\_»

Structural Validation

«fta\_required\_new\_model\_bus\_testing\_struc»

Distortion

The bus, loaded to GVWR and under static conditions, shall not exhibit deflection or deformation that impairs the operation of the steering mechanism, doors, windows, passenger escape mechanisms or service doors. Static conditions shall include the vehicle at rest with any one wheel or dual set of wheels on a 6 in. curb or in a 6 in. deep hole.

Resonance and Vibration

All structure, body and panel-bending mode frequencies, including vertical, lateral and torsional modes, shall be sufficiently removed from all primary excitation frequencies to minimize audible, visible or sensible resonant vibrations during normal service.

Propulsion Compartment Bulkheads

The passenger and propulsion system compartments shall be separated by a fire-resistant bulkhead. This bulkhead shall preclude or retard propagation of exhaust gasses and/or a propulsion compartment fire into the passenger compartment. The bulkhead shall be in accordance with the Recommended Fire Safety Practices defined in FMVSS 302. Only necessary openings shall be allowed in the bulkhead, and these shall be fire-resistant. Any passageways for the climate control system air shall be separated from the propulsion compartment by fire-resistant material. Piping through the bulkhead shall have fire-resistant fittings sealed at the bulkhead. Wiring may pass through the bulkhead only if connectors or other means are provided to prevent or retard fire propagation through the bulkhead. Propulsion access panels in the bulkhead shall be fabricated of fire-resistant material and secured with fire-resistant fasteners. These panels, their fasteners and the bulkhead shall be constructed and reinforced to minimize warping of the panels during a fire that will compromise the integrity of the bulkhead.

«propulsion\_compartment\_bulkhead»

Crashworthiness (Transit Coach)

The bus body and roof structure shall withstand a static load equal to 150% of the curb weight evenly distributed on the roof with no more than a 6 in. reduction in any interior dimension. Windows shall remain in place and shall not open under such a load. These requirements must be met without the roof-mounted equipment installed.

The bus shall withstand a 25 mph impact by a 4000 lb automobile at any side, excluding doorways, along either side of the bus and the articulated joint, if applicable, with no more than 3 in. of permanent structural deformation at seated passenger hip height. This impact shall not result in sharp edges or protrusions in the bus interior.

Exterior surfaces below 35 in. from ground level shall withstand a static load of 2000 lb applied perpendicular to the bus by a pad no larger than 5 in.2. This load shall not result in deformation that prohibits restoration of original appearance of the bus.

«crashworthiness\_transit\_coach»

Corrosion

The bus flooring, sides, roof, understructure and axle suspension components shall be designed to resist corrosion, including deterioration from environmental conditions and deicing materials for a period of 12 years or 500,000 miles, whichever comes first. It shall maintain structural integrity and nearly maintain original appearance throughout its service life, with the Agency’s use of proper cleaning and neutralizing agents.

All materials that are not inherently corrosion-resistant shall be protected with corrosion-resistant coatings. All joints and connections of dissimilar metals shall be corrosion-resistant and shall be protected from galvanic corrosion. Representative samples of all materials and connections shall withstand a two-week (336-hour) salt spray test in accordance with ASTM Procedure B-117. Samples tested shall meet Criterion 10 of ASTM D610 and, if painted, have no perceptible blistering in accordance with ASTM D714.

«corrosion\_header»

«corrosion»

Towing

Each towing device shall withstand, without permanent deformation, tension loads up to 1.2 times the curb weight of the bus within 20 deg of the longitudinal axis of the bus. If applicable, the rear towing device(s) shall not provide a toehold for unauthorized riders. The method of attaching the towing device shall not require the removal or disconnection of front suspension or steering components. Removal of the bike rack is permitted for attachment of towing devices. The OEM shall provide a towing procedure that ensures that the traction motor does not generate high voltage during towing.

«towing\_lifted\_»

Two rear recovery towing provision locations shall permit lifting and towing of the bus for a short distance, such as in cases of an emergency, to allow access to provisions for front towing of the bus. The method of attaching the tow bar or adapter shall require the specific approval of the Agency. Any tow bar or adapter exceeding 60 lb should have means to maneuver or allow for ease of use and application. Each towing provision location shall accommodate a towing adaptor or a crane hook with a 1 in. throat.

«towing\_connector»

«towing\_provision»

Jacking

It shall be possible to safely jack up the bus, at curb weight, with a common 10-ton floor jack with or without special adapter, when a tire or dual set is completely flat and the bus is on a level, hard surface, without crawling under any portion of the bus. Jacking from a single point shall permit raising the bus sufficiently high to remove and reinstall any wheel and tire assembly. Jacking pads located on the axle or suspension near the wheels shall permit easy and safe jacking with the flat tire or dual set on a 6 in. high run-up block not wider than a single tire. The bus shall withstand such jacking at any one or any combination of wheel locations without permanent deformation or damage.

«jacking»

Hoisting

The bus axles or jacking plates shall accommodate the lifting pads of a two-post hoist system. Jacking plates, if used as hoisting pads, shall be designed to prevent the bus from falling off the hoist. Other pads or the bus structure shall support the bus on jack stands independent of the hoist.

The vehicle shall be capable of lifting by the wheels and, as necessary to meet tire load requirements, the proper number for wheel lifts and/or adapters must be used.

Floor

Design (Transit Coach)

The floor shall be essentially a continuous plane, except at the wheel housings and platforms. Where the floor meets the walls of the bus, as well as other vertical surfaces such as platform risers, the surface edges shall be blended with a circular section of radius not less than ¼ in. or installed in a fully sealed butt joint. Similarly, a molding or cover shall prevent debris accumulation between the floor and wheel housings. The vehicle floor in the area of the entrance and exit doors shall have a lateral slope not exceeding 2 deg to allow for drainage.

«floor\_design\_transit\_coach\_header»

«floor\_design\_transit\_coach»

Design (Commuter Coach)

“Reserved”

Design (Articulated Transit Coach)

“Reserved”

Strength

The floor deck may be integral with the basic structure or mounted on the structure securely to prevent chafing or horizontal movement and designed to last the life of the bus. Sheet metal screws shall not be used to retain the floor, and all floor fasteners shall be serviceable from one side only. Any adhesives, bolts or screws used to secure the floor to the structure shall last and remain effective throughout the life of the coach. Tapping plates, if used for the floor fasteners, shall be no less than the same thickness as a standard nut, and all floor fasteners shall be secured and protected from corrosion for the service life of the bus.

The floor deck shall be reinforced as needed to support passenger loads. At GVWR, the floor shall have an elastic deflection of no more than 0.60 in. from the normal plane. The floor shall withstand the application of 2.5 times gross load weight without permanent detrimental deformation. The floor, with coverings applied, shall withstand a static load of at least 150 lb applied through the flat end of a ½ in. diameter rod, with 1∕32 in. radius, without permanent visible deformation.

Construction

The floor shall consist of the subfloor and the floor covering that will last the life of the bus. The floor as assembled, including the sealer, attachments and covering, shall be waterproof, non-hygroscopic and resistant to mold growth. The subfloor shall be resistant to the effects of moisture, including decay (dry rot). It shall be impervious to wood-destroying insects such as termites.

«floor\_construction\_»

Construction (Commuter Coach)

“Reserved”

Platforms

Driver’s Area

The covering of platform surfaces and risers, except where otherwise indicated, shall be the same material as specified for floor covering. Trim shall be provided along the top edges of platforms unless integral nosing is provided.

«platforms\_drivers\_area»

Driver’s Platform

The driver’s platform shall be of a height such that, in a seated position, the driver can see an object located at an elevation of 42 in. above the road surface, 24 in. from the leading edge of the bumper or bike rack. Notwithstanding this requirement, the platform height shall not position the driver such that the driver’s vertical upward view is less than 15 deg.

«platforms\_drivers\_platform\_»

Figure 3 illustrates a means by which the platform height can be determined, using the critical line of sight.

|  |
| --- |
| FIGURE 3  Determining Platform Height |
|  |

Farebox

Farebox placement should minimize impact to passenger access and minimize interference with the driver’s line of sight. The floor under the farebox shall provide a sturdy mounting platform to prevent shaking of the farebox. Farebox installation shall not interfere with the driver’s protection barrier or door.

«platforms\_farebox»

Wheel Housing

Design and Construction

Sufficient clearance and air circulation shall be provided around the tires, wheels and brakes to preclude overheating of wheel end components when the bus is operating on the design operating profile. Wheel housings shall be constructed of corrosion-resistant and fire-resistant material.

Wheel housings, as installed and trimmed, shall withstand impacts of a 2 in. steel ball with at least 200 ft-lb of energy without penetration.

Design and Construction (Transit Coach)

Interference between the tires and any portion of the bus shall not be possible in maneuvers up to the limit of tire adhesion with weights from curb weight to GVWR. Wheel housings shall be adequately reinforced where seat pedestals are installed. Wheel housings shall have sufficient sound insulation to minimize tire and road noise and meet all noise requirements of this specification.

Design and construction of front wheel housings shall allow for the installation of a radio or electronic equipment storage compartment on the interior top surface.

The finish of the front wheel housings shall be scratch-resistant and complement interior finishes of the bus to minimize the visual impact of the wheel housing.

The lower portion extending above the floor shall be equipped with scuff-resistant coating or stainless steel trim.

Wheel housings not equipped with seats or equipment enclosure shall have a horizontal assist mounted on the top portion of the housing no more than 4 in. higher than the wheel well housing.

Where wheel housings are equipped with seats or equipment enclosures, all fasteners passing through to the outside of the coach shall be fully sealed to prevent the intrusion of water into the coach.

«wheel\_housing\_design\_and\_construction\_tr»

Articulated Joint (Articulated Transit Coach)

“Reserved”

Raceway (Articulated Transit Coach)

“Reserved”

Bellows

Replacement fabric-type bellows with draft-free, no-sag bottom closure and water drains shall be provided between the lead and trailing sections to seal the bus interior and keep it free of water, dirt and drafts. Bellows hardware shall be corrosion-resistant, and the underfloor area of the bellows shall be easy to clean when necessary. The passageway between the lead unit and trailing unit shall have an inside cross-section that is as nearly equal as possible to the inside cross-section of the bus bodies, with no tripping or pinching hazards created by the turntable cross-section or closeouts. The bellows shall be durable, and its supporting structure and stiffeners shall support the bellows material in a neat, sag-free manner. The Contractor shall supply information on the actual service life achieved by the type of bellows being proposed. A sample of the bellows and attaching hardware may be requested for evaluation at the Agency’s option. Bellows shall be approved by the Agency.

«wheel\_housing\_bellows»

CHASSIS

Suspension

General Requirements

The front, rear and mid (if articulated) suspensions shall be pneumatic type. The basic suspension structure shall last the service life of the bus without major overhaul or replacement, with the exception of hoses, shock absorbers, air bellows and other items defined within the “Warranty Requirements” section. Adjustment points shall be minimized and shall not be subject to a loss of adjustment in service. Routine adjustments shall be easily accomplished by limiting the removal or disconnecting the components.

Alignment

All axles should be properly aligned for even tire wear and for the vehicle to track accurately within the size and geometry of the vehicle.

Springs and Shock Absorbers

* + 1. Suspension Travel

The suspension system shall permit a minimum wheel travel of 2.75 in. jounce-upward travel of a wheel when the bus hits a bump (higher than street surface), and 2.75 in. rebound-downward travel when the bus comes off a bump and the wheels fall relative to the body. Elastomeric bumpers shall be provided at the limit of jounce travel. Rebound travel may be limited by elastomeric bumpers or hydraulically within the shock absorbers. Suspensions shall incorporate appropriate devices for automatic height control so that regardless of load the bus height relative to the centerline of the wheels does not change more than ½ in. at any point from the height required. The safe operation of a bus cannot be impacted by ride height up to 1 in. from design normal ride height.

* + 1. Damping

Vertical damping of the suspension system shall be accomplished by hydraulic shock absorbers mounted to the suspension arms or axles and attached to an appropriate location on the chassis. Damping shall be sufficient to control coach motion to three cycles or fewer after hitting road perturbations. The shock absorber bushing shall be made of elastomeric material that will last the life of the shock absorber. The damper shall incorporate a secondary hydraulic rebound stop.

* + 1. Lubrication

«suspension\_springs\_and\_shock\_absorbers\_l»

* + 1. Kneeling

«suspension\_springs\_and\_shock\_absorbers\_k»

Wheels and Tires

Wheels

All wheels shall be interchangeable and shall be removable without a puller. Middle axle of articulated buses may utilize a super single if alternative is selected. Wheels shall be compatible with tires in size and load-carrying capacity. Front wheels and tires shall be balanced as an assembly.

«wheels\_and\_tires\_wheels»

«wheels\_and\_tires\_wheels\_monitoring\_syste»

«wheels\_and\_tires\_wheels\_lug\_nut»

Tires

Tires shall be suitable for the conditions of transit service and sustained operation at the maximum speed capability of the bus. Load on any tire at GVWR shall not exceed the tire supplier’s rating.

«wheels\_and\_tires\_tires»

Steering

«steering»

Steering Axle (Transit Coach)

«steering\_axle\_transit\_coach\_header»

«steering\_axle\_transit\_coach»

All friction points on the front axle shall be equipped with replaceable bushings or inserts and, if needed, lubrication fittings easily accessible from a pit or hoist.

Ackermann design shall reduce tire wear, minimize turn radius and optimize driver control during all operating conditions.

Steering and Tag Axles (Commuter Coach)

“Reserved”

Steering Wheel

* + 1. Turning Effort

Steering effort shall be measured with the bus at GVWR, stopped with the brakes released and propulsion system engaged and, as appropriate, in idle on clean, dry, level, commercial asphalt pavement and the tires inflated to recommended pressure.

Under these conditions, the torque required to turn the steering wheel 10 deg shall be no less than 5 ft-lb and no more than 10 ft-lb. Steering torque may increase to 70 ft-lb when the wheels are approaching the steering stops, as the relief valve activates.

Power steering failure shall not result in loss of steering control. With the bus in operation, the steering effort shall not exceed 55 lb at the steering wheel rim, and perceived free play in the steering system shall not materially increase as a result of power assist failure. Gearing shall require no more than seven turns of the steering wheel lock-to-lock.

Caster angle shall be selected to provide a tendency for the return of the front wheels to the straight-ahead position with minimal assistance from the driver.

* + 1. Steering Wheel, General

The steering wheel diameter shall be approximately 18 to 20 in.; the rim diameter shall be ⅞ to 1¼ in. and shaped for firm grip with comfort for long periods of time.

Steering wheel spokes and wheel thickness shall ensure visibility of the dashboard so that instrumentation is clearly visible at center neutral position (within the range of a 95th-percentile male, as described in SAE 1050a, Sections 4.2.2 and 4.2.3). Placement of steering column must be as far forward as possible, but either in line with or behind the instrument cluster.

* + 1. Steering Column Tilt

The steering column shall have full tilt capability with an adjustment range of no less than 40 deg from the vertical and easily adjustable by the driver and shall be accessible by a 5th-percentile female and 95th-percentile male. Driver’s knees shall not contact wheel spokes at any adjustment or driving position.

«steering\_column\_tilt»

* + 1. Steering Wheel Telescopic Adjustment

The steering wheel shall have full telescoping capability and have a minimum telescopic range of 1.75 in. and a minimum low-end adjustment of 29 in., measured from the top of the steering wheel rim in the horizontal position to the cab floor at the heel point. See Table 4.

|  |  |  |  |
| --- | --- | --- | --- |
| TABLE 4  Steering Wheel Height1 Relative to Angle of Slope | | | |
| **At Minimum Telescopic Height Adjustment (29 in.)** | | **At Maximum Telescopic Height Adjustment (5 in.)** | |
| **Angle of Slope** | **Height** | **Angle of Slope** | **Height** |
| 0 deg | 29 in. | 0 deg | 34 in. |
| 15 deg | 26.2 in. | 15 deg | 31.2 in. |
| 25 deg | 24.6 in. | 25 deg | 29.6 in. |
| 35 deg | 22.5 in. | 35 deg | 27.5 in. |
| 1. Measured from bottom portion closest to driver. | | | |

Drive Axle

The bus shall be driven by one or more heavy-duty axles with a load rating sufficient for the bus loaded to GVWR. The drive axle shall have a design life to operate for not less than 300,000 miles on the design operating profile without major repairs. The lubricant drain plug shall be magnetic type. If a planetary gear design is employed, then the oil level in the planetary gears shall be easily checked through the plug. The axle and driveshaft components shall be rated for both propulsion and retardation modes with respect to duty cycle. If a planetary gear design is employed, then the planetary gear drain plugs shall also be magnetic. Proper venting shall be provided, and it shall be sufficiently well constructed so as to not plug, kink or become otherwise degraded.

NOTE: The retardation duty cycle can be more aggressive than propulsion.

The drive shaft shall be guarded to prevent hitting any critical systems, including brake lines, coach floor or the ground, in the event of a tube or universal joint failure.

Tag Axles (Commuter Coach)

“Reserved”

Turning Radius

|  |  |  |
| --- | --- | --- |
| TABLE 5  Maximum Turning Radius | | |
| Bus Length (approximate) | **Maximum Turning Radius (see** Figure 4**)** | Agency Requirement |
| 30 ft | 34 ft (TR0) |  |
| 35 ft | 39 ft (TR0) |  |
| 40 ft | 44 ft (TR0) |  |
| 45 ft | 49 ft (TR0) |  |
| 60 ft | 44.5 ft (outside front axle, TR0)  17 ft (inside rearmost axle, TR4) |  |

|  |
| --- |
| FIGURE 4  Turning Radius |
| http://www.transitpool.com/UserFiles/Image/SBPG_40ft_LFCNG/image043.gif |

Brakes

Service Brake

«brakes\_service\_brake»

* + 1. Regenerative Braking (Electric or Hybrid)

In addition to traditional mechanical friction service braking, the bus shall be equipped with regenerative braking designed to improve energy efficiency and extend brake lining service life. The application of regenerative braking shall cause a smooth blending of both regenerative and service brake function. Actuation of ABS and/or automatic traction control (ATC) shall override the operation of the regenerative brake. The ESS system should be designed to prevent overcharge during regenerative braking.

Actuation

«brakes\_actuation\_brakes»

«brakes\_actuation\_automatic\_traction\_cont»

Friction Material

The brake linings shall be made of non-asbestos material. In order to aid maintenance personnel in determining extent of wear, a provision such as a scribe line or a chamfer indicating the thickness at which replacement becomes necessary shall be provided on each brake lining. The complete brake lining wear indicator shall be clearly visible from the hoist or pit without removing backing plates.

«brakes\_friction\_material»

Hubs and Drums/Discs)

Replaceable wheel bearing seals shall run on replaceable wear surfaces or be of an integral wear surface sealed design. Wheel bearing and hub seals and unitized hub assemblies shall not leak or weep lubricant when operating on the design operating profile for the duration of the initial manufacturer’s warranty.

«brakes\_hubs\_and\_drums\_discs\_header»

«brakes\_hubs\_and\_drums\_discs»

The brake system material and design shall be selected to absorb and dissipate heat quickly so that the heat generated during braking operation does not glaze the brake linings.

Parking/Emergency Brake

«brakes\_parking\_emergency\_brake\_header»

«brakes\_parking\_emergency\_brake»

Pneumatic System

General

The bus air system shall operate the air-powered accessories and the braking system with reserve capacity. New buses shall not leak down more than 5 psi over a 15-minute period of time as indicated on the dash gauge(s).

Provision shall be made to apply shop air to the bus air systems. A quick disconnect fitting shall be easily accessible and located in the powertrain compartment and near the front bumper area for towing. Retained caps shall be installed to protect fitting against dirt and moisture when not in use. Air for the compressor shall be filtered. The air system shall be protected per FMVSS 121.

Air Compressor

The air compressor shall be sized to charge the air system from 40 psi to the governor cutoff pressure in less than 4 minutes while not exceeding the fast idle speed setting of the engine, if equipped.

Air Lines and Fittings

Air lines, except necessary flexible lines, shall conform to the installation and material requirements of SAE J1149 for copper tubing with standard, brass, flared or ball sleeve fittings, or SAE J844 for nylon tubing if not subject to temperatures over 200 °F. The air on the delivery side of the compressor where it enters nylon housing shall not be above the maximum limits as stated in SAE J844. Nylon tubing shall be installed in accordance with the following color-coding standards:

«pneumatic\_system\_air\_lines\_and\_fittings»

Line supports shall prevent movement, flexing, tension, strain and vibration. Copper lines shall be supported to prevent the lines from touching one another or any component of the bus. To the extent practicable and before installation, the lines shall be pre-bent on a fixture that prevents tube flattening or excessive local strain. Copper lines shall be bent only once at any point, including pre-bending and installation. Rigid lines shall be supported at no more than 5 ft intervals. Nylon lines may be grouped and shall be supported at 30 in. intervals or less.

The compressor discharge line between body-mounted equipment shall be flexible convoluted copper or stainless steel line, or may be flexible Teflon hose with a braided stainless steel jacket. Other lines necessary to maintain system reliability shall be flexible Teflon hose with a braided stainless steel jacket. End fittings shall be standard SAE or JIC brass or steel, flanged fittings. Flexible hoses shall be as short as practicable and individually supported. They shall not touch one another or any part of the bus except for the supporting grommets. Flexible lines shall be supported at 2 ft intervals or less.

Air lines shall be clean before installation and shall be installed to minimize air leaks. All air lines shall be routed to prevent water traps to the extent possible. Grommets or insulated clamps shall protect the air lines at all points where they pass through understructure components.

Air Reservoirs

All air reservoirs shall meet the requirements of FMVSS 121 and SAE J10 and shall be equipped with drain plugs and guarded or flush-type drain valves. Major structural members shall protect these valves and any automatic moisture ejector valves from road hazards. Reservoirs shall be sloped toward the drain valve. All air reservoirs shall have drain valves that discharge below floor level with lines routed to eliminate the possibility of water traps and/or freezing in the drain line.

Air System Dryer

An air dryer shall prevent accumulation of moisture and oil in the air system. An air dryer in the new condition shall provide a minimum dew point depression from ambient of 25 °F at ambient temperatures below 100 °F and operating at nominal full system pressure. This assumes the air temperature at the inlet of the air dryer is within 15 °F of ambient. The dew point depression from ambient shall be no less than 20 °F under those conditions at any time before recommended overhaul provided that the air dryer is serviced properly. The air dryer shall be able to provide these levels of dew point depression with the compressor running continuously. The air dryer system shall include one or more replaceable desiccant cartridges.

«pneumatic\_system\_air\_system\_dryer»

Electrical, Electronic and Data Communication Systems

Overview

The electrical system will consist of vehicle battery systems and components that generate, distribute and store power throughout the vehicle (e.g., generator, voltage regulator, wiring, relays and connectors).

Electronic devices are individual systems and components that process and store data, integrate electronic information or perform other specific functions.

The data communication system consists of the bidirectional communication networks that electronic devices use to share data with other electronic devices and systems. Communication networks are essential to integrating electronic functions, both onboard the vehicle and off.

Information level systems that require vehicle information for their operations or provide information shall adhere to J1939 data standard.

Data communication systems are divided into three levels for the use of multiple data networks (see Figure 5 and Figure 6):

* Powertrain level
* Information level
* Multiplex level

|  |
| --- |
| FIGURE 5  Data Communication Systems Levels – Diesel Powertrain |
| Diagram  Description automatically generated |

FIGURE 6

Data Communication Systems Levels – Battery Electric Powertrain

A screenshot of a computer

Description automatically generated with low confidence

The signal name lists below show the minimum performance data signals that each system is required to make available to the ITS vehicle logic unit controller for a traditional diesel bus. The lists represent commonly monitored signals by the vehicle monitoring system. These lists are not to be referred to or be construed as being the only data points required from components at any time, but the minimum data set required in addition to every other data element described within this document. All data, including faults, performance points, and subsystem controller firmware versions, are to be externalized by any onboard computer or component shall be provided to the ITS vehicle logic unit specified. All data must be configured in a nonproprietary format compliant with an industry standard protocol.

Vehicle Signal Names

1 Vehicle Speed (mph)

2 Engine Speed (RPM)

3 Brake Pedal Position (applied or not applied)

4 Engine Load (%)

5 Throttle Position (%)

6 Odometer Pulse – square wave (must be delivered as a discrete voltage signal to vehicle logic unit)

7 Front Door Open – discrete

8 Rear Door Open – discrete (if there is a center door, this signal should be combined with the rear door)

9 Wheeled Mobility Device Deployed – discrete

10 Stop Request – discrete (include wheeled mobility device stop request)

11 Reverse – discrete (active high)

Engine Signal Names

1 All Diagnostic Fault Codes

2 Software Identification

3 Boost Pressure

4 Electrical Potential (Voltage)

5 Engine Average Fuel Economy

6 Engine Coolant Level

7 Engine Coolant Temperature

8 Engine Crankcase Pressure

9 Engine Fuel Rate – High Resolution

10 Engine Idle Shutdown has Shutdown Engine

11 Engine Intake Manifold 1 Temperature

12 Engine Oil Level

13 Engine Oil Pressure

14 Engine Protection System Has Shutdown Engine

15 Engine Shutdown Override Switch

16 Exhaust Gas Temp 1 = DPF Inlet Gas Temp

17 Exhaust Gas Temp 3 = DPF Outlet Gas Temp

18 Particulate Trap Active Regeneration Inhibited Due to Inhibit Switch

19 Particulate Trap Active Regeneration Status

20 Total Vehicle Distance

21 Wheel-Based Vehicle Speed

22 Vehicle Identification Number

23 Particulate Trap Outlet Gas Temperature

24 Unit Number (Power Unit)

25 Trip Distance – High Resolution

26 Maximum Vehicle Speed Limit

27 Intake Manifold Pressure

28 Engine Turbocharger Boost Pressure

29 Engine Trip Fuel – High Resolution

30 Engine Total Idle Hours

31 Engine Total Idle Fuel Used

32 Engine Total Hours of Operation

33 Engine Total Fuel Used – High Resolution signal

34 Engine Speed

35 Component Identification (Engine Serial Number)

36 Engine Exhaust Temperature

37 Catalyst Tank Temperature

38 Catalyst Tank Level

39 Engine Air Inlet Pressure

40 Number of Emergency Stops

41 Software Identification (Calibration Version)

42 Road Speed PGN65265 SPN84 at a consistent 100 ms broadcast rate

43 Calibration Information (DM19)

44 Engine Total Hours of Operation

45 Engine Air Inlet Temperature

46 Engine Serial Number

Transmission Signal Names

1 All Diagnostic Fault Codes

2 Software Identification

3 Battery Potential (Voltage)

4 Hydraulic Retarder Oil Temperature

5 Transmission Input Shaft Speed

6 Transmission Output Shaft Speed

7 Transmission Oil Temperature

8 Transmission Oil Level High/Low

9 Transmission Oil Life Remaining

10 Transmission Shift Position

Multiplex System Broadcast via J1939 CAN Network Signal Names

1 Exhaust Regen Off

2 IVN Regen Enable

3 IVN Status

4 Reverse

5 Network Failure – Individual Modules

6 Engine Fuel Filter Clogged

7 Engine Air Filter Clogged

8 ABS Indicator

9 Alternator Charge Indicator

10 Coolant Level (as a percentage 0% to 100%

11 Low Air Pressure

12 Check Engine

13 Stop Engine

14 Kneeling Active

15 Throttle Malfunction

16 A/C Failure

17 Wheeled Mobility Device Ramp Deployed – J1939

18 Wheeled Mobility Device Stop Request

19 Passenger Stop Request (does not include Wheeled Mobility Device Stop Request) – J1939

20 Fire Suppression System Active

21 Fire Shutdown Engine

22 Software Identification (if applicable)

23 Parking Brake Engaged

24 Air Compressor Status (Duty Cycle)

25 Wheeled Mobility Device – rate of deployment or system health (for example, amp draw of motor)

26 Charging System Monitor – Low Charge Indicator

27 Front Door Open Signal – J1939

28 Rear Door Open Signal – J1939

29 Wheeled Mobility Device Cycle Counts

30 Bus Battery Voltage

31 Seat Belt Status (if applicable)

32 Seat Alarm (pressure switch status) – if applicable

33 All Available Diagnostic Fault Codes

34 Air Pressure API (Each Tank Reporting Individually)

ABS System Signal Names

1 All Diagnostic Fault Codes

2 Road Speed

3 ABS Active

4 Software Identification

5 Wheel Speed PGN65215 SPN904 at a consistent 100 ms broadcast rate

Door Systems Signal Names

1 Diagnostic Fault Codes

2 Software Identifications

3 Front Door Open

4 Front Door Close

5 Rear Door #1 Open (bus with two or three doors only)

6 Rear Door #1 Close (bus with two or three doors only)

7 Rear Door #2 Open (bus with three doors only)

8 Rear Door #2 Close (bus with three doors only)

Climate Control System Signal Names

1 All Diagnostic Fault Codes

2 Software Identification

3 Ambient Air Temperature

4 Discharge Air Temperature

5 Discharge Air #2 Temperature (if applicable on artic bus)

6 Return Air Temperature

7 Return Air All Zones Temperature (only apply to artic bus)

8 Water Inlet Temperature

9 Discharge Pressure

10 Suction Pressure

11 Operating Mode

12 Performance Data

13 Configuration File

14 Compressor Clutch Cycles

15 Compressor Hours

Artic Joint System Signal Names (Applies to Articulated Bus Only)

1 All Diagnostic Fault Codes

2 Software Identification

Vehicle Logic Unit Signal Names

1 All Diagnostic Fault Codes

2 Software Identification

Electric Vehicle Data Elements Signal Names

1 All Diagnostic Fault Codes

2 Software Identification

The lists above are applicable to an electric vehicle drive system, while the following list the *minimum* performance data signals that each system is required to make available to the ITS vehicle logic unit controller for a battery electric bus. The lists below represent commonly monitored signals by the vehicle monitoring system. These lists are not to be referred to or be construed as being the only data points required from components at any time, but the minimum data set required in addition to every other data element described within this document. All data, including faults, performance points and subsystem controller firmware versions, are to be externalized by any onboard computer or component and shall be provided to the ITS vehicle logic unit specified. All data must be configured in nonproprietary format compliant with an industry standard protocol.

Powertrain System (Traction Motor/Propulsion Control/ESS) Signal Names

1 Odometer

2 Trip Odometer

3 Vehicle Speed

4 ESS Operational SoC

5 ESS Current

6 ESS Voltage

7 ESS Charging Activity

8 Minimum and Maximum ESS Cell Temperature

9 Minimum and Maximum ESS Cell SoC

10 Minimum and Maximum ESS Cell Voltage

11 ESS Power Discharged

12 Master Run Switch Status

13 Accelerator Pedal Position

14 Brake Pedal Position

15 Parking or Emergency Brake Application

16 J1939 Health and Diagnostic Messages

17 Propulsion and Ancillary Systems Health and Diagnostic Messages

18 Visual/Audible Indications/Alarms

19 Traction Motor Power Input

20 Traction Motor Torque Percentage

21 Traction Motor RPM

22 Propulsion Inverter Power Input

23 Low Propulsion System Coolant Level

24 Regenerative Braking Power Recovered

25 Miles to 0% of Usable SoC

26 SoC per Unit of Distance

27 SoC per Unit of Elapsed Time

28 SoC per X Completed Stops

29 SoC Below X% When Returning to the Garage

30 Idle Time (foot brake applied)

31 Idle Time (parking brake applied)

Charging System Signal Names

1 Charging system power input

2 Charging system performance

3 Garage charger power Input

4 Opportunity charger power input

5 Time to complete a full charge

Electric Vehicle Pneumatic System Signal Names

1 Primary Pneumatic System Pressure

2 Secondary Pneumatic System Pressure

3 Auxiliary Pneumatic System Pressure (if applicable).

4 Air Compressor Inverter Power Input

Electric Vehicle HVAC System Signal Names

1 HVAC Power Input

2 HVAC Status On/Off

3 HVAC Supply Air Temperature

4 HVAC Return Air Temperature

5 HVAC Wattage Consumption

6 HVAC Cabin Temperature Setpoint

7 Outside Air Temperature

8 Front Door Position

9 Exit Door Position

10 Diesel Fuel Fired Heater Fuel Consumption

11 Diesel Fuel Fired Heater Fuel Level

12 Low HVAC Systems Coolant Level

13 Primary HVAC Heat Source Fuel Supply Below X% When Returning to the Garage

Electric Vehicle Auxiliary Systems Signal Names

1 Wheeled Mobility Device Ramp Position

2 Hydraulic Pump Inverter Power Input

3 DC to DC Converter Power Input

Design

The electrical, electronic and data communication systems shall be easily separable from their interconnects by means of connectors.

Environmental and Mounting Requirements

All electrical/electronic hardware mounted in the interior of the vehicle shall be resistant to tampering from passengers.

All electrical/electronic hardware mounted on the exterior of the vehicle that is not designed to be installed in an exposed environment shall be mounted in a protective enclosure. The hardware shall be mounted in such a manner as to protect it from the environment.

The electrical system and its electronic components shall be capable of operating in the area of the vehicle in which they will be installed and comply with the shock and vibration requirements as recommended in SAE J1455, to the extent practical.

Electrical and electronic equipment shall not be located in an environment that will reduce the performance or shorten the life of the component or electrical system when operating within the design operating profile.

The Agency shall follow recommendations from bus manufacturers and subsystem suppliers regarding methods to prevent damage from voltage spikes generated from welding, jump-starts, shorts, etc.

All electrical/electronic hardware and its mounting shall comply with the shock and vibration requirements of published industry standards (SAE, ISO, etc.).

General Electrical Requirements

Low-Voltage (Starting, Lighting and Ignition) Batteries

The batteries shall be selected with sufficient cold-cranking amps (CCA) and have enough reserve capacity (RC) based on the small accessory electrical loads when the bus is parked/shut down. In order to maintain the SoC of the 24 VDC batteries during long periods when a bus is parked, a low SoC disconnect system is required. If the SoC drops below a preset value (e.g., 70% SoC), the system will pulse a bistable relay that opens the circuits of the small accessories, thereby isolating the 24 VDC batteries. When the bus driver turns the main switch to “ON,” the relay is pulsed again, reconnecting the 24 VDC batteries to the vehicle loads.

* + 1. Low-Voltage Batteries (24 V)

«general\_electrical\_requirements\_low\_vol1»

«general\_electrical\_requirements\_low\_volt»

* + 1. Low-Voltage Battery Cables

The battery terminal ends and cable ends shall be color-coded with red for the primary positive, black for negative and another color for any intermediate voltage cables. Positive and negative battery cables shall not cross each other if at all possible, shall be flexible, shall be sufficiently long to reach the batteries with the tray in the extended position without stretching or pulling on any connection, and shall not lie directly on top of the batteries. Except as interrupted by the master battery switch, battery and starter wiring, where applicable, shall be continuous cables with connections secured by bolted terminals and shall conform to specification requirements of SAE J1127–Type SGR, SGT, SGX or GXL, and SAE J541 as applicable.

«general\_electrical\_requirements\_low\_vol2»

* + 1. Jump-Start Connector

«general\_electrical\_requirements\_jump\_sta»

* + 1. Battery Compartment

The battery compartment shall prevent accumulation of snow, ice and debris on top of the batteries and shall be vented and self-draining. It shall be accessible only from the outside of the vehicle. All components within the battery compartment, and the compartment itself, shall be protected from damage or corrosion from the electrolyte. The inside surface of the battery compartment’s access door shall be electrically insulated, as required, to prevent the battery terminals from shorting on the door if the door is damaged in an accident or if a battery comes loose. The battery compartment temperature should not exceed battery manufacturer’s specification.

The vehicle shall be equipped with one or more 12 VDC and 24 VDC quick disconnect switches. The battery compartment door shall conveniently accommodate operation of 12 VDC and 24 VDC quick disconnect switch(es). A lockout/tagout means shall be provided to safeguard maintenance from the unexpected startup or power-on high voltage.

The battery quick disconnect access door shall be identified with a decal. The decal size shall not be less than 3.5 × 5 in. (8.89 × 12.7 cm).

The door shall be flush-fitting and incorporate a spring tensioner or equal to retain the door in a closed position when not in use.

«general\_electrical\_requirements\_battery1»

«general\_electrical\_requirements\_battery\_»

The batteries shall be securely mounted on a stainless steel or equivalent tray that can accommodate the size and weight of the batteries. The battery tray, if applicable, shall pull out or swing out easily and properly support the batteries while they are being serviced. The tray shall allow each battery cell to be easily serviced. A locking device shall retain the battery tray to the stowed position.

If not located in the engine compartment, the same fire-resistant properties must apply to the battery compartment. No sparking devices should be located within the battery box.

* + 1. Auxiliary Electronic Power Supply

If required, gel-pack or any form of sealed (non-venting) batteries used for auxiliary power are allowed to be mounted on the interior of the vehicle if they are contained in an enclosed, non-airtight compartment and accessible only to maintenance personnel. This compartment shall contain a warning label prohibiting the use of vented (flooded) lead-acid batteries.

* + 1. Master Battery Switch

The location of the master battery switch shall be clearly identified on the exterior access panel, be accessible in less than 10 seconds for deactivation, and prevent corrosion from fumes and battery acid when the batteries are washed off or are in normal service.

The master switch shall be capable of carrying and interrupting the total circuit load.

«general\_electrical\_requirements\_master\_1»

«general\_electrical\_requirements\_master\_b»

* + 1. Low-Voltage Generation and Distribution

The low-voltage generating system shall maintain the charge on fully charged batteries within battery supplier’s specifications.

Voltage monitoring and overvoltage output protection (recommended at 32 V) shall be provided. Charging profile shall be maintained within battery manufacturer’s guidelines or specifications.

Dedicated power and ground shall be provided as specified by the component or system manufacturer. Cabling to the equipment must be sized to supply the current requirements with no greater than a 5% volt drop across the length of the cable.

* + 1. Low-Voltage Circuit Protection

All branch circuits, except battery-to-starting-motor and battery-to-generator/alternator circuits, shall be protected by current-limiting devices such as circuit breakers, fuses or solid-state devices sized to the requirements of the circuit. The circuit breaker fuses shall be easily accessible for authorized personnel. Fuses shall be used only where it can be demonstrated that circuit breakers are not practicable. This requirement applies to inline fuses supplied by either the Contractor or a Supplier. Fuse holders shall be constructed to be rugged and shall be rated at appropriate IP rating for location of fuse holder based on manufacturer’s recommendations. All manual reset circuit breakers critical to the operation of the bus shall be mounted in a location convenient to the Agency mechanic with visible indication of open circuits. The Contractor shall show all in-line fuses in the final harness drawings.

«general\_electrical\_requirements\_low\_vol2»

Circuit breakers or fuses shall be sized to a minimum of 15% larger than the total circuit load. The current rating for the wire used for each circuit must exceed the size of the circuit protection being used.

Grounds

The battery shall be grounded to the vehicle chassis/frame at one location only, as close to the batteries as possible. When using a chassis ground system, the chassis shall be grounded to the frame in multiple locations, evenly distributed throughout the vehicle to eliminate ground loops. No more than three ring terminal connections shall be made per ground stud with adequate spacing between studs, ensuring conductivity and serviceability. Electronic equipment requiring an isolated ground of the battery (i.e., electronic ground) shall not be grounded through the chassis.

Low-Voltage and High-Voltage Wiring and Terminals

All power and ground wiring shall conform to specification requirements of SAE J1127, J1128 and J1292, except for the color code of J1292. All high-voltage power and ground wiring shall conform to specification requirements of SAE J1654 and J2910. In the case of conflicts with the requirements below, SAE standards shall apply. Double insulations shall be maintained as close to the junction box, electrical compartment or terminals as possible. The requirement for double insulations shall be met by wrapping the harness with plastic electrical tape or by sheathing all wires and harnesses with nonconductive, rigid or flexible conduit.

The bus shall be manufactured so that high-voltage systems and cabling do not interfere with the operation of low-voltage control systems. To this end, high-voltage cabling and low-voltage control wiring must be separated as far as practicable. Cabling and wiring must be installed damage-free. Additionally, parallel runs of high-voltage cabling and low-voltage control wiring shall be minimized.

Wiring shall be grouped, numbered and/or color-coded. Wiring harnesses shall not contain wires of different voltage classes unless all wires within the harness are insulated for the highest voltage present in the harness. Kinking, grounding at multiple points, stretching and exceeding minimum bend radius shall be prevented.

Strain-relief fittings shall be provided at all points where wiring enters electrical compartments. Grommets or other protective material shall be installed at points where wiring penetrates metal structures outside of electrical enclosures. Wiring supports shall be protective and nonconductive at areas of wire contact and shall not be damaged by heat, water, solvents or chafing.

To the extent practicable, wiring shall not be located in environmentally exposed locations under the vehicle or near high heat sources. Wiring and electrical equipment necessarily located under the vehicle shall be insulated from water, heat, corrosion and mechanical damage. Where feasible, front-to-rear electrical harnesses should be installed above the window line of the vehicle.

All wiring harnesses over 5 ft long and containing at least five wires shall include 10% (minimum one wire) excess wires for spares. This requirement for spare wires does not apply to data links and communication cables. Wiring harness length shall allow end terminals to be replaced twice without pulling, stretching or replacing the wire. Terminals shall be crimped to the wiring according to the connector manufacturer’s recommendations for techniques and tools. All cable connectors shall be locking type, keyed and sealed, unless enclosed in watertight cabinets or the vehicle interior. Pins shall be removable, crimp contact type, of the correct size and rating for the wire being terminated. Unused pin positions shall be sealed with sealing plugs. Adjacent connectors shall use either different inserts or different insert orientations to prevent incorrect connections.

Terminals shall be crimped, corrosion-resistant and full ring type or interlocking lugs with insulating ferrules. When using pressure-type screw terminal strips, only stranded wire shall be used. Insulation clearance shall ensure that wires have a minimum of “visible clearance” and a maximum of two times the conductor diameter or 1∕16 in., whichever is less. When using shielded or coaxial cable, upon stripping of the insulation, the metallic braid shall be free from frayed strands that can penetrate the insulation of the inner wires.

Ultrasonic and T-splices may be used with 8 AWG or smaller wire. When a T-splice is used, it shall meet these additional requirements:

* It shall include a mechanical clamp in addition to solder on the splice.
* The wire shall support no mechanical load in the area of the splice.
* The wire shall be supported to prevent flexing.
* All splices shall be identified by placards or permanent labels in their appropriate location within the harness.

All splicing shall be staggered in the harness so that no two splices are positioned in the same location within the harness.

The instrument panel and wiring shall be easily accessible for service from the driver’s seat or top of the panel. The instrument panel shall be separately removable and replaceable without damaging the instrument panel or gauges. Wiring shall have sufficient length and be routed to permit service without stretching or chafing the wires.

Electrical Components

All electrical components, including switches, relays, flashers and circuit breakers, shall be heavy-duty designs with either a successful history of application in heavy-duty vehicles or design specifications for an equivalent environment.

All electric motors shall be heavy-duty brushless type where practical and have a continuous duty rating of no fewer than 40,000 hours (except cranking motors, washer pumps and wiper motors). All electric motors shall be easily accessible for servicing.

Electrical Compartments

All relays, controllers, flashers, circuit breakers and other electrical components shall be mounted in easily accessible electrical compartments. All compartments exposed to the outside environment shall be corrosion-resistant and sealed according to SAE J1455. The components and their functions in each electrical compartment shall be identified and their location permanently recorded on a drawing attached to the inside of the access panel or door. The drawing shall be protected from oil, grease, fuel and abrasion.

The front compartment shall be completely serviceable from the driver’s seat, the vestibule or the outside. For vehicles with an internal combustion engine, “Rear start and run” controls shall be mounted in an accessible location in the engine compartment and shall be protected from the environment.

Terminals

«general\_electrical\_requirements\_termina1»

«general\_electrical\_requirements\_terminal»

General Electronic Requirements

If an electronic component has an internal real-time clock, it shall provide its own battery backup to monitor time when battery power is disconnected, and/or it may be updated by a network component. If an electronic component has an hour meter, it shall record accumulated service time without relying on battery backup.

All electronic component suppliers shall ensure that their equipment is self-protecting in the event of shorts in the cabling, and also in overvoltage (over 32 VDC on a 24 VDC nominal voltage rating with a maximum of 60 VDC) and reverse polarity conditions. If an electronic component is required to interface with other components, it shall not require external pull-up and/or pull-down resistors. Where this is not possible, the use of a pull-up or pull-down resistor shall be limited as much as possible and be easily accessible and labeled.

Wiring and Terminals

Kinking, grounding at multiple points, stretching and reducing the bend radius below the manufacturer’s recommended minimum shall not be permitted according to SAE J1127. Proper work instructions, including for regular internal audits and calibration of tools, shall be provided.

* + 1. Discrete I/O (Inputs/Outputs)

All wiring to I/O devices, either at the harness level or individual wires, shall be labeled or color-coded in a fashion that allows unique identification at a spacing not exceeding 4 in. Wiring for each I/O device shall be bundled together. If the I/O terminals are the same voltages, then jumpers may be used to connect the common nodes of each I/O terminal.

* + 1. Shielding

All wiring that requires shielding shall meet the following minimum requirements. A shield shall be generated by connecting to a ground, which is sourced from a power distribution bus bar or chassis. A shield shall be connected at one location only, typically at one end of the cable. However, certain standards or special requirements, such as SAE J1939 or radio frequency applications, have separate shielding techniques that also shall be used as applicable.

NOTE: A shield grounded at both ends forms a ground loop, which can cause intermittent loss of control or faults.

When using shielded or coaxial cable, upon stripping of the insulation, the metallic braid shall be free from frayed strands, which can penetrate the insulation of the inner wires. To prevent the introduction of noise, the shield shall not be connected to the common side of a logic circuit.

* + 1. Communication

The data network cabling shall be selected and installed according to the selected protocol requirements. The physical layer of all network communication systems shall not be used for any purpose other than communication among the system components, unless provided for in the network specifications.

Communication networks that use power line carriers (e.g., data modulated on a 24 V power line) shall meet the most stringent applicable wiring and terminal specifications.

* + 1. Radio Frequency (RF)

RF components, such as radios, video devices, cameras, GPS, etc., shall use coaxial cable to carry the signal where applicable. All RF systems require special design consideration for losses along the cable. Connectors shall be minimized, since each connector and crimp has a loss that will contribute to attenuation of the signal. Cabling should allow for the removal of antennas or attached electronics without removing the installed cable between them. If this cannot be done, then a conduit of sufficient size shall be provided for ease of attachment of the antenna and cable assembly. The corresponding component vendors shall be consulted for proper application of equipment, including installation of cables.

* + 1. Audio

Cabling used for microphone level and line level signals shall meet EMC requirements per SAE J1113/1.

Multiplexing

General

Versatility and future expansion shall be provided for by expandable system architecture. The multiplex system shall be capable of accepting new inputs and outputs through the addition of new modules and/or the utilization of existing spare inputs and outputs. All like components in the multiplex system shall be modular and interchangeable with self-diagnostic capabilities. The modules shall be easily accessible for troubleshooting electrical failures and performing system maintenance. Multiplex input/output modules shall use solid-state devices to provide extended service life and individual circuit protection.

«multiplexing\_general»

System Configuration

Multiplexing may either be distributed or centralized. A distributed system shall process information on multiple control modules within the network. A centralized system shall process the information on a single control module. Either system shall consist of several modules connected to form a control network.

* + 1. I/O Signals

The input/output for the multiplex system may contain four types of electrical signals: discrete, modulating, analogue and serial data.

Discrete signals shall reflect the on/off status of switches, levers, limit switches, lights, etc. Analog signals shall reflect numerical data as represented by a voltage signal (0 to 12 V, 10 to 24 V, etc.) or current signal (4 to 20 mA). Both types of analog signals shall represent the status of variable devices such as rheostats, potentiometers, temperature probes, etc. Serial data signals shall reflect ASCII or alphanumeric data used in the communication between other onboard components.

Data Communication

General

All data communication networks shall be either in accordance with a nationally recognized interface standard, such as those published by SAE, IEEE or ISO, or shall be published to the Agency with the following minimum information:

* Protocol requirements for all timing issues (bit, byte, packet, inter-packet timing, idle line timing, etc.) packet sizes, error checking and transport (bulk transfer of data to/from the device).
* Data definition requirements that ensure access to diagnostic information and performance characteristics.
* The capability and procedures for uploading new application or configuration data.
* Access to revision level of data, application software and firmware.
* The capability and procedures for uploading new firmware or application software.
* Evidence that applicable data shall be broadcast to the network in an efficient manner such that the overall network integrity is not compromised.
* Data communication initialization and after run time for components after the MRS is turned on or off—what the standard is and how the OEM defines it.

Any electronic vehicle components used on a network shall be conformance tested to the corresponding network standard.

Drivetrain Level

Drivetrain components, consisting of the motor(s), motor inverter(s), engine, transmission, retarder, antilock braking system and all other related components, shall be integrated and communicate fully with respect to vehicle operation with data using SAE Recommended Communications Protocols such as J1939 and/or J1708/J1587, with forward and backward compatibilities or other open protocols. At a minimum, drivetrain components shall be powered by a dedicated and isolated ignition supply voltage to ensure that data communication among components exists when the vehicle ignition is switched to the “on” position.

* + 1. Diagnostics, Fault Detection and Data Access

Drivetrain performance, maintenance and diagnostic data, and other electronic messages shall be formatted and transmitted on the communication networks.

The drivetrain level shall have the ability to record abnormal events in memory and provide diagnostic codes and other information to service personnel. At a minimum, this network level shall provide live/fail status, current hardware serial number, software/data revisions and uninterrupted timing functions.

* + 1. Programmability (Software)

The drivetrain-level components shall be programmable by the Agency with limitations as specified by the subsystem Supplier.

Multiplex Level

* + 1. Data Access

At a minimum, information shall be made available via a communication port on the multiplex system. The location of the communication port shall be easily accessible. A hardware gateway and/or wireless communication system are options if requested by the Agency. The communication port(s) shall be located as specified by the Agency.

* + 1. Diagnostics and Fault Detection

The multiplex system shall have a proven method of determining its status (system health and input/output status) and detecting either active (online) or inactive (offline) faults through the use of onboard visual/audible indicators.

In addition to the indicators, the system shall employ an advanced diagnostic and fault detection system, which shall be accessible via either a personal computer or a handheld unit. Either unit shall have the ability to check logic function.

«data\_communication\_multiplex\_level\_diagn»

* + 1. Programmability (Software)

The multiplex system shall have security provisions to protect its software from unwanted changes. This shall be achieved through any or all of the following procedures:

* password protection
* limited distribution of the configuration software
* limited access to the programming tools required to change the software
* hardware protection that prevents undesired changes to the software

Provisions for programming the multiplex system shall be possible through a PC, laptop or portable device. The multiplex system shall have proper revision control to ensure that the hardware and software are identical on each vehicle equipped with the system. Revision control shall be provided by all of the following:

* hardware component identification where labels are included on all multiplex hardware to identify components
* hardware series identification where all multiplex hardware displays the current hardware serial number and firmware revision employed by the module
* software revision identification where all copies of the software in service display the most recent revision number
* a method of determining which version of the software is currently in use in the multiplex system

«data\_communication\_multiplex\_level\_progr»

Electromagnetic Compatibility (EMC)

Electrical and electronic subsystems and components on all buses shall not emit electromagnetic radiation that will interfere with onboard systems, components or equipment, telephone service, radio or TV reception, or violate regulations of the Federal Communications Commission.

Electrical and electronic subsystems on the coaches shall not be affected by external sources of RFI/EMI. This includes, but is not limited to, radio and TV transmission, portable electronic devices including computers in the vicinity of or onboard the buses, AC or DC power lines, and RFI/EMI emissions from other vehicles.

As a recommendation, no vehicle component shall generate or be affected by RFI/EMI that can disturb the performance of electrical/electronic equipment as defined in CAN/CSA-CISPR 12-10, SAE J1113, SAE J1455 or UNECE Council Directive 95/54 (R10).

DRIVER PROVISIONS, CONTROLS AND INSTRUMENTATION

Driver’s Area Controls

General

In general, when designing the driver’s area, it is recommended that SAE J833, “Human Physical Dimensions,” be used.

Switches and controls shall be divided into basic groups and assigned to specific areas, in conformance with customer requirements and Manufacturer input. Switches and controls shall be essentially within the hand reach envelope of a 95th-percentile male and 5th-percentile female.

Glare

The driver’s work area shall be designed to minimize glare to the extent possible. The driver’s work area includes all forward areas that reflect lighted objects to show reflection in windshield, as well as side window and door glass. Objects within and adjacent to this area shall be matte black or dark gray in color wherever possible to reduce the reflection of light onto the windshield. The use of polished metal and light-colored surfaces within and adjacent to the driver’s area shall be avoided. Such objects include dash panels, switches and controls, cowlings, windshield wipers and arms, barriers and modesty panels, fare stanchions, access panels and doors, fasteners, flooring, ventilation and heating ducting, window and door frames, and visors. Interior lighting located ahead of the standee line shall be controllable by the driver. Manufacturers shall make every effort to reduce glare and shall provide a plan response for how they mitigate glare on reflective materials to be reviewed by the Agency.

Visors/Sun Shades

Front and Side Sun Shade/Visor

Full-width adjustable sun visors shall be provided for the driver’s windshield and the driver’s-side window. Visors shall be shaped to minimize light leakage between the visor and windshield pillars. Visors shall store out of the way and shall not obstruct airflow from the climate control system or interfere with other equipment, such as the radio handset or the destination control. Deployment of the visors shall not restrict vision of the rearview mirrors. Visor adjustments shall be made easily by the operator. Sun visor construction and materials shall be strong enough to resist breakage during adjustments. Visors shall be opaque, and when deployed, shall be adjustable downward to plain at the elevation of a 5th-percentile female seated eye height.

Driver’s Controls

Frequently used controls must be in easily accessible locations. These include the door control, kneel control, windshield wiper/washer controls, ramp, and lift and run switch. Any switches and controls necessary for the safe operation while underway shall be conveniently located and shall be tactilely identifiable or illuminated. for ease of night time operation to the extent possible.

All panel-mounted switches and controls shall be easily identifiable. Graphic symbols shall conform to SAE J2402, “Road Vehicles–Symbols for Controls, Indicators, and Tell Tales,” where available and applicable. Color of switches and controls shall be dark with contrasting typography or symbols.

Mechanical switches and controls shall be replaceable, and the wiring at these controls shall be serviceable from a convenient location. Switches, controls and instruments shall be dust- and water-resistant.

Normal Bus Operation Instrumentation and Controls

Table 6 identifies common controls and indicators used to operate the bus. This table is for reference only and is not meant to be inclusive. Controls shall be placed as conveniently as possible based on frequency of use and operator ergonomic considerations.

Systems or components monitored by onboard diagnostics system shall be displayed in clear view of the operator and provide visual and/or audible indicators. The intensity of indicators shall permit easy determination of on/off status in bright sunlight but shall not cause a distraction or visibility problem at night. All indicators shall be illuminated using backlighting.

The indicator panel shall be located in Area 1 or Area 5, within easy view of the operator instrument panel. All indicators shall have a method of momentarily testing their operation. The audible alarm shall be tamper-resistant and shall have an outlet level between 80 and 83 dBA when measured at the location of the operator’s ear.

Onboard displays visible to the operator shall be limited to indicating the status of those functions described herein that are necessary for the operation of the bus. All other indicators needed for diagnostics and their related interface hardware shall be concealed and protected from unauthorized access.

All switches and controls shown in Table 6 shall be placed based on frequency of use and ergonomic considerations.

| TABLE 6 (Transit Coach)  Transit Bus Instruments and Alarms | | |
| --- | --- | --- |
| **Device** | **Function** | **Visual/Audible** |
| Master run switch | Master control for bus, off, day run, night run and clearance ID lights |  |
| System start, front | Activates vehicle systems |  |
| System start, rear | Activates vehicle systems |  |
| System run, rear | Permits activating vehicle system from rear start, normal front run position and off | Amber light |
| Drive selector | Provides selection of propulsion: forward, reverse and neutral | Gear selection |
| HVAC | Permits selection of passenger ventilation: off, cool, heat, low fan, high fan, or full auto with on/off only |  |
| Driver’s ventilation | Permits supplemental ventilation: fan off, low or high |  |
| Defroster fan | Permits defroster: fan off, low, medium or high |  |
| Defroster temperature | Adjusts defroster water flow and temperature |  |
| Windshield wiper | Variable speed control of left and right windshield wipers |  |
| Windshield washer | Activates windshield washers |  |
| Dash panel lights | Provides adjustment for light intensity in night run position |  |
| Interior lights | Selects mode of passenger compartment lighting |  |
| WC ramp/kneel enable | Permits operation of ramp and kneel operations at each door remote panel | Amber light |
| Front door ramp/kneel enable | Permits ramp and kneel activation from front door area, key required1 | Amber light |
| Front door ramp | Permits deploy and stow of front ramp | Red light |
| Front kneel | Permits kneeling activation and raise and normal at front door remote location | Amber or red dash indicator exterior alarm and amber light |
| Rear door ramp/kneel enable | Permits ramp and kneel activation from rear door area; key required1 | Red light |
| Rear door ramp | Permits deploy and stow of rear ramp |  |
| Rear kneel | Permits kneeling activation and raise and normal at rear door remote location |  |
| Silent alarm | Activates emergency radio alarm at dispatch and permits covert microphone and/or enables destination sign emergency message |  |
| Video system event switch | Triggers event equipment and event light on dash | Amber light |
| Left remote mirror | Permits two-axis adjustment of left exterior mirror |  |
| Right remote mirror | Permits two-axis adjustment of right exterior mirror |  |
| Mirror heater | Permits heating of outside mirrors when required |  |
| Passenger door control | Permits open/close control of front and rear passenger doors | Red light |
| Rear door override | Allows driver to override activation of rear door |  |
| System shutdown override | Permits driver to override auto system shutdown |  |
| Hazard flashers | Activates emergency flashers | Two green lights |
| Fire suppression | Permits driver to override and manually discharge fire suppression system | Red light |
| Mobile data terminal | Facilitates driver interaction with communication system and master log-on | LCD display with visual status and text messages |
| Farebox interface | Facilitates driver interaction with farebox system | LCD display |
| Destination sign interface | Facilitates driver interaction with destination sign system, manual entry | LCD display |
| Turn signals | Activates left and right turn signals | Two green lights and optional audible indicator |
| PA manual | Permits driver to manually activate public address microphone |  |
| Low-profile microphone | Permits driver to make announcements with both hands on the wheel and focusing on road conditions |  |
| High beam | Permits driver to toggle between low and high beam | Blue light |
| Parking brake | Permits driver to apply and release parking brake | Red light |
| Hill holder | Applies brakes to prevent bus from rolling |  |
| Master door/interlock | Permits driver override to disable door and brake/throttle interlock | Red light |
| Warning interlocks deactivated | Illuminates to warn driver that interlocks have been deactivated | Red light |
| Retarder disable | Permits driver override to disable brake retardation/regeneration | Red light |
| Rear door passenger sensor disable | Permits driver to override rear door passenger sensing system |  |
| Indicator/alarm test button | Permits driver to activate test of sentry, indicators and audible alarms | All visuals and audibles |
| Auxiliary power | Property to specify what function to supply |  |
| Speedometer | Visual indication of speed and distance traveled, accumulated vehicle mileage, fault condition display | Visual |
| Air pressure gauge | Visual indication of primary and secondary air systems | Visual |
| Fire detection | Indication of fire detection activation by zone/location | Buzzer and red light |
| Door obstruction | Indication of rear door sensitive edge activation | Red light and buzzer |
| Door ajar | Indication of rear door not properly closed | Buzzer or alarm and red light |
| Low system air pressure | Indication of low air system pressure | Buzzer and red light |
| System coolant indicator | Detects low coolant condition | Amber light |
| Hot system indicator | Detects system overheat condition and initiates time delay shutdown | Red light |
| ABS indicator | Displays system failure | Amber light |
| HVAC indicator | Displays system failure | Amber or red light |
| LV charging system indicator (12/24 V) | Detects no-charge condition and optionally detects battery high, low, imbalance, no-charge condition, and initiates time-delayed shutdown | Red light flashing or solid based on condition |
| Bike rack deployed indicator | Indicates bike rack not being in fully stowed position | Amber or red light |
| HV charging system indicator (ESS) | Indicates when bus is connected to off-board charger and ESS is accepting charge | Visual |
| State of charge indicator | Indicates usable SoC of ESS | Visual |
| Low fuel indicator | Indicates low fuel level | Visual |
| Low DEF indicator | Indicates low DEF level | Visual |
| Turntable (articulated buses only) | Warning indication for hinge locking | Audible and amber warning and red light if locked |
| Turntable (articulated buses only) | Momentarily release interlock brakes due to overangled condition |  |
| 1. Indicate area by drawing. Break up switch control from indicator lights. | | |

Driver Foot Controls

Accelerator and brake pedals shall be designed for ankle motion. Foot surfaces of the pedals shall be faced with wear-resistant, nonskid, replaceable material.

* + 1. Pedal Angle

The vertical angle of the accelerator and brake pedals shall be determined from a horizontal plane regardless of the slope of the cab floor. The accelerator and brake pedals shall be positioned at an angle of 37 to 50 deg at the point of initiation of contact and extend downward to an angle of 10 to 27 deg at full throttle.

The location of the brake and accelerator pedals shall be determined by the manufacturer, based on space needs, visibility, lower edge of windshield and vertical H-point.

* + 1. Pedal Dimensions and Position

The floor-mounted accelerator pedal shall be 9 to 12 in. long and 3 to 4 in. wide. Clearance around the pedal must allow for no interference precluding operation.

The accelerator and brake pedals shall be positioned such that the spacing between them, measured at the heel of the pedals, is between 1 and 2 in. Both pedals should be located approximately on the same plane coincident to the surface of the pedals.

Brake and Accelerator Pedals

«drivers\_area\_controls\_brake\_and\_acceler1»

«drivers\_area\_controls\_brake\_and\_acceler»

Driver Foot Switches

Floor-Mounted Foot Control Platform

The angle of the turn signal platform shall be determined from a horizontal plane, regardless of the slope of the cab floor. The turn signal platform shall be angled at a minimum of 10 deg and a maximum of 37 deg. It shall be located no closer to the seat front than the heel point of the accelerator pedal.

«drivers\_area\_controls\_driver\_foot\_switc»

«drivers\_area\_controls\_driver\_foot\_switc1»

Driver’s Amenities

Coat Hanger

«drivers\_amenities\_driver\_coat\_hanger\_he»

«drivers\_amenities\_driver\_coat\_hanger\_»

Drink Holder

«drivers\_amenities\_drink\_holder»

Storage Box

«drivers\_amenities\_storage\_box»

Windshield Wipers and Washers

Windshield Wipers

The bus shall be equipped with a windshield wiper for each half of the windshield and shall comply with FMVSS 104. For two-piece windshields, both wipers shall park along the center edges of the windshield glass. For single-piece windshields, wipers shall park along the bottom edge of the windshield. Windshield wiper motors and mechanisms shall be easily accessible for repairs or service. The fasteners that secure any of the wiper system serviceable components shall be corrosion-resistant.

«windshield\_wipers»

Windshield Washers

The windshield washer system, when used with the wipers, shall deposit washing fluid evenly and completely wet the entire wiped area.

The windshield washer system shall have a minimum 3 gal reservoir, located for easy refilling from outside the bus. Reservoir pumps, lines and fittings shall be corrosion-resistant and must include a means to determine fluid level.

Driver’s Seat

|  |
| --- |
| FIGURE 7  Driver’s Seat |
| Seat base  Headrest  Seat back  Seat back lumbar support  Seat belt  Seat base  Head rest  Seat back  Seat back lumbar support  Seat belt  Seat base  Head rest  Seat back  Seat back lumbar support  Seat belt  Seat base  Head rest  Seat back  Seat back lumbar support  Seat belt  Seat base  Seat cushion pan  Head rest  Seat back  Seat back lumbar support  Seat belt  Seat base  Head rest  Seat back  Seat back lumbar support  Seat belt  Seat base  Head rest  Seat back  Seat back lumbar support  Seat belt  Armrest |

Dimensions

The driver’s seat shall be comfortable and adjustable so that people ranging in size from a 95th-percentile male to a 5th-percentile female may operate the bus, based on Hybrid III ADT MIL-STD-1472E.

* + 1. Seat Cushion Pan Length

Measurement shall be from the front edge of the seat pan to the rear at its intersection with the seat back. The adjustment of the seat pan length shall be no less than 16.5 in. at its minimum length and no more than 20.5 in. at its maximum length.

«dimensions\_seat\_cushion\_pan\_length»

* + 1. Seat Height Adjustment

«dimensions\_seat\_height\_adjustment\_header»

«dimensions\_seat\_height\_adjustment»

* + 1. Seat Pan Cushion Slope

The cushion should have an upward angle of at least 12 deg and cannot have a downward angle less than −5 deg.

* + 1. Seat Base Fore/Aft Adjustment

Seat shall have minimum of 9 in. of fore/aft travel. Seat shall be conformed and installed to accommodate people ranging in size from a 95th-percentile male to a 5th-percentile female to allow easy access to the operator’s station. Seat shall be supplied with seat locking tracks with positive latching.

«dimensions\_seat\_base\_fore\_aft\_adjustment»

* + 1. Seat Pan Cushion Width

Measurement is the horizontal distance across the seat cushion. The seat pan cushion shall be 17 to 21 in. across at the front edge of the seat cushion and 20 to 23 in. across at the side bolsters.

* + 1. Seat Suspension

The driver’s seat shall be appropriately dampened to support a minimum weight of 380 lb. The suspension shall be capable of dampening in both directions in the Z axis.

Rubber bumpers shall be provided to prevent metal-to-metal contact.

«dimensions\_seat\_suspension\_»

* + 1. Seat Back

Width

Measurement is the distance between the outermost points of the front of the seat back, at or near its midpoint in height. The seat back width shall be no less than 19 in. Seat back will include dual recliner gears on both sides of the seat.

Height

Standard height seat back.

* + 1. Headrests

«dimensions\_headrests»

* + 1. Seat Back Lumbar Support

Measurement is from the bottom of the seat back at its intersection with the seat pan to the top of the lumbar cushioning. The seat back shall provide adjustable-depth lumbar back support with three individual operating lumbar cells or functional equivalent to fit people ranging from the 5th percentile female to 95th percentile male.

* + 1. Seat Back Angle Adjustment

The seat back angle shall be measured relative to a level seat pan, where 90 deg is the upright position and 90 deg-plus represents the amount of recline.

The seat back shall adjust in angle from a minimum of no more than 90 deg (upright) to at least 105 deg (reclined), with infinite adjustment in between.

Seat Belt

All seat belts should be stored in automatic retractors. The belts shall be mounted to the seat frame so that the driver may adjust the seat without resetting the seat belt.

The seat and seatbelt assemblies as installed in the bus shall withstand static horizontal forces as required in FMVSS sections 207, 208 (section 4.4.2.2), 209 and 210.

«drivers\_seat\_seat\_belt\_type»

«drivers\_seat\_seat\_belt\_webbing»

«drivers\_seat\_seat\_belt\_length»

Adjustable Armrest

«drivers\_seat\_adjustable\_armrest\_»

Seat Control Locations

While seated, the driver shall be able to make seat adjustments by hand without complexity, excessive effort or being pinched. Adjustment mechanisms shall hold the adjustments and shall not be subject to inadvertent changes.

Seat Structure and Materials

Cushions

Cushions shall be fully padded with at least 3 in. of materials in the seating areas at the bottom and back.

Cushion Materials

«seat\_structure\_and\_materials\_cushion\_mat»

Pedestal

«seat\_structure\_and\_materials\_pedestal»

Seat Options

Choose among the following:

* heated seat
* occupant seat sensor
* fabric options
* seat air ventilation/cooling
* side bolsters adjustments
* Docket 90–compliant silicone foam cushion
* removable seat cushions for maintenance exchangeability

Mirrors

* + 1. Exterior Mirrors

The bus shall be equipped with corrosion-resistant, outside rearview mirrors mounted with stable supports to minimize vibration. Mirrors shall be firmly attached to the bus to minimize vibration and to prevent loss of adjustment. Mirrors shall permit the driver to view the roadway along the sides of the bus, including the rear wheels. Mirrors should be positioned to prevent blind spots. Mirrors shall be mounted to allow the head and shoulders of a 95th-percentile male/5th-percentile female to be unobstructed.

Mirrors shall comply with FMVSS 111.

Mirrors shall retract or fold sufficiently to allow bus-washing operations but avoid contact with glazing or bus body.

«mirrors\_exterior\_mirrors\_installation\_»

«mirrors\_exterior\_mirrors\_type»

Curbside Mirrors

The curbside rearview mirror shall be mounted so that its lower edge is no less than 76 in. above the street surface. A lower mount may be required due to mirror configuration requests.

«mirrors\_curbside\_mirrors»

Street-Side Mirrors

«mirrors\_\_street\_side\_mirrors\_»

* + 1. Interior Mirrors

Mirrors shall be provided for the driver to observe passengers throughout the bus without leaving the seat and without shoulder movement. The driver shall be able to observe passengers in the front/entrance and rear/exit areas (if applicable), anywhere in the aisle, and in the rear seats.

«mirrors\_interior\_mirrors»

WINDOWS

General

A minimum of 10,000 in.2 of window area, including operator and door windows, shall be required on each side of the standard configuration bus.

Windshield

The windshield shall permit an operator’s field of view as referenced in SAE J1050. The vertically upward view shall be a minimum of 14 deg, measured above the horizontal and excluding any shaded band. The vertically downward view shall permit detection of an object 3½ ft high no more than 2 ft in front of the bus. The horizontal view shall be a minimum of 90 deg above the line of sight. Any binocular obscuration due to a center divider may be ignored when determining the 90 deg requirement, provided that the divider does not exceed a 3 deg angle in the operator’s field of view. Windshield pillars shall not exceed 10 deg of binocular obscuration. The windshield shall be designed and installed to minimize internal and external glare and reflections.

The windshield shall be easily replaceable by removing zip-locks from the windshield retaining moldings. Bonded-in-place windshields shall not be used. Winglets may be bonded.

«windshield»

Glazing

The windshield glazing material shall have a ¼ in. nominal thickness laminated safety glass conforming to the requirements of ANSI Z26.1 Test Grouping AS-1 and the recommended practices defined in SAE J673.

«windshield\_glazing\_»

Glare

The windshield, operator-side window and door glass shall be designed to minimize glare to the extent possible. This includes all forward areas that reflect lighted objects to show reflection in the windshield, as well as side window and door glass. Manufacturers shall make every effort to reduce glare and shall provide a plan response for how they mitigate glare on reflective materials to be reviewed by the Agency.

Driver’s-Side Window

The driver’s-side window shall be the sliding type, requiring only the rear half of the sash to latch upon closing, and shall open sufficiently to permit the seated operator to easily access and/or adjust the street-side outside rearview mirror. When in an open position, the window shall not rattle or close during braking. This window section shall slide in tracks or channels designed to last the service life of the bus. The operator’s side window shall be easily replaceable. The glazing material shall have a single-density tint.

The driver’s view, perpendicular through the operator’s-side window glazing, should extend a minimum of 33 in. (840 mm) to the rear of the heel point on the accelerator, and in any case must accommodate a 95th-percentile male operator. The view through the glazing at the front of the assembly should begin not more than 26 in. (560 mm) above the operator’s floor to ensure visibility of an under-mounted convex mirror. Driver’s window construction shall maximize ability for full opening of the window.

«driver\_side\_window\_safety\_glass»

The design shall prevent sections from freezing closed in the winter. Light transmittance shall be 75% on the glass area below 53 in. from the operator platform floor. On the top-fixed-over-bottom-slider configuration, the top fixed area above 53 in. may have a maximum 5% light transmittance.

«driver\_side\_window\_frame»

Side Windows

Configuration

Side windows shall not be bonded in place, but shall be easily replaceable without disturbing adjacent windows and shall be mounted so that flexing or vibration from engine operation or normal road excitation is not apparent. All aluminum and steel material will be treated to prevent corrosion.

Emergency Exit (Egress) Configuration

«side\_windows\_emergency\_exit\_egress\_conf1»

«side\_windows\_emergency\_exit\_egress\_confi»

Configuration

«side\_windows\_passenger\_side\_configuratio»

Materials

«side\_windows\_materials\_glazing»

«side\_windows\_materials\_glazing\_requireme»

SHGC and light transmission performance shall be defined by the National Fenestration Rating Council.

Rear Window

«side\_windows\_rear\_window»

HEATING, VENTILATING AND AIR CONDITIONING

HVAC Capacity and Performance

The HVAC climate control system shall be capable of controlling the temperature and maintaining the humidity levels of the interior of the bus as defined in the following paragraphs.

«hvac\_capacity\_and\_performance\_\_hvac\_requ»

«hvac\_capacity\_and\_performance\_\_hvac\_loca»

With the bus running at the design operating profile with corresponding door opening cycle, and carrying a number of passengers equal to 150% of the seated load, the HVAC system shall control the average passenger compartment temperature within a range between 65 and 80 °F, while maintaining the relative humidity to a value of 50% or less. The system shall maintain these conditions while subjected to any outside ambient temperatures within a range of 10 to 95 °F and at any ambient relative humidity levels between 5% and 50%.

When the bus is operated in outside ambient temperatures of 95 to 115 °F, the interior temperature of the bus shall be permitted to rise 0.5 °F for each degree of exterior temperature in excess of 95 °F.

When the bus is operated in outside ambient temperatures in the range of −10 to 10 °F, the interior temperature of the bus shall not fall below 55 °F while the bus is running on the design operating profile.

NOTE: The recommended locations of temperature probes are only guidelines and may require slight modifications to address actual bus design. Care must be taken to avoid placement of sensing devices in the immediate path of an air duct outlet. In general, the locations are intended to accurately represent the interior passenger area.

Additional testing shall be performed as necessary to ensure compliance to performance requirements stated herein.

«hvac\_capacity\_and\_performance\_\_additiona»

Pull-Down/Pull-Up Test Requirements

The requirements of this section shall be subject to APTA BTS-HVAC-RP-003-04, “Transit Bus HVAC System Instrumentation and Performance Testing.”

«hvac\_pull\_down\_pull\_up\_test\_requirement1»

«hvac\_pull\_down\_pull\_up\_test\_requirements»

Note: Refrigerant selection may impact pull-down performance.

HVAC Controls and Temperature Uniformity

The HVAC system excluding the driver’s heater/defroster shall be centrally controlled with an advanced electronic/diagnostic control system with provisions for extracting/reading data. The system shall be compliant with SAE J1939 for receiving and broadcasting of data. The system shall comply with relevant portions of “Electrical, Electronic and Data Communication Systems” regarding data communication.

HVACs that use coolant pumps for driver’s defroster/heat shall be sized for the required flow and be brushless, having a minimum maintenance-free service life for both the brushless motor and the pump of at least 40,000 hours at full power.

«hvac\_controls\_temperature\_control\_system»

«hvac\_controls\_temperature\_uniformity»

Interior temperature distribution shall be uniform to the extent practicable to prevent hot and cold spots. After stabilization with doors closed, the temperatures between any two points in the passenger compartment in the same vertical plane, and 6 to 72 in. above the floor, shall not vary by more than 5 °F with doors closed. The interior temperatures, measured at the same height above the floor, shall not vary more than ±5 °F from the front to the rear from the average temperature determined in accordance with APTA BTS-HVAC-RP-003-04, “Transit Bus HVAC System Instrumentation and Performance Testing.” Variations of greater than ±5 °F will be allowed for limited, localized areas provided that the majority of the measured temperatures fall within the specified requirement.

Auxiliary Heater

«hvac\_controls\_auxiliary\_heater»

Load-Shedding and De-rating (Battery Electric Bus)

“Reserved”

HVAC Airflow

Passenger Area

The cooling mode of the interior climate control system shall introduce air into the bus at or near the ceiling height at a minimum rate of 25 cubic feet per minute (cfm) per passenger based on the standard configuration bus carrying a number of passengers equal to 150% of the seated load. Airflow shall be evenly distributed throughout the bus, with air velocity not exceeding 100 ft per minute on any passenger. The ventilating mode shall provide air at a minimum flow rate of 20 cfm per passenger.

Airflow may be reduced to 15 cfm per passenger (150% of seated load) when operating in the heating mode. The fans shall not activate until the heating element has warmed sufficiently to ensure at least 70 °F air outlet temperature. The heating air outlet temperature shall not exceed 120 °F under any normal operating conditions.

The climate control blower motors and fan shall be designed such that their operation complies with the interior noise level requirements.

«hvac\_airflow\_passenger\_area»

Driver’s Area

The bus interior climate control system shall deliver no less than 100 cfm of air to the driver’s area when operating in the heating, ventilating and cooling modes. Adjustable vents shall permit variable distribution or shutdown of the airflow. Airflow in the heating mode shall be reduced proportionally to the reduction of airflow into the passenger area.

The windshield defroster unit shall meet the requirements of SAE J382, “Windshield Defrosting Systems Performance Requirements,” and shall have the capability of diverting heated air to the driver’s feet and legs. The defroster or interior climate control system shall maintain visibility through the driver’s-side window.

Controls for the Climate Control System

The controls for the driver’s compartment for heating, ventilation and cooling systems shall be integrated and shall meet the following requirements:

* The heat/defrost system fan shall be controlled by a separate switch that has an “off” position and at least two positions for speed control. All switches and controls shall preclude the possibility of clothing becoming entangled, and shields shall be provided, if required. If the fans are approved by the Agency, an “on/off” switch shall be located to the right of or near the main defroster switch.
* Manually operated control.
* If a cable-operated manual control valve is used, then the cable length shall be kept to a minimum to reduce cable seizing.
* Heater water control valves shall be “positive” type, closed or open. The method of operating remote valves shall require the concurrence of the Agency project manager.

Driver’s Compartment Requirements

A separate heating, ventilation and defroster system for the driver’s area shall be provided and shall be controlled by the driver. The system shall meet the following requirements:

* The heater and defroster system shall provide heating for the driver and heated air to completely defrost and defog the windshield, driver’s-side window and the front door glasses in all operating conditions. Fans shall be able to draw air from the bus body interior and/or exterior through a control device and pass it through the heater core to the defroster system and over the driver’s feet. A minimum capacity of 100 cfm shall be provided. The driver shall have complete control of the heat and fresh airflow for the driver’s area.
* APTA BTS-HVAC-RP-003-04, “Transit Bus HVAC System Instrumentation and Performance Testing,” shall apply as applicable.
* The defroster supply outlets shall be located at the lower edge of the windshield. These outlets shall be durable and shall be free of sharp edges that can catch clothes during normal daily cleaning. The system shall be such that foreign objects such as coins or tickets cannot fall into the defroster air outlets. Adjustable ball vents or louvers shall be provided at the left of the driver’s position to allow direction of air onto the side windows.
* A ventilation system shall be provided to ensure driver comfort and shall be capable of providing fresh air in both the foot and head areas. Vents shall be controllable by the driver from the normal driving position. Decals shall be provided, indicating “operating instructions” and “open” and “closed” positions. When closed, vents shall be sealed to prevent the migration of water or air into the bus.

Driver’s Cooling

«hvac\_airflow\_drivers\_cooling»

HVAC Air Filtration

Air shall be filtered before entering the AC system and being discharged into the passenger compartment. The filter shall meet ANSI/ASHRAE 52.2 for the maximum possible MERV rating based upon the Manufacturer’s design and the design operating environment. Air filters shall be easily removable for service.

«hvac\_air\_filtration»

Roof Ventilators

Each ventilator shall be easily opened and closed manually. When open with the bus in motion, this ventilator shall provide fresh air inside the bus. The ventilator shall cover an opening area no less than 425 in.2 and shall be capable of being positioned as a scoop with either the leading or trailing edge open no less than 3 in., or with all four edges raised simultaneously to a height of no less than 33 in. An escape hatch shall be incorporated into the roof ventilator. Roof ventilator(s) shall be sealed to prevent entry of water when closed.

«roof\_ventilators\_»

HVAC Maintainability

«hvac\_maintainability\_»

«hvac\_location»

HVAC Entrance/Exit Area Heating

«hvac\_entrance\_exit\_area\_heating»

Floor-Level Heating

Transit Coach

«floor\_level\_heating\_transit\_coach»

Commuter Coach

“Reserved”

EXTERIOR PANELS, FINISHES and Exterior Lighting

Design

The bus shall have a clean, smooth, simple design, primarily derived from bus performance requirements and passenger service criteria. The exterior and body features, including grilles and louvers, shall be shaped to facilitate cleaning by automatic bus washers without snagging washer brushes. Water and dirt shall not be retained in or on any body feature to freeze or bleed out onto the bus after leaving the washer. The body and windows shall be sealed to prevent leaking of air, dust or water under normal operating conditions and during cleaning in automatic bus washers for the service life of the bus.

Exterior panels shall be sufficiently stiff to minimize vibration, drumming or flexing while the bus is in service. When panels are lapped, the upper and forward panels shall act as a watershed. However, if entry of moisture into the interior of the vehicle is prevented by other means, then rear cap panels may be lapped otherwise. The windows, hatches and doors shall be able to be sealed. Accumulation of spray and splash generated by the bus’s wheels shall be minimized on windows and mirrors.

Materials

Body materials shall be selected and the body fabricated to reduce maintenance, extend durability and provide consistency of appearance throughout the service life of the bus. Detailing shall be kept simple, and add-on devices and trim shall be minimized and integrated into the basic design.

«design\_body\_materials»

Roof-Mounted Equipment (Transit Coach)

Coaches with roof mounted equipment shall install a nonskid, clearly marked walkway, or steps shall be incorporated on the roof, to provide access to equipment without damaging any system or bus paneling.

Pedestrian Safety

Exterior protrusions along the side and front of the bus greater than ½ in. and within 80 in. of the ground shall have a radius no less than the amount of the protrusion. The exterior rearview mirrors, cameras and required lights and reflectors are exempt from the protrusion requirement. Advertising frames shall protrude no more than ⅞ in. from the body surface. Grilles, doors, bumpers and other features on the sides and rear of the bus shall be designed to minimize toeholds or handholds.

Exterior protrusions shall not cause a line-of-sight blockage for the driver.

Side Body Panel Repair and Replacement

Transit Coach

Structural elements supporting exterior body panels shall allow side body panels below the windows to be repaired.

«side\_body\_panel\_repair\_and\_replacement\_t»

Commuter Coach

“Reserved”

Rain Gutters

Rain gutters shall be provided to prevent water flowing from the roof onto the passenger doors and driver’s-side window. When the bus is decelerated, the gutters shall not drain onto the windshield, driver’s-side window or door boarding area. Cross-sections of the gutters shall be adequate for proper operation.

License Plate Provisions

Provisions shall be made to mount standard-size U.S./Canada license plates per SAE J686 on the front and rear of the bus. These provisions shall direct-mount or recess the license plates so they can be cleaned by automatic bus-washing equipment without being caught by the brushes. The rear license plate provision shall be illuminated per SAE J587.

«license\_plate\_provisions»

Rub rails

No requirement for rub rails.

Fender Flares

«fender\_flares»

Wheel Covers (Transit Coach)

«wheel\_covers\_transit\_coach»

Splash Aprons

«wheel\_covers\_splash\_aprons»

Service Compartments and Access Doors

Access Doors (Transit Coach)

Access openings shall be sized for easy performance of tasks within the compartment, including tool operating space. Access doors shall be of rugged construction and shall maintain mechanical integrity and function under normal operations throughout the service life of the bus. They shall close flush with the body surface. All doors shall be hinged at the top or on the forward edge and shall be prevented from coming loose or opening during transit service or in bus-washing operations. All access doors shall be retained in the open position by props or counterbalancing with overcenter or gas-filled springs with safety props and shall be easily operable by one person. Springs and hinges shall be corrosion-resistant. Latch handles shall be flush with, or recessed behind, the body contour and shall be sized to provide an adequate grip for opening. Access doors, when opened, shall not restrict access for servicing other components or systems.

If precluded by design, the Manufacturer shall provide door design information specifying how the requirements are met.

Access Doors (Commuter Coach)

“Reserved”

Access Door Latch/Locks

«access\_door\_latch\_locks\_»

Bumpers

Location

Bumpers shall provide impact protection for the front and rear of the bus with the top of the bumper being 27 in., ±3 in., above the ground. Bumper height shall be such that when one bus is parked behind another, a portion of the bumper faces will contact each other.

Front Bumper

No part of the bus, including the bumper, shall be damaged as a result of a 5 mph impact of the bus at curb weight with a fixed, flat barrier perpendicular to the bus’s longitudinal centerline. The bumper shall return to its pre-impact shape within 10 minutes of the impact. The bumper shall protect the bus from damage as a result of 6.5 mph impacts at any point by the common carriage with contoured impact surface defined in Figure 2 of FMVSS 301 loaded to 4000 lb parallel to the longitudinal centerline of the bus. It shall protect the bus from damage as a result of 5.5 mph impacts into the corners at a 30 deg angle to the longitudinal centerline of the bus. The energy absorption system of the bumper shall be independent of every power system of the bus and shall not require service or maintenance in normal operation during the service life of the bus. The bumper may increase the overall bus length specified by no more than 7 in.

«front\_bumper\_»

Rear Bumper

No part of the bus, including the bumper, shall be damaged as a result of a 2 mph impact with a fixed, flat barrier perpendicular to the longitudinal centerline of the bus. The bumper shall return to its pre-impact shape within 10 minutes of the impact. When using a yard tug with a smooth, flat plate bumper 2 ft wide contacting the horizontal centerline of the rear bumper, the bumper shall provide protection at speeds up to 5 mph, over pavement discontinuities up to 1 in. high, and at accelerations up to 2 mph per second. The rear bumper shall protect the bus when impacted anywhere along its width by the common carriage with contoured impact surface defined in Figure 2 of FMVSS 301 loaded to 4000 lb, at 4 mph parallel to or up to a 30 deg angle to the longitudinal centerline of the bus. The rear bumper shall be shaped to prevent unauthorized riders standing on the bumper. The bumper shall not require service or maintenance in normal operation during the service life of the bus. The bumper may increase the overall bus length specified by no more than 7 in.

Bumper Material

Bumper material shall be corrosion-resistant and shall withstand repeated impacts of the specified loads without sustaining damage. These bumper qualities shall be sustained throughout the service life of the bus.

Finish and Color

Appearance

All exterior surfaces shall be smooth and free of wrinkles and dents. Exterior surfaces to be painted shall be properly prepared as required by the paint system Supplier prior to application of paint to ensure a proper bond between the basic surface and successive coats of original paint for the service life of the bus. Drilled holes and cutouts in exterior surfaces shall be made prior to cleaning, priming and painting, where possible, to prevent corrosion. The bus shall be painted prior to installation of exterior lights, windows, mirrors and other items that are applied to the exterior of the bus. Body filler materials may be used for surface dressing, but not for repair of damaged or improperly fitted panels.

Paint shall be applied smoothly and evenly with the finished surface free of visible dirt and the following other imperfections:

* blisters or bubbles appearing in the topcoat film
* chips, scratches or gouges of the surface finish
* cracks in the paint film
* craters where paint failed to cover due to surface contamination
* overspray
* peeling
* runs or sags from excessive flow and failure to adhere uniformly to the surface
* chemical stains and water spots
* dry patches due to incorrect mixing of paint activators
* buffing swirls

All exterior finished surfaces shall be impervious (rubber components shall be resistant) to diesel fuel, gasoline and commercial cleaning agents. Finished surfaces shall resist damage by controlled applications of commonly used graffiti-removing chemicals.

Proper adhesion between the basic surface and successive coats of the original paint shall be measured using an Elcometer Adhesion Tester as outlined in ASTM D4541-85. Adhesion shall be a minimum 300 ft-lb. The bus Manufacturer shall supply test samples of the exterior surface for each step of the painting process that may be subject to adhesion testing per ASTM G4541-87 and ASTM D4145-85. ASTM D4541-93 may be used for inspection testing during assembly of the vehicle.

«finish\_and\_color\_appearance\_finish\_quali»

«finish\_and\_color\_appearance\_paint\_system»

Decals, Numbering and Signing

Energy storage and delivery systems shall be identified in accordance with federal, state and local requirements, codes and standards.

«decals\_numbering\_and\_signing\_»

NOTE: The Agency should supply a list of interior and exterior decals, including size and location.

Passenger Information

ADA priority seating signs as required and defined by 49 CFR 38.27 shall be provided to identify the seats designated for passengers with disabilities.

Requirements for a public information system in accordance with 49 CFR 38.35 shall be provided.

Exterior Lighting

All exterior lights shall be designed to prevent entry and accumulation of moisture or dust. Lamps, lenses and fixtures shall be interchangeable to the extent practicable. Two hazard lamps at the rear of the bus shall be visible from behind when the engine service doors are opened. Light lenses shall be designed and located to prevent damage when running the vehicle through an automatic bus washer.

Commercially available LED-type lamps shall be used at all exterior lamp locations.

Standard Lamps

All LED lamps shall be standard installation of the OEM. The entire assembly shall be specifically coated to protect the light from chemical and abrasion degradation.

«exterior\_lighting\_size»

«exterior\_lighting\_clearance\_lights»

«exterior\_lighting\_size\_exterior\_emergenc»

Backup Light/Alarm

Visible and audible warnings shall inform following vehicles or pedestrians of reverse operation. Visible reverse operation warning shall conform to SAE J593. Audible reverse operation warning shall conform to SAE J994 Type C or D.

Doorway Lighting

Lamps at the front and rear passenger doorways (if applicable) shall comply with ADA requirements and shall activate only when the doors open. These lamps shall illuminate the street surface to a level of no less than 1 fc for a distance of 3 ft outward from the outboard edge of the door threshold. The lights may be positioned above or below the lower daylight opening of the windows and shall be shielded to protect passengers’ eyes from glare.

Turn Signals

Turn-signal lights, including any wraparound turn signals, shall be provided on the front, rear, curb and street sides of the bus in accordance with federal regulations.

Headlamps

Headlamps shall be designed for ease of replacement.

«exterior\_lighting\_headlamps»

Brake Lamps

* + 1. Transit Coach

Brake lamps shall be provided in accordance with federal regulations.

«brake\_lamp\_transit\_coach\_»

* + 1. Commuter Coach

“Reserved”

Service Area Lighting (Interior and Exterior)

LED lamps shall be provided in the engine and all other compartments where service may be required to generally illuminate the area for night emergency repairs or adjustments. These service areas shall include, but not be limited to, the engine compartment, the communication box, junction/apparatus panels and passenger door operator compartments. Lighting shall be adequate to light the space of the service areas to levels needed to complete typical emergency repairs and adjustments. The service area lamps shall be suitable for the environment in which they are mounted.

Engine compartment lamps shall be controlled by a switch mounted near the rear start controls or in an approved location. All other service area lamps shall be controlled by switches mounted on or convenient to the lamp assemblies. Power to the service area lighting shall be programmable. Power shall latch on with activation of the switch. Power shall be automatically discontinued (timed out) after 30 minutes or turned off when the PLC is shut down after a predetermined time to prevent damage caused by inadvertently leaving the service area lighting switch in the “on” position after repairs are made.

INTERIOR PANELS AND FINISHES

General Requirements

Materials shall be selected on the basis of maintenance, durability, appearance, safety, noise reduction, flammability and tactile qualities. Materials shall be strong enough to resist everyday abuse and be vandalism- and corrosion-resistant. Trim and attachment details shall be kept simple and unobtrusive. Interior trim shall be secured to avoid resonant vibrations under normal operational conditions.

Interior surfaces more than 10 in. below the lower edge of the side windows or windshield shall be shaped so that objects placed on them fall to the floor when the coach is parked on a level surface. Any components and other electrical components within close proximity to these surfaces shall also be resistant to this cleaning method.

«interior\_panels\_and\_finishes\_general\_req»

Interior Panels

Panels shall be easily replaceable and tamper-resistant. They shall be reinforced, as necessary, to resist vandalism and other rigors of transit bus service. Individual trim panels and parts shall be interchangeable to the extent practicable.

«interior\_panels»

Driver Area Barrier

* + 1. Transit Coach

A barrier or bulkhead between the driver and the street-side front passenger seat shall be provided. The barrier shall minimize glare and reflections in the windshield directly in front of the barrier from interior lighting during night operation. Location and shape must permit full seat travel and reclining possibilities that can accommodate the shoulders of a 95th-percentile male. The partition shall have a side return and stanchion to prevent passengers from reaching the driver by standing behind the driver’s seat. The lower area between the seat and panel must be accessible to the driver. The partition must be strong enough in conjunction with the entire partition assembly for optional mounting of such equipment as flare kits, fire extinguishers (1.2 kg), microcomputer, public address amplifier, etc. The panel should be properly attached to minimize noise and rattles.

The driver’s barrier shall extend from the ceiling to the surface below (e.g., floor or wheel well) and shall fit close to the bus-side windows and wall to prevent passengers from reaching the driver or the driver’s personal effects. The driver’s barrier shall extend continuously from the bus wall to the first stanchion immediately behind the driver to provide security to the driver and to limit passenger conversation.

* + 1. Driver Protection Door

The bus operator’s area shall be isolated from passengers by a protective barrier. The barrier should be glazed on the upper section with a ⅜ in. laminated safety glass compliant to the latest requirements of ANSI/SAE Z26.1. The barrier shall be glazed on the upper section with a ⅜ in. AS2 type laminated safety glass or equivalent. The glass shall have anti-glare, nonreflective coating on both sides. The barrier shall not obscure the driver’s vision of the side windows or the rearview mirror. The barrier shall be mounted securely to the bus structure with a single hinge post. Individual strap hinges or piano-type hinges shall not be allowed. The barrier shall not interfere with access to the farebox or other devices mounted to the farebox pedestal. The barrier shall latch securely in the closed position. The latch shall be of a non-rattling type with a paddle handle release located such that the driver may reach over a closed barrier to open and gain access to the driver’s area.

When mounted, the barrier shall comply with all ADA accessibility regulations for wheeled mobility device access.

«interior\_panels\_driver\_protection\_door»

* + 1. Commuter Coach

“Reserved”

Modesty Panels

Sturdy divider panels constructed of durable, unpainted, corrosion-resistant material complementing the interior shall be provided to act as both a physical and visual barrier for seated passengers.

Design and installation of modesty panels located in front of forward-facing seats shall include a handhold or grab handle along their top edge. These dividers shall be mounted on the sidewall and shall project toward the aisle no farther than passenger knee projection in longitudinal seats or the aisle side of the transverse seats. Modesty panels shall extend from at least the window opening of the side windows, and those forward of transverse seats shall extend downward to 1 and 1½ in. no more than 8.25 in. above the floor. At doorways, the panels shall extend downward to no more than 2 in. above the floor. Panels forward of longitudinal seats shall extend to below the level of the seat cushion. To prevent passengers from being pinched, dividers positioned at the doorways, where applicable, shall provide no less than a 2½ in. clearance between the modesty panel and a fully open, inward-opening door, or the path of a deploying flip-out ramp to protect passengers from being pinched. At the aft of the exit door, clearance shall be no less than 1.9 in. between the modesty panel and an inward opening door. Modesty panels installed at doorways shall be equipped with grab rails if passenger assists are not provided by other means.

The modesty panel and its mounting shall withstand a static force of 250 lb applied to a 4 × 4 in. area in the center of the panel without permanent visible deformation.

«interior\_panels\_modesty\_panels\_»

Front End

The entire front end of the bus shall be sealed to prevent debris accumulation behind the dash and to prevent the driver’s feet from kicking or fouling wiring and other equipment. The front end shall be free of protrusions that are hazardous to passengers standing at the front of the standee line area of the bus during rapid decelerations. Paneling across the front of the bus and any trim around the driver’s compartment shall be formed metal or composite material. Composite dash panels shall be reinforced as necessary, vandal-resistant and replaceable. All colored, painted and plated parts forward of the driver’s barrier shall be finished with a surface that reduces glare. Any mounted equipment must have provision to support the weight of equipment.

Rear Bulkhead

The rear bulkhead (and articulated bus joint if applicable) and rear interior surfaces shall be of material suitable for exterior skin; painted and finished to exterior quality; or paneled with melamine-type material, composite, scratch-resistant plastic or carpeting and trimmed with stainless steel, aluminum or composite.

The rear bulkhead paneling shall be contoured to fit the ceiling, sidewalls and seat backs so that any litter or trash will tend to fall to the floor or seating surface when the bus is on a level surface. Any air vents in this area shall be louvered to reduce airflow noise and to reduce the probability of trash or litter being thrown or drawn through the grille. If it is necessary to remove the panel to service components located on the rear bulkhead, then the panel shall be hinged or shall be able to be easily removed and replaced. Grilles where access to or adjustment of equipment is required shall be heavy-duty and designed to minimize damage and limit unauthorized access.

Headlining

Ceiling panels shall be made of durable, corrosion-resistant, easily cleanable material. Headlining shall be supported to prevent buckling, drumming or flexing and shall be secured without loose edges. Headlining materials shall be treated or insulated to prevent marks due to condensation where panels are in contact with metal members. Moldings and trim strips, as required to make the edges tamperproof, shall be stainless steel, aluminum or plastic, colored to complement the ceiling material. Headlining panels covering operational equipment that is mounted above the ceiling shall be on hinges for ease of service but retained to prevent inadvertent opening.

Fastening

Interior panels shall be attached so that there are no exposed unfinished, rough edges or rough surfaces. Fasteners should be corrosion-resistant. Panels and fasteners shall not be easily removable by passengers. Exposed interior fasteners should be minimized, and shall be tamper-resistant where required by the Agency.

Insulation

Any insulation material used between the inner and outer panels shall minimize the entry and/or retention of moisture. Insulation properties shall be unimpaired during the service life of the bus. Any insulation material used inside the engine compartment shall not absorb or retain oils or water and shall be designed to prevent casual damage that may occur during maintenance operations.

The combination of inner and outer panels on the sides, roof, wheel wells and ends of the bus, and any material used between these panels, shall provide a thermal insulation sufficient to meet the interior temperature requirements. The bus body shall be thoroughly sealed so that the driver or passengers cannot feel drafts during normal operations with the passenger doors closed.

«interior\_panels\_insulation\_header»

«interior\_panels\_insulation\_»

Floor Covering

The floor covering shall have a nonskid walking surface that remains effective in all weather conditions. The floor covering, as well as transitions of flooring material to the main floor and to the entrance and exit area, shall be smooth and present no tripping hazards. Seams shall be sealed/welded per manufacturer’s specifications and shall not extend into the aisle. The color and pattern shall be consistent throughout the floor covering. The standee line shall be approximately 2 in. wide and shall extend across the bus aisle and contrast with the rest of the floor covering.

«interior\_panels\_floor\_covering»

The floor shall be easily cleaned and shall be arranged to minimize debris accumulation.

A one-piece center strip shall extend from the vertical wall of the rear settee between the aisle sides of transverse seats to the standee line. If the floor is of a bi-level construction, then the center strip shall be one piece at each level. The covering between the center strip and the wheel housings may be separate pieces. At the rear door, however, a separate strip as wide as the door shall extend from the center strip to the outboard edge of the rear/exit area. In the case of prefabricated floors with an integrated floor covering, the number of sections shall be minimized.

The floor under the seats shall be covered with smooth surface flooring material. The floor covering shall closely fit the sidewall. Flooring may fit the sidewall with a fully sealed butt joint, extend to the top of the cove, or be captured by the seat rail.

Interior Lighting

The light source shall be located to minimize windshield glare, with distribution of the light focused primarily on the passengers’ reading plane while casting sufficient light onto the advertising display. The lighting system may be designed to form part of or the entire air distribution duct.

The lens material shall be translucent polycarbonate. Lenses shall be designed to effectively “mask” the light source. Lenses shall be sealed to inhibit incursion of dust and insects yet be easily removable for service. Access panels shall be provided to allow servicing of components located behind light panels. If necessary, the entire light fixture shall be hinged.

Passenger Area Lighting

«interior\_lighting\_passenger\_area\_lighti1»

«interior\_lighting\_passenger\_area\_lightin»

All interior lighting shall be turned off whenever the vehicle is in reverse and the engine run switch is in the “on” position.

Interior passenger area lights shall be LED. The interior lighting design, including color or brightness, shall require the approval of the Agency.

Driver’s Area Lighting

The driver’s area shall have a light to provide general illumination, and it shall illuminate the half of the steering wheel nearest the driver to a level of 10 to 30 fc.

Seating Area Lighting (Transit Coach)

The interior lighting system shall provide a minimum 15 fc illumination on a 1 ft2 plane at an angle of 45 deg from horizontal, centered 33 in. above the floor and 24 in. in front of the seat back at each seat position. Allowable average light level for the rear bench seats shall be 7 fc.

Seating Area Lighting (Commuter Coach)

“Reserved”

Vestibules/Doors Lighting (Transit Coach)

Floor surface in the aisles shall be a minimum of 10 fc, and the vestibule area a minimum of 4 fc with the front doors open and a maximum of 2 fc with the front doors closed. The front entrance area and curb lights shall illuminate when the front door is open and the master run switch is in the “lights” or “night run” position. Rear exit area and curb lights shall illuminate when the rear door is unlocked.

Vestibules/Doors Lighting (Commuter Coach)

“Reserved”

Step Lighting

Step lighting for the intermediate steps between lower and upper floor levels shall be a minimum of 4 fc and shall illuminate in all vehicle run positions. The step lighting shall be low-profile to minimize tripping and snagging hazards for passengers and shall be shielded as necessary to protect passengers’ eyes from glare.

Ramp Lighting (Transit Coach)

Exterior and interior ramp lighting shall comply with federal regulations.

Turntable Lighting (Articulated Coach)

“Reserved”

Farebox/Card Reader Lighting

* + 1. Transit Coach

«farebox\_card\_reader\_lighting\_transit\_coa»

* + 1. Commuter Coach

“Reserved”

Fare Collection

Space and structural provisions shall be made for installation of currently available fare collection devices, including card readers or validators as specified by the Agency, which shall be as far forward as practicable. Location of the fare collection device shall not restrict traffic in the vestibule, including wheeled mobility devices if a front door loading device is used, and shall allow the driver to easily reach the farebox controls and to view the fare register. The farebox shall not restrict access to the driver’s area, shall not restrict operation of driver controls, and shall not—either by itself or in combination with stanchions, transfer mounting, cutting and punching equipment, or route destination signs—restrict the driver’s field of view per SAE J1050. The location and mounting of the fare collection device shall allow use, without restriction, by passengers. The farebox location shall permit accessibility to the vault for easy manual removal or attachment of suction devices. Meters and counters on the farebox shall be readable on a daily basis. The floor under the farebox shall be reinforced as necessary to provide a sturdy mounting platform and to prevent shaking of the farebox.

«fare\_collection\_differently\_designed\_bus»

Contractor shall provide fare collection installation layout to the Agency for approval.

«fare\_collection\_install»

Interior Access Panels and Doors

Access for maintenance and replacement of equipment shall be provided by panels and doors that appear to be an integral part of the interior. Access doors shall be hinged with gas props or overcenter springs, where practical, to hold the doors out of the mechanic’s way. Panels shall prevent entry of mechanism lubricant into the bus interior. All fasteners that retain access panels shall be captive in the cover.

«interior\_access\_panels\_doors\_header»

«interior\_access\_panels\_doors\_»

Floor Panels

Access openings in the floor shall be sealed to prevent entry of fumes and water into the bus interior. Flooring material at or around access openings shall be flush with the floor and shall be edge-bound with stainless steel or another material or sealant that is acceptable to the Agency to prevent the edges from coming loose. Access openings shall be asymmetrical or have distinct surface features or surface finishes indicating the proper part orientation so that reinstalled flooring shall be properly aligned. Fasteners protrusion shall be minimized, or flush with the floor.

The number of special fastener tools required for panel and access door fasteners shall be minimized.

Passenger Accommodations

Passenger Seating

Arrangements and Seat Style (Transit Coach)

The passenger seating arrangement in the bus shall be such that seating capacity is maximized and in compliance with the following requirements.

Note: The Agency should recognize that ramp location, foot room, hip-to-knee room, doorway type, width, seat construction, floor level type, seat spacing requirements, ramp or lift, number of wheeled mobility device positions, etc. ultimately affect seating capacity and layout.

«passenger\_seating\_arrangements\_and\_seat\_»

Rearward Facing Seats (Transit Coach)

«passenger\_seating\_rearward\_facing\_seats\_»

Turntable Seating (Articulated Coach)

“Reserved”

Seat USB

«passenger\_seating\_seat\_usb»

Padded Inserts/Cushioned Seats (Transit Coach)

«passenger\_seating\_padded\_inserts\_cushio1»

«passenger\_seating\_padded\_inserts\_cushion»

Seat Back Configuration

«passenger\_seating\_seat\_back\_configuratio»

Drain Hole in Seats

«passenger\_seating\_drain\_hole\_in\_seats»

Arrangements and Seat Style (Commuter Coach)

“Reserved”

Hip-to-Knee Room

Hip-to-knee room measured from the center of the seating position, from the front of one seat back horizontally across the highest part of the seat to a vertical surface immediately in front, shall be a minimum of 26 in. At all seating positions in paired transverse seats immediately behind other seating positions, hip-to-knee room shall be no less than 26.5 in.

Foot Room

Foot room, measured at the floor forward from a point vertically below the front of the seat cushion, shall be no less than 14 in. Seats immediately behind the wheel housings and modesty panels may have foot room reduced (Agency will approve acceptable dimensions).

Aisles (Transit Coach)

The aisle between the seats shall be no less than 20 in. wide at seated passenger hip height. Seat backs shall be shaped to increase this dimension to no less than 24 in. at 32 in. above the floor (standing passenger hip height).

Aisles (Commuter Coach)

“Reserved”

Dimensions (Transit Coach)

|  |
| --- |
| FIGURE 8  Seating Dimensions and Standard Configuration |
| Figure 1 |

«passenger\_seating\_dimensions\_transit\_coa»

Structure and Design (Transit Coach)

Seating shall meet all acceptance criteria in Table 7.

The passenger seat frame and its supporting structure shall be constructed and mounted so that space under the seat is maximized and is completely free of obstructions to facilitate cleaning.

Seats, structures and restraints around the securement area should not infringe into the mobility device envelope or maneuverability.

The transverse seat structure shall be fully cantilevered from the sidewall with sufficient strength for the intended service. The lowest part of the seat assembly that is within 12 in. of the aisle shall be at least 10 in. above the floor.

In locations at which cantilevered installation is precluded by design and/or structure, other seat mounting may be allowed.

The back of each transverse seat shall incorporate a handhold no less than ⅞ in. in diameter for standees and seat access/egress. The handhold shall not be a safety hazard during severe decelerations. The handhold shall extend above the seat back near the aisle so that standees shall have a convenient vertical assist, no less than 4 in. long, that may be grasped with the full hand. This handhold shall not cause a standee using this assist to interfere with a seated 50th-percentile male passenger. The handhold shall also be usable by a 5th-percentile female, as well as by larger passengers, to assist with seat access/egress for either transverse seating position. The upper rear portion of the seat back and the seat back handhold immediately forward of transverse seats shall be padded and/or constructed of energy-absorbing materials. During a 10g deceleration of the bus, the HIC number (as defined by SAE J211a) shall not exceed 400 for passengers ranging in size from a 5th-percentile female through a 95th-percentile male.

The seat back handhold may be deleted from seats that do not have another transverse seat directly behind and where a vertical assist is provided.

Longitudinal seats shall be the same general design as transverse seats but without seat back handholds. Longitudinal seats may be mounted on the wheelhouses. Armrests shall be included on the ends of each set of longitudinal seats except on the forward end of a seat set that is immediately to the rear of a transverse seat, the driver’s barrier or a modesty panel, when these fixtures perform the function of restraining passengers from sliding forward off the seat. Armrests are not required on longitudinal seats located in the wheeled mobility device parking area that fold up when the armrest on the adjacent fixed longitudinal seat is within 3½ in. of the end of the seat cushion. Armrests shall be located from 7 to 9 in. above the seat cushion surface. The area between the armrest and the seat cushion shall be closed by a barrier or panel. The top and sides of the armrests shall have a minimum width of 1 in. and shall be free from sharp protrusions that form a safety hazard.

«passenger\_seating\_structure\_and\_design\_t»

| **Table 7** Passenger Seating Tests | | |
| --- | --- | --- |
| **Test** | **Description** | **Acceptance Criteria** |
| Pendulum | Mass of two 95th-percentile males striking seat back during 10g deceleration | Permanent deformation <2 in. measured at aisle side seat frame; seat back deflection <14 in. measured at top of seat back |
| Vertical load | 500 lb applied to top of each seat cushion | Permanent deformation <¼ in. in seat or mountings |
| Horizontal | 500 lb evenly distributed along the top of the seat back of seat assembly | Permanent deformation <¼ in. in seat or mountings |
| Swing | Two 40 lb sandbags, suspended on 36 in. pendulum, strike seat back from front and rear, 10,000 times from distances of 6, 8, 10 and 12 in. (40,000 total impacts) | No visible deterioration |
| Drop Bag | 40 lb sandbag, dropped on seat cushions 1000 times from heights of 6 ,8, 10 and 12 in. (4000 total impacts) | No visible deterioration |
| Grabrail/Armrest Load | 250 lb applied anywhere along the length, in both horizontal and vertical direction | Permanent deformation <¼ in. |
| Grabrail/Armrest Cyclic | 125 lb horizontal force for 25,000 impacts in both directions | Permanent deformation <¼ in. and no visible deterioration |
| Jounce and Squirm | 100,000 randomly positioned 3.5 in. drops of squirming, 150 lb, smooth surfaced, buttocks-shaped striker | Minimal wear of seat coverings, no failures to seat structure |
| HIC | Defined by SAE J211a for 10g deceleration | HIC number <400 |
| Knee Impact | 10g deceleration of 5th-percentile female to 95th-percentile male | Compressive load <1000 lb on femur |

Structure and Design (Commuter Coach)

“Reserved”

Construction and Materials (Transit Coach)

Selected materials shall minimize damage from vandalism and shall reduce cleaning time. The seats shall be attached to the frame with tamper-resistant fasteners. Coloring shall be consistent throughout the seat material, with no visually exposed portion painted. Any exposed metal touching the sides or the floor of the bus shall be stainless steel. The seat, pads and cushions shall be contoured for individuality, lateral support and maximum comfort and shall fit the framework to reduce exposed edges.

The minimum radius of any part of the seat back, handhold or modesty panel in the head or chest impact zone shall be a nominal ¼ in. The seat back and seat back handhold immediately forward of transverse seats shall be constructed of energy-absorbing materials to provide passenger protection and, in a severe crash, to allow the passenger to deform the seating materials in the impact areas. Complete seat assemblies shall be interchangeable to the extent practicable.

Construction and Materials (Commuter Coach)

“Reserved”

Passenger Assists (Transit Coach)

Passenger assists in the form of full grip, vertical stanchions or handholds shall be provided for the safety of standees and for ingress/egress. Passenger assists shall be convenient in location, shape and size for both the 5th‑percentile female standee and the 95th-percentile male standee and shall comply with most current, relevant regulations set forth in the ADA Accessibility Guidelines for Transportation Vehicles. Starting from the entrance door and moving anywhere in the bus and out the exit door, a vertical assist shall be provided either as the vertical portion of the seat back assist or as a separate item so that a 5th-percentile female passenger may easily move from one assist to another using one hand and then the other without losing support. All handholds and stanchions at the front doorway, around the farebox, and at interior steps for bi-level designs shall be powder-coated in a high-contrast yellow color.

«passenger\_assists\_transit\_coach»

Assists (Transit Coach)

Excluding those mounted on the seats and doors, the assists shall have a cross-sectional diameter between 1¼ and 1½ in. or shall provide an equivalent gripping surface with no corner radii less than ¼ in. All passenger assists shall permit a full hand grip with no less than 1½ in. of knuckle clearance around the assist. Passenger assists shall be designed to minimize catching or snagging of clothes or personal items and shall be capable of passing the National Highway Traffic Safety Administration Drawstring Test.

Any joints in the assist structure shall be underneath supporting brackets and securely clamped to prevent passengers from moving or twisting the assists. Seat handholds may be of the same construction and finish as the seat frame. Door-mounted passenger assists shall be of anodized aluminum, stainless steel or powder-coated metal. Connecting tees and angles may be powder-coated metal castings. Assists shall withstand a force of 300 lb applied over a 12 in. lineal dimension in any direction normal to the assist without permanent visible deformation. All passenger assist components, including brackets, clamps, screw heads and other fasteners used on the passenger assists, shall be designed to eliminate pinching, snagging and cutting hazards and shall be free from burrs or rough edges.

Front Doorway

Front doors, or the entry area, shall be fitted with ADA-compliant assists. Assists shall be as far outward as practicable, but shall be located no farther inboard than 6 in. from the outside edge of the entrance step and shall be easily grasped by a 5th-percentile female boarding from street level. Door assists shall be functionally continuous with the horizontal front passenger assist, the vertical assist, and the assists on the wheel housing or on the front modesty panel.

Vestibule (Transit Coach)

The aisle side of the driver’s barrier, the wheel housings, and when applicable the modesty panels shall be fitted with vertical passenger assists that are functionally continuous with the overhead assist and that extend to within 36 in. of the floor. These assists shall have sufficient clearance from the barrier to prevent inadvertent wedging of a passenger’s arm.

A horizontal passenger assist shall be located across the front of the bus and shall prevent passengers from sustaining injuries on the fare collection device or windshield in the event of a sudden deceleration. Without restricting the vestibule space, the assist shall provide support for a boarding passenger from the front door through the fare collection procedure. The assist shall be no less than 36 in. above the floor. The assists at the front of the bus shall be arranged to permit a 5th-percentile female passenger to easily reach from the door assist, to the front assist, to vertical assists on the driver’s barrier, wheel housings or front modesty panel.

Rear Doorway(s) (Transit Coach)

Vertical assists that are functionally continuous with the overhead assist shall be provided at the aisle side of the transverse seat immediately forward of the rear door and on the aisle side of the rear door modesty panel(s). Passenger assists shall be provided on modesty panels that are functionally continuous with the rear door assists. Rear doors, or the exit area, shall be fitted with assists having a cross-sectional diameter between 1¼ and 1½ in. or providing an equivalent gripping surface with no corner radii less than ¼ in., and shall provide at least 1½ in. of knuckle clearance between the assists and their mounting. The assists shall be designed to permit a 5th‑percentile female to easily move from one assist to another during the entire exiting process. The assists shall be located no farther inboard than 6 in. from the outside edge of the rear doorway step.

For an articulated bus, passenger assists will be provided to aid in the transition between the front and rear sections of the bus.

Overhead (Transit Coach)

Except forward of the standee line and at the rear door, a continuous, full-grip, overhead assist shall be provided. This assist shall be located over the center of the aisle seating position of the transverse seats. The assist shall be no less than 70 in. above the floor. In the case of rear podium sections where headroom is constrained, the assist shall be no less than 67 in. above the floor.

«passenger\_assists\_overhead\_requirements\_»

«passenger\_assists\_overhead\_material\_tran»

Overhead assists shall simultaneously support 150 lb on any 12 in. length. No more than 5% of the full grip feature shall be lost due to assist supports.

Longitudinal Seat Assists (Transit Coach)

Longitudinal seats shall have vertical assists located between every other designated seating position, except for seats that fold/flip up to accommodate wheeled mobility device securement. Assists shall extend from near the leading edge of the seat and shall be functionally continuous with the overhead assist. Assists shall be staggered across the aisle from each other where practicable and shall be no more than 52 in. apart or functionally continuous for a 5th‑percentile female passenger.

Wheel Housing Barriers/Assists (Transit Coach)

Unless passenger seating is provided on top of wheel housings, passenger assists shall be mounted around the exposed sides of the wheel housings (and propulsion compartments if applicable), which shall also be designed to prevent passengers from sitting on wheel housings. Such passenger assists shall also effectively retain items, such as bags and luggage, placed on top of wheel housings.

Passenger Doors

Transit Coach

Doorways will be provided in locations and styles as follows. Passenger doors and doorways shall comply with ADA requirements.

* + 1. Front door

Door shall be forward of the front wheels and under direct observation of the driver.

* + 1. Rear Door(s)

«passenger\_doors\_rear\_door»

In cases where street-side and curbside doors are chosen, provisions shall be made for operating the front door, curbside rear door(s) and street-side rear door(s) independently or in the combinations shown in Table 8 while providing positive tactile feedback to the operator identifying the door control selection.

|  |  |  |
| --- | --- | --- |
| TABLE 8  Door Operating Combinations | | |
| **Front** | **Curbside Rear** | **Street-Side Rear** |
| Closed | Closed | Closed |
| Open | Closed | Closed |
| Open | Open | Closed |
| Open | Closed | Open |
| Open | Open | Open |
| Closed | Open | Closed |
| Closed | Closed | Open |
| Closed | Open | Open |

«passenger\_doors\_rear\_door\_system»

Commuter Coach

“Reserved”

Materials and Construction

Structure of the doors, their attachments, inside and outside trim panels, and any mechanism exposed to the elements shall be corrosion-resistant. Door panel construction shall be of corrosion-resistant metal or reinforced nonmetallic composite materials. When fully opened, the doors shall provide a firm support and shall not be damaged if used as an assist by passengers during ingress or egress. Door edges shall be sealed to minimize infiltration of exterior moisture, noise, dirt and air elements from entering the passenger compartment, to the maximum extent possible based on door types.

The closing edge of each door panel shall have no less than 2 in. of soft weather stripping. The doors, when closed, shall be effectively sealed, and the hard surfaces of the doors shall be at least 4 in. apart (not applicable to single doors). The combined weather seal and window glazing elements of the front door shall not exceed 10 deg of binocular obstruction of the driver’s view through the closed door.

Dimensions

* + 1. Transit Coach

|  |
| --- |
| FIGURE 9  Transit Bus Minimum Door Opening |
|  |

When open, the doors shall leave an opening no less than 75 in. in height.

«dimensions\_transit\_coach»

* + 1. Commuter Coach

“Reserved”

Door Glazing

The upper section of both front and rear doors shall be glazed for no less than 45% of the respective door opening area of each section. The lower section of the front door shall be glazed for no less than 25% of the door opening area of the section. Glazing material in the rear doorway door panels shall be defined by the Agency.

Door glazing shall be easily replaceable.

«passenger\_doors\_door\_glazing\_a»

«passenger\_doors\_door\_glazing\_b»

Door Projection (Transit Coach)

* + 1. **Exterior**

The exterior projection of the front doors beyond the side of the bus shall be minimized and shall not block the line of sight of the rear exit door via the curbside mirror when the doors are fully open. The exterior projection of both doors shall be minimized and shall not exceed 14 in. during the opening or closing cycles or when doors are fully opened.

* + 1. **Interior**

Projection inside the bus shall not cause an obstruction of the rear door mirror or cause a hazard for standees.

Door Height Above Pavement

It shall be possible to open and close either passenger door when the bus, loaded to gross vehicle weight rating, is not knelt and is parked with the tires touching an 8 in. high curb on a street sloping toward the curb so that the street-side wheels are 5 in. higher than the right-side wheels.

Closing Force

Closing door edge speed shall not exceed 12 in. per second, and opening door speed shall not exceed 19 in. per second. Power doors shall not slam closed under any circumstance, even if the door is obstructed during the closing cycle. If a door is obstructed during the closing cycle, the pressure exerted on the obstruction shall not increase once initial contact has been made.

Power-close front and rear doors shall be equipped with an obstruction-sensing system. If a contactless obstruction sensing system is employed, then it shall be capable of discriminating between the normal doorway environment and passengers or other obstructions within the doorway, and of altering the zones of detection based upon the operating state of the door system.

Doors closed by a return spring or counterweight-type device shall be equipped with an obstruction-sensing device that, at a minimum, alerts the driver if an obstruction is detected between the closing doors. Doors closed by a return spring or counterweight type device, when unlocked, shall be capable of being pushed to the point where the door starts to open with a force not to exceed 25 lb applied to the center edge of the forward door panel.

Whether or not the obstruction-sensing system is present or functional, it shall be possible to withdraw a 1½ in. diameter cylinder from between the center edges of a closed and locked door with an outward force not greater than 35 lb.

* + 1. Rear Door Closing Force (Transit Coach)

Power-close rear doors shall be equipped with an obstruction-sensing system such that if an obstruction is within the path of the closing doors, the doors will stop and/or reverse direction prior to imparting a 10 lb force on 1 in.2 of that obstruction.

Actuators

Doors shall open or close completely in not more than 3.5 seconds from the time of initial door movement and shall be subject to the closing force requirements.

Control algorithms shall ensure satisfaction of the above requirements while maintaining safe door operation. In cases where these requirements are mutually exclusive, the safety requirement must be prioritized. Actuators and the complex door mechanism shall be concealed from passengers but shall be easily accessible for servicing. The door actuators shall be rebuildable. If powered by compressed air, exhaust from the door system shall be routed below the floor of the bus to prevent accumulation of any oil that may be present in the air system and to muffle sound.

Door actuators and associated linkages shall maximize door holding forces in the fully open and fully closed positions to provide firm, non-rattling, non-fluttering door panels while minimizing the force exerted by the doors on an obstruction midway between the fully open and closed positions.

«passenger\_doors\_actuators\_»

Doors that employ a “swing” or pantograph geometry and/or are closed by a return spring or counterweight-type device shall be equipped with a positive mechanical holding device that automatically engages and prevents the actuation mechanism from being back-driven from the fully closed position. The holding device shall be overcome only when the driver’s door control is moved to an “Exit Door Enable” position and the vehicle is moving at a speed of less than 2 mph, or in the event of actuation of the emergency door release.

Locked doors shall require a force of more than 300 lb to open manually. When the locked doors are manually forced to open, damage shall be limited to the bending of minor door linkage with no resulting damage to the doors, actuators or complex mechanism.

* + 1. Actuator (Commuter Coach)

“Reserved”

Emergency Operation

In the event of an emergency, it shall be possible to manually open doors designated as emergency exits from inside the bus using a force of no more than 25 lb after actuating an unlocking device. The unlocking device shall be clearly marked as an emergency-only device and shall require two distinct actions to actuate. The respective door emergency unlocking device shall be accessible from the doorway area. The unlocking device shall be easily reset by the operator without special tools or opening the door mechanism enclosure. Doors that are required to be classified as “emergency exits” shall meet the requirements of FMVSS 217.

Door Control

The door control shall be located in the operator’s area toward the street side of the operator’s controls within the hand reach envelope described in SAE J287, “Driver Hand Control Reach.” The driver’s door control shall provide tactile feedback to indicate commanded door position and resist inadvertent door actuation.

«passenger\_doors\_door\_control»

Door Controller

* + 1. Transit Coach

«door\_controller\_transit\_coach»

* + 1. Commuter Coach

“Reserved”

Door Open/Close

«passenger\_doors\_door\_open\_close»

Passenger Door Interlocks

In nonemergency operation, to prevent opening mid and rear passenger doors while the bus is in motion, a speed sensor shall be integrated with the door controls to prevent the mid/rear doors from being enabled or opened unless the bus speed is less than 2 mph.

A positive brake application shall be required to engage or disengage the interlock system.

Doors shall not open until the bus is less than 2 mph and the brake interlock is engaged. Once the vehicle has come to a full stop, to preclude movement of the bus, an accelerator interlock shall lock the accelerator in the closed position, and a brake interlock shall engage the service brake system to stop movement of the bus when the driver’s door control is moved to a mid/rear door enable or open position, or a mid or rear door panel is opened more than 3 in. from the fully closed position (as measured at the leading edge of the door panel from the door closed position). Sensors will be used to sense the closed position of each door panel. The interlock engagement shall be capable of holding a fully loaded bus on a 6% grade until the interlocks are released; for diesel and CNG propulsion, this holding capability on a 6% grade may be met with the transmission in gear. These interlock functions shall be active whenever the vehicle master run switch is in any run position.

See Table 9.

«passenger\_door\_interlocks\_interlock\_syst»

«passenger\_door\_interlocks\_interlock\_fron»

**Table 9**Passenger Door Interlocks

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Brake Pedal** | **Vehicle Speed** | **Rear Door Controller Position** | **Brake/ Accelerator Interlocks** | **Service Brakes** | **Doors** | **Remarks** |
| **Normal Driving** | | | | | | |
| OFF | >2 mph | Closed | Off | Off | Closed |  |
| ON | >2 mph | Closed | Off | Off | Closed |  |
| OFF | <2 mph | Closed | Off | Off | Closed |  |
| ON | <2 mph | Closed | Off | Off | Closed |  |
| **Accidental or Intentional Door Control Actuation** | | | | | | |
| OFF | >2 mph | Open | Off | Off | Closed | Driver accidentally places door controller in open position. |
| ON | >2 mph | Open | Off | Off | Closed |  |
| OFF | <2 mph | Open | Off | Off | Closed | Bus coasts below 2 mph. |
| ON | <2 mph | Open | On | Off | Open | Interlocks turn on and doors start to open *after* brake application when speed is below 2 mph. |
| ON | <2 mph | Open | On | On | Open | Full stop. Doors fully open. |
| OFF | <2 mph | Open | On | On | Open | Driver releases brake pedal. |
| OFF | <2 mph | Close | On | On | Open | Driver commands door to close. Doors start to close. |
| OFF | <2 mph | Close | On | On | Closed | Doors fully closed and locked. Interlocks remain on. Brake application required to cancel. |
| ON | <2 mph | Close | Off | Off | Closed | Positive brake application cancels interlocks. Bus can now move. |

Accessibility Provisions

Space and body structural provisions shall be provided at the front or rear door of the bus to accommodate a wheeled mobility device loading system and shall comply with relevant regulations on mobility aid accessibility in the ADA.

Loading Systems

There are two options:

* low-floor ramp
* platform (boarding bridge plate) level boarding

Loading System for 30 to 60 ft Low-Floor Bus

The wheeled mobility device ramp control system must be capable of receiving multiplex commands from vehicle interlocks.

An automatically controlled, power-operated ramp system compliant to requirements defined in 49 CFR Part 38, Subpart B, §38.23c, shall provide ingress and egress quickly, safely and comfortably, both in forward and rearward directions, for a passenger in a wheeled mobility device from a level street or curb. This ramp system shall allow manual deployment when necessary.

«accessibility\_provisions\_loading\_system\_»

Configuration

«accessibility\_provisions\_configuration\_h»

«accessibility\_provisions\_configuration\_»

Loading System for Level Boarding on a 45 to 60 ft Low-Floor BRT

For level-entry boarding in applications such as BRT, where the vertical transition from the vehicle floor and the boarding and alighting surface is no more than 3 in., a bridge plate shall be used. Bridge plates 30 in. or longer shall support a load of 600 lb, placed at the centroid of the ramp or bridge plate distributed over an area of 26 × 26 in., with a safety factor of at least 3, based on the ultimate strength of the material. Bridge plates shorter than 30 in. shall support a load of 300 lb. When deployed to boarding and alighting surface, the slope of the bridge plate shall not exceed 6:1.

«accessibility\_provisions\_loading\_system1»

Wheeled Mobility Device Accommodations

All passenger securement devices must be stowed off the floor and out of the way when not in use.

NOTE: Agency will approve acceptable securement system.

«accessibility\_provisions\_wheelchair\_acco»

Interior Circulation

Maneuvering room inside the bus shall be compliant with 49 CFR Part 38, Subpart B, §38.29, and accommodate easy travel for a passenger in a wheeled mobility device from the loading device and from the designated securement area. It shall be designed so that no portion of the wheeled mobility device protrudes into the aisle of the bus when parked in the designated parking space(s). When the positions are fully utilized, an aisle space of no less than 22 in. shall be maintained. As a guide, no width dimension should be less than 34 in. Areas requiring 90 deg turns of wheeled mobility devices should have a clearance arc dimension no less than 45 in., and in the parking area where 180 deg turns are expected, space should be clear in a full 60 in. diameter circle. A vertical clearance of 12 in. above the floor surface should be provided on the outside of turning areas for wheeled mobility device footrests.

Wheeled Mobility Device Lifts (Commuter Coach)

Lift

“Reserved”

Lift Door

“Reserved”

Lift Doorway

“Reserved”

Lighting Requirements

“Reserved”

Securement System

“Reserved”

SIGNAGE AND COMMUNICATION

Destination Signs

«destination\_signs\_location»

All signs shall be controlled via a single human-machine interface (HMI). In the absence of a single mobile data terminal, the HMI shall be conveniently located for the bus driver within reach of the seated driver.

«destination\_signs\_controller»

«destination\_signs\_requirements»

Passenger Information and Advertising (Transit Coach)

Interior Displays

Provisions shall be made on the rear of the driver’s barrier or equipment box located on the wheel well for a frame to retain information such as routes and schedules.

Advertising media 11 in. high and 0.09 in. thick shall be retained near the juncture of the bus ceiling and sidewall. The retainers may be concave and shall support the media without adhesives. The media shall be illuminated by the interior light system.

Exterior Displays

Provisions shall be made to integrate advertising into the exterior design of the bus. Advertising media, frames or supporting structures shall not detract from the readability of destination signs and signal lights, and shall not compromise passenger visibility. Advertising provisions shall not cause pedestrian hazards or foul automatic bus-washing equipment, and shall not cover or interfere with doors, air passages or vehicle fittings, or in any other manner restrict the operation or serviceability of the bus.

Passenger Stop Request/Exit Signal

Transit Coach

«passenger\_stop\_exit\_transit\_coach\_signal»

«passenger\_stop\_exit\_transit\_coach\_locati»

Commuter Coach

“Reserved”

Signal Chime

«communications\_signal\_chime\_transit\_coac»

Communications

Camera Surveillance System

«communications\_camera\_surveillance\_syste»

Public Address System

A public address system shall be provided on each bus for facilitating automated stop announcements and driver-originated announcements to passengers.

* + 1. Speakers

«communications\_public\_address\_system\_spe» interior loudspeakers shall be provided, semi–flush mounted, on alternate sides of the bus passenger compartment, installed with proper phasing. Speaker impedance shall match load requirements of the amplifier.

Automatic Passenger Counter (APC)

«communications\_automatic\_passenger\_count»

Radio Handset and Control System Options

* + 1. Driver’s Speaker

Each bus shall have a recessed speaker in the ceiling panel above the driver. This speaker shall be the same component used for the speakers in the passenger compartment. It shall have 8 ohms of impedance.

* + 1. Handset

Contractor shall install a handset for driver use.

* + 1. Driver Display Unit

Contractor shall install a driver display unit as close to the driver’s instrument panel as possible.

* + 1. Emergency Alarm

Contractor shall install an emergency alarm that is accessible to the driver but hidden from view.

Event Data Recorder

«event\_data\_recorder\_»

Approved Equals

Table 10 lists products that have been approved for the bus procurement. The list contains products that are of interest to the Agency and is not intended to be a comprehensive listing of every product required for the manufacture of the subject buses. Product categories not listed are left to the discretion of the Contractor so long as the product complies with the specifications. Product specification information is for reference only and may not reflect the latest or future improvements by manufacturers. Any change, revision or substitution of specified products requires approval of the Agency. To add to or revise this list, the Contractor must submit a written request per the Specification by the due date found in the RFP for approved equals.

Note: Agencies are encouraged to list as many suppliers as possible.

|  |  |  |
| --- | --- | --- |
| TABLE 10  Approved Equals Products | | |
| **Product** | **Manufacturer** | **Product Specification** |
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Life Cycle Cost

Manufacturer shall provide a 12-year life cycle cost projection based on the Agency’s duty cycle with its cost proposal.

Fuel or energy consumption, all preventive and corrective maintenance labor, parts and supplies expense, and any rehabilitation or other required investment to maintain the bus in a state of good repair for 12 years, shall be included. Bus operator labor and daily servicing labor shall not be included.