TABLE OF CONTENTS

1.0 SCOPE

1.1 GENERAL

This specification establishes the requirements for Zero Emissions Buses (ZEB); both Battery Electric Buses (BEB) and Fuel Cell Electric Buses (FCEB).

The State of California Department of General Services (DGS) in collaboration with the transportation districts within the State, seek to establish agreement(s) for the purchase of the most modern heavy-duty transit buses available. Intent is to maximize passenger appeal in appearance, comfort, and safety, combined with excellence in reliability, operating characteristics, and economy of operation.

Heavy-duty buses shall be purchased with a basic configuration of 30 ft., 35 ft., 40 ft., 45 ft. and articulated 60 ft., low or high-floor, fuel cell, battery electric, extended-range, zero emission "advanced design". These buses shall be designed for general service in densely populated areas on urban arterial streets and shall be designed to operate in transit service for at least 40,000 miles per year for a minimum expected life of twelve (12) years or 500,000 miles, whichever comes first.

Note: Extended range of a BEB is defined as an operating range of ≥100 miles. Operating range is defined as usable energy/operating efficiency.

These buses are intended for a wide possible spectrum of passengers, including children, adults, the elderly and people with disabilities.

All vehicles offered by any prospective contractor shall meet the following applicable requirements or equivalent, but not limited to these listed:

- Americans with Disabilities Act (ADA)
- Altoona Testing Requirements
- American Society of Mechanical Engineers (ASME)
- American Society for Testing and Materials (ASTM)
- Code of Federal Regulations (CFR)
- California Vehicle Codes (CVC)
- Department of Transportation (DoT)
- Environmental Protection Agency (EPA) - Federal Emission Certification for Heavy-Heavy Duty Vehicles
- Federal Motor Carrier Safety Administration (FMCSA)
- Federal Motor Carrier Safety Standards (FMCSS)
- Federal Motor Vehicle Safety Standards (FMVSS)
- Federal Transportation Agency (FTA) - Buy America guidelines
- NFPA 52 - CNG/LNG Fuel Systems (Standard for California due to CVC requirements)
- Society of Automotive Engineers (SAE)

1.2 OPERATING ENVIRONMENT

The bus shall achieve normal operation in ambient temperature ranges of 10 ºF to 115 ºF, at relative humidity between 5 percent and 100 percent. Degradation of performance due to atmospheric conditions shall be minimized at temperatures below 10 °F, above 115 °F. Speed, gradability and acceleration performance requirements shall be met at, or corrected to, per Section 2.2 of this document.

1.3 MATERIALS

Materials used in the construction of the passenger compartment of the bus shall be in accordance with the Recommended Fire Safety Practices defined in FMVSS 302.

1.4 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.

1.5 SERVICE LIFE

The minimum useful design life of the bus in transit service shall be at least twelve (12) years or 500,000 miles. It shall be capable of operating at least 40,000 miles per year, including the 12th year.

2.0 SPECIFICATIONS, STANDARDS AND CODES

2.1 GENERAL

These specifications are not intended to dictate any specific design, but rather are intended to indicate the base type of bus and equipment desired by the State and minimum requirements of bus performance, which must be achieved. These specifications define requirements for a base heavy-duty zero-emissions fuel cell and battery-electric transit bus to be used for both suburban express service and general service on urban arterial streets. Specific bus options not included in the specification and base bus shall be configured directly with the bus manufacturer and/or dealer.

2.2 ALTOONA TESTING

The buses shall be Altoona tested and meet any other bus testing requirements. Prior to acceptance of first bus, the vehicle must have completed any FTA required Altoona testing. Any items that require repeated repairs or replacement must undergo the corrective action with supporting test and analysis.

2.3 VEHICLE CODES

The contractor shall comply with all applicable federal, state and local regulations. These shall include but not be limited to ADA, as well as state and local accessibility, safety and security requirements. Buses shall meet all applicable FMCSS and CVC regulations and shall accommodate all applicable FMCSS regulations in effect at the location of the transit agency and the date of manufacture. The mounting of hardware shall not be used to provide the sole source ground, and all hardware shall be isolated from potential Electromagnetic Interference/Radio-Frequency Interference (EMI/RFI), as referenced in SAE J1113. The electrical system and its electronic components shall be capable of operating in the area of the vehicle in which they will be installed, as recommended in SAE J1455. Electrical/electronic hardware and its mounting shall comply with the shock and vibration requirements of SAE J1455.

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. As a recommendation, no vehicle component shall generate, or be affected by, electromagnetic interference or radio-frequency interference (EMI/RFI) that can disturb the performance of electrical/electronic equipment as defined in SAE J1113 and UNECE Council Directive 95/54 (R10).

The contractor shall be responsible for ensuring that the entire fuel system, to include, fuel containers, brackets, mounting systems, delivery lines, operating pressures, fuel pressure regulators, fuel cell, piping, connections, gauges, breakaway connections, valves, pressure relief devices, path for the fuel flow, fuel cell requirements and any other related to the hydrogen fuel system meets all applicable Federal, State and Local codes, and represent the highest state of industry practice. In the absence of applicable regulation or specification, decisions shall be based upon safety, reliability and ability to be maintained.

3.0 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 transit 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.

3.1 WEIGHT

It shall be a design goal to construct each bus as light in weight as possible without degradation of safety, appearance, comfort, traction or performance. Buses at a capacity load shall not exceed the tire factor limits, brake test criteria or structural design criteria.

3.2 CAPACITY

The vehicle shall be designed to carry the gross vehicle load weight, which shall not exceed the bus Gross Vehicle Weight Rating (GVWR).

3.3 BUS LENGTHS

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.

Configuration	Length	Dimensions (to include tolerance)
1	30-Foot Bus	29 ft. 11 in.to 34 ft., 11 in.
2	35-Foot Bus	35 ft. to 39 ft., 11 in.
3	40-Foot Bus	40 ft. to 44 ft., 11 in.
4	45-Foot Bus	45 ft. to 47 ft.
5 (Articulated)	60-Foot Bus	59 ft. to 65ft.

3.4 BUS WIDTH

Body width shall be ≥ 95 ≤ 102 inches.

3.5 POWERPLANT

3.5.1 Drive System Description

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

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

The drive system shall be sized to provide sufficient power to enable the bus to meet Altoona Federal Bus Test for Performance, and operate all drive accessories.

The bus shall be powered by a zero-emission fuel cell or battery electric drive system. The power source for the vehicle shall be derived from established fuel cell or battery technology that has a field-proven track record of safe, reliable, and durable operation in similar traction applications.

3.5.2 Traction Motor

The traction motor shall be able to provide and recover kinetic energy as well as retard mechanical momentum (regenerative braking). The traction motor shall be a permanent magnet or equivalent AC induction type with a minimum power rating of at least 160 kW and be able to achieve torque ≥1019 N*m(750 lb-ft). Traction motor speed control shall be continuously variable.

3.5.3 Energy Storage System (ESS): Battery Electric and Fuel Cell

Design and performance shall be provided to the transit agency. Energy storage shall be of a commercial design capable of operating in the transit agency environment. The total nominal system storage capacity shall be suitable for the desired operating profile and range of the bus. A thermal management system separate from the cooling system of the traction motor shall be provided to ensure optimal life and performance of the battery system over the environmental operating range.

3.5.3.1 Battery Electric System (BES)

Function and operation of the bus shall be transparent to the bus operator and passengers. The BES 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 storage types and shall comply with UN/DOT 38.3 requirements for batteries.

3.5.3.2 Fuel Cell System

The fuel cell bus shall be comprised of a hydrogen fuel cell system generating electrical power to a battery, which transmits mechanical power to the drive axle using a motor. A BES shall augment the drive system by supplying high levels of power to assist in acceleration of the vehicle as well as storing energy during regeneration while braking. The ESS, fuel cell and/or BES drive system combination must have application testing and approval from their respective manufacturers.

All included components shall be capable of diagnostics, archive of failure data, adaptive learning (as applicable) and programming via electronic interfaces.

The bus shall be capable of being reliably fueled to within 95 to 100 percent of the tank's useable capacity, regardless of beginning fuel tank(s) pressure. The fuel system shall incorporate provisions for individual tank de-fueling.

The tank manufacturer shall permanently mark on every fuel tank the capacity, date of manufacture or expiration date, manufacturer name, and certification of compliance to FMCSR, ASME or DOT to include applicable pressure rating. These markings shall be clearly visible when the fuel tank's storage door is opened. DO NOT STEP ON THE HYDROGEN TANK shall be clearly visible and permanently marked on all fuel tanks. Additionally, every tank shall be permanently marked at every location where a securing strap or a fixed reference point is located to indicate if each fuel tank is experiencing physical displacement or rotating movement during the operation of the bus.

Note: With full understanding that Fuel Cell System storage regulations for heavy duty vehicles continue to be in flux, the fuel system shall be expected to meet at minimum the following overall requirements:

- HGV 2-2014 (or more recent if applicable)
- SAE J2578
- SAE J2579

3.5.4 Electric Vehicle System Controller (EVSC)

The drive system shall be able to self-regulate, manage and control energy flow throughout the drive system in order to provide motive performance, storage and accessory loads, as applicable, while maintaining critical system parameters (e.g., voltages, currents, temperatures, etc.) within specified operating ranges.

3.5.5 Shop/Depot Charging/Fueling Connections

The battery electric bus (BEB) shall able to interface and receive a charge from shop/depot charging equipment. The shop/depot charger connection interface shall be located in an appropriate location based on the transit agency's infrastructure for charging and the charger interface shall have its own access door.

Note: For Battery Electric Bus Charging, Standard J1772 Charging capability shall be included with manufacturer's suggested charging location.

The fuel cell bus shall have a shop/depot fueling connection/interface and shall be located in an appropriate location based on the transit agency's infrastructure for fueling and the fuel connector shall have its own access door.

Fueling ports shall be provided in a configuration whereby a/either port can be used to refill the hydrogen storage system.

The fueling port(s) receptacle, nozzle/receptacle shall be ANSI/AGA/ NFPA 2 certified and the bus shall be capable of being fueled by a nozzle at high or low flow rates. The transit agency, at the pre-production meeting, shall provide detailed information about fueling nozzle(s).

Note: The fueling port(s) receptacle shall be such that connection, by fueling personnel shall be performed without physical strain or interference.

3.6 COOLING AND THERMAL MANAGEMENT SYSTEM

The cooling/thermal management systems shall be of sufficient size to maintain all drive system operating temperatures during severe transit duty cycles in accordance to ambient conditions as specified in Section 1.2 and in accordance with the drive system manufacturers' temperature requirements.

3.7 ENERGY STORAGE SYSTEM THERMAL MANAGEMENT

The ESS shall be supported by a full thermal management system to keep the Li-ion batteries at optimal operational temperature to assure performance and long life. The ESS thermal management system shall be independent and separate from the traction motor cooling system.

When heat is required, an independent heating system specifically tailored to ESS heating shall apply heat to the batteries.

3.8 STRUCTURE

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 transit agency shall be considered for this purpose.

3.9 CHASSIS

3.9.1 Suspension

The front, rear and mid (if articulated bus) suspensions shall be pneumatic type. The basic suspension system shall last the service life of the bus without major overhaul or replacement. 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.

3.9.1.1 Kneeling

A kneeling system shall lower the entrance(s) of the bus a minimum of 2 in. during loading or unloading operations regardless of load up to GVWR, measured at the longitudinal centerline of the entrance door(s) by the driver.

3.9.1.2 Mounting

All traction motor mounting shall be mechanically isolated to minimize transfer of vibration to the body structure and provide a minimum clearance of 0.75 in. from the body/frame. Mounts shall control the movement of the traction motor so as not to cause strain in piping and wiring connections to the traction motor.

3.10 WHEELS AND TIRES

3.10.1 Wheels

All wheels shall be interchangeable. Wheels shall be compatible with tires in size and load-carrying capacity. Front and rear wheels and tires shall be balanced as an assembly per SAE J1986.

3.10.2 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 manufacturer's rating.

3.11 BRAKES

3.11.1 Service Brake

Buses shall be equipped with brake systems that conform to the requirements of all Federal and State of California regulations, designed so such conformance can be maintained throughout the normal adjustment cycle. The braking system shall include service brakes, a parking and emergency brake. Brakes shall be self-adjusting.

3.11.2 Actuation

Service brakes shall be controlled and actuated either pneumatically, electrically or hydraulically. Force to activate the brake pedal control shall be an essentially linear function of the bus deceleration rate and shall not exceed 75 lbs. at a point 7 in. above the heel point of the pedal to achieve maximum braking. The heel point is the location of the driver's heel when his or her foot is rested flat on the pedal and the heel is touching the floor or heel pad of the pedal.

3.12 INTERLOCKS

3.12.1 Passenger Door Interlocks

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.

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).The interlock engagement shall bring the bus to a smooth stop and shall be capable of holding a fully loaded bus on a 6 percent grade, with the traction motor in gear, until the interlocks are released. These interlock functions shall be active whenever the vehicle master run switch is in any run position.

3.13 ELECTRICAL/ELECTRONIC AND DATA COMMUNICATION SYSTEMS

3.13.1 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. Shield(s) shall be connected to at least one location, typically at the end of the cable. However, certain standards or special requirements, such as SAE J1939 or RF applications, have separate shielding techniques that also shall be used, as applicable.

3.13.2 Data Communications

All data communication networks shall be either in accordance with a nationally recognized interface standard, such as those published by SAE, Institute of Electrical and Electronics Engineers (IEEE) or International Organization for Standardization (ISO).

3.14 DRIVER PROVISIONS/CONTROLS AND INSTRUMENTATION

3.14.1 Driver's Area Controls

The driver's area shall conform to SAE J833, "Human Physical Dimensions,". Switches and controls shall be divided into basic groups and assigned to specific areas, in conformance with SAE Recommended Practice J680, revised 1988, "Location and Operation of Instruments and Controls in Motor Truck Cabs," and be essentially within the hand reach envelope described in SAE Recommended Practice J287, "Driver Hand Control Reach".

Please Note: As applicable to this requirement, prime importance/intent is the basic premise that all controls requiring operation while the vehicle is in motion be located so that the driver can manipulate them with his right hand and keep his left hand on the steering wheel.

3.14.2 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 of the bus shall be conveniently located and shall provide for ease of operation. They shall be identifiable by shape, touch and permanent markings. Controls also shall be located so that passengers may not easily tamper with control settings.

All panel-mounted switches and controls shall be marked with easily read identifiers. Graphic symbols shall conform to SAE Recommended Practice 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.

3.14.3 Driver Seat

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, in height and weight, may operate the bus.

3.14.4 Driver Seat Belt

The belt assembly should be an auto-locking retractor (ALR) or Emergency Locking Retractor (ELR) type system or equivalent. All seat belts should be stored in automatic retractors. The belt 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 207 and 210.

3.14.5 Driver's Amenities

A suitable coat hanger shall be installed in a convenient, approved location for the driver's coat.

3.14.6 Storage Box

An enclosed driver storage area shall be provided with a positive latching door and/or lock.

3.15 MIRRORS

3.15.1 Exterior Mirrors

The bus shall be equipped with either manual or remote operated flat mirrors with manual convex mirrors, heated or non-heated, 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 with an auto-return breakaway mounting system. 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 retract or fold sufficiently to allow bus washing operations but avoid contact with windshield.

3.15.2 Interior Mirrors

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.

3.16 WINDOWS

3.16.1 Windshield

The windshield shall permit an operator's field of view as referenced in SAE Recommended Practice 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 external glare as well as reflections from inside the bus.

Note: Additional mounted mirror(s) may be provided to assist with driver detection of object to meet the above requirement.

3.16.2 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. The upper portion of the windshield above the driver's field of view shall have at a minimum of either a dark, shaded band and marked AS-3, with a minimum luminous transmittance of 5 percent when tested in accordance to ASTM D-1003 or single shade, black, non-transparent masking with a zero light transmittance. Zero light transmittance will void all glare from the upper portion of the windshield.

3.16.3 Driver's Side Window

The driver's side window shall be the sliding type or three (3) section driver's side window (upper-section non-opening) and shall allow the seated operator to easily adjust the street-side outside rearview mirror. This window section shall slide in tracks or channels designed to last the service life of the bus. The operator's side window shall not be bonded in place and shall be easily replaceable. The glazing material shall have either a single-density tint throughout or in the upper-section of the three (3) section window option if utilized.

The driver's side window glazing material shall have a ¼ in. nominal thickness laminated safety glass conforming to the requirements of ANSI Z26.1-1996 Test Grouping AS-2 and the recommended practices defined in SAE J673.

Note: 5 mm nominal thickness tempered glass is also an acceptable material for the driver's side window glazing if laminated glass is not available due to design/shape based on vehicle window configuration.

3.16.4 Passenger Windows

Passenger windows shall be easily replaceable without disturbing adjacent windows and shall be mounted so that flexing or vibration from drive system operation or normal road excitation is not apparent. All aluminum and steel material will be treated to prevent corrosion.

3.16.5 Emergency Exit (Egress) Configuration

All side windows shall be fixed in position, except as necessary to meet the emergency escape requirements per 49 CFR 571.217 - Bus Emergency Exits and Window Retention and Release.

3.17 HEATING, VENTILATING AND AIR CONDITIONING (HVAC)

3.17.1 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. With the bus running at the design operating profile with corresponding door opening cycle, and carrying a number of passengers equal to 150 percent 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 percent 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 percent.

3.17.2 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 J1939 Communication Protocol for receiving and broadcasting of data.

3.17.3 Heater

The bus shall have an electric heater or heat pump and shall be equipped with safety devices to avoid overheating during operation.

The unit shall be electronically controlled with appropriate diagnostics for troubleshooting. Operation, as well as diagnostic data, shall be stored and shall be retrievable through a PC. The auxiliary heater maintenance/diagnostic information shall be communicated through the appropriate protocol, SAE J1708 or J1939.

3.17.4 Controls for the Climate Control System (CCS)

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

3.17.5 Heat/Defrost System Fan

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.

3.17.5.1 Cable length

If a cable-operated manual control valve is used, then the cable length shall be kept to a minimum to reduce cable seizing.

3.17.6 Driver's Heating, Ventilation and Defroster System

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:

3.17.6.1 Driver's heater and defroster system

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. Fan(s) 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 cubic feet per minute (cfm) shall be provided. The driver shall have complete control of the heat and fresh airflow for the driver's area.

3.17.6.2 Defroster supply outlets

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.

3.17.7 Air Filtration

Air shall be filtered before entering the Air Conditioning (AC) system and being discharged into the passenger compartment.

3.17.8 Roof Ventilator(s)

Each ventilator shall be easily opened and closed manually. When open with the bus in motion, ventilator(s) shall provide fresh air inside the bus. An escape hatch shall be incorporated into the roof ventilator(s). Roof ventilator(s) shall be sealed to prevent entry of water when closed.

3.18 EXTERIOR PANELS, FINISHES AND EXTERIOR LIGHTING

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 anybody feature to freeze or bleed out onto the bus aft.er 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.

3.18.1 Exterior panels

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.

3.18.2 Body 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.

3.18.3 Roof-Mounted Equipment

A non-skid, clearly marked walkway or steps shall be incorporated on the roof to provide access to equipment without damaging any system or bus paneling.

3.18.4 Repair and Replacement - Side Body Panels

Structural elements supporting exterior body panels shall allow side body panels below the windows to be repaired in lengths not greater than 12.5 ft.

Note: If composite body used for body design, repair and replacement body panel requirement may not apply. However, Section 3.18.11 Finish and Color requirements still apply to body.

3.18.5 Rain Gutters

Rain gutters or equivalent system 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.

3.18.6 License Plate Provisions

Provisions shall be made to mount standard-size U.S. license plates per SAE J686 on the front and rear of the bus. These provisions shall direct-mount or recess the license plates so that 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.

3.18.7 Splash Aprons

Splash aprons, composed of ¼ in. minimum composition or rubberized fabric, shall be installed behind and/or in front of wheels as needed to reduce road splash and to protect under floor components. The splash aprons shall extend downward to within 6 in. off the road surface at static conditions. Apron widths shall be no less

than tire widths. Splash aprons shall be bolted to the bus understructure. Splash aprons and their attachments shall be inherently weaker than the structure to which they are attached. The flexible portions of the splash aprons shall not be included in the road clearance measurements. Splash apron shall be installed as necessary to protect the wheelchair loading device from road splash. Other splash aprons shall be installed where necessary to protect bus equipment.

3.18.8 Service Compartments and Access Doors

Conventional or pantograph hinged doors shall be used for the rear ESS compartment and for all auxiliary equipment compartments. 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 over-center 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 shall allow for the servicing of other components or systems.

3.18.9 Access Door Latch/Locks

Access doors larger than 100 sq. in. in area shall be equipped with corrosion-resistant flush-mounted latches or locks except for fuel fill access doors. All such access doors that require a tool to open shall be standardized throughout the vehicle and will require a nominal 5/16 in. square male tool to open or lock.

3.18.10 Bumpers

Bumpers shall provide impact protection for the front and rear of the bus. Bumper height shall be such that when one bus is parked behind another, a portion of the bumper faces will contact each other.

3.18.10.1 Front Bumper

No part of the bus, including the bumper, shall be damaged as a result of a greater than 1.5 mph impact of the bus at curb weight with a fixed, flat barrier perpendicular to the bus's longitudinal centerline. 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 FMVSS 301, loaded to 4000 lbs. parallel to the longitudinal centerline of the bus. It shall protect the bus from damage as a result of a 3.2 mph impact 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.

3.18.10.2 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/sec. 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 lbs., 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 preclude 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.

3.18.11 Finish and Color

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.

Note: If equipment is pre-installed prior to painting, the equipment installed will be considered part of the bus body system when applying finish and color. Color and finishes shall match and be consistent as a system.

Proper adhesion between the basic surface and successive coats of the original paint shall be measured using an adhesion tester as outlined in ASTM D4541-85. Adhesion shall be a minimum 300 ft.-lbs. 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.

The bus shall be the manufacturer's basic paint color bus, with no clear coat and no customer specific exterior decals such as transit agency logos. Fleet number & safety decals are still required prior to acceptance of the vehicle.

Note: Optional color paint/coatings or decaling shall be provided separately for review.

3.18.12 Decals, Numbering and Signing

Bus numbers and other required signing shall be applied to the inside and outside of the bus as required. Signs shall be durable and fade-, chip- and peel-resistant. They may be painted signs, decals or pressure-sensitive appliqués. Signs shall be provided in compliance with the ADA requirements.

3.18.13 Passenger Information

ADA priority seating signs as required shall be provided to identify the seats designated for passengers with disabilities.

3.18.14 Backup Light/Alarm

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

3.18.15 Doorway Lighting

Lamps at the front and rear passenger doorways 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 foot-candle 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.

3.18.16 Turn Signals

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

3.18.17 Headlights

Headlamps shall be designed for ease of replacement.

3.18.18 Brake Lights

Brake lights shall be provided in accordance with federal regulations. The bus shall include red, high and center mount brake lamp(s) along the backside of the bus in addition to the lower brake lamps required under FMVSS. The high and center mount brake lamp(s) shall illuminate steadily with brake application. Transit agency to specify the size of the high and center mount brake lamp(s).

3.18.19 Service Area Lighting (Interior and Exterior)

LED lamps shall be provided in the rear ESS compartment (as applicable) 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 rear ESS 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.

3.19 INTERIOR PANELS/FINISHES AND LIGHTING

Materials shall be selected on the basis of maintenance, durability, appearance, safety, 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.

3.19.1 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 are required to meet FMVSS 302.

3.19.2 Driver Area Barrier

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 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.

3.19.3 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 its 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. above the floor. Panels forward of longitudinal seats shall extend to below the level of the seat cushion. 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. 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 lbs. applied to a 4 × 4 in. area in the center of the panel without permanent visible deformation.

3.19.4 Fastening

Interior panels shall be attached so that there are no exposed unfinished or 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 where required shall be tamper resistant.

3.19.5 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 rear ESS 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.

3.19.6 Floor Covering

The floor covering shall have a non-skid 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. The standee line shall be approximately 2 in. wide and shall extend across the bus aisle. The color and pattern shall be consistent throughout the floor covering.

3.19.7 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.

3.19.8 Driver's Area

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 5 to 10 foot-candles.

3.19.9 Seating Areas

The interior lighting system shall provide a minimum 15 foot-candle illumination on a 1 sq. ft. plane at an angle of 45 degrees 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 foot-candles.

3.19.10 Vestibules/Doors

Floor surface in the aisles shall be a minimum of ten (10) foot-candles, and the vestibule area a minimum of four (4) foot-candles with the front doors open and a minimum of Zero foot-candles with the front doors closed. The front entrance area and curb lights shall illuminate when the front door is open and master run switch is in the "lights" positions. Rear exit area and curb lights shall illuminate when the rear door is unlocked.

3.19.11 Step Lighting

Step lighting for the intermediate steps between lower and upper floor levels shall be a minimum of 4 foot-candles and shall illuminate in all drive system 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.

3.19.12 Ramp Lighting

Exterior and interior ramp lighting shall comply with federal regulations.

3.19.13 Turntable Lighting (Articulated Coach)

Lighting in the turntable can be reduced to 7 foot-candles.

3.19.14 Farebox Lighting

A light fixture shall be mounted in the ceiling above the farebox location. The fixture shall be capable of projecting a concentrated beam of light on the farebox. This light will automatically come on whenever the front doors are opened and the run switch is in the “night run” or “night park” position.

3.19.15 Fare Collection

Space and structural provisions shall be made for installation of currently available fare collection devices, which shall be as far forward as practicable. Location of the fare collection device shall not restrict traffic in the vestibule, including wheelchairs 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 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 Recommended Practice 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.

3.19.16 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 over-center 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.

3.20 PASSENGER ACCOMMODATIONS

3.20.1 Passenger Seating - Arrangements and Seat Style

The passenger seating arrangement in the bus shall be such that seating capacity is maximized and in compliance to the following requirements. Passenger seats shall be arranged in a transverse, forward-facing configuration, except at the wheel housings and turntable, if applicable, where aisle-facing seats may be arranged as appropriate with due regard for passenger access and comfort. Other areas where aisle-facing seats may be provided are at wheelchair securement areas and platforms. However, if wheelchair accommodation only allows for up to one (1) rearward facing space, and ADA requirements are met, this configuration may be acceptable.

3.20.2 Turntable Seating (Articulated Coach)

Handholds or leaning rail shall be provided.

3.20.3 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 27 in.

3.20.4 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.

3.20.5 Aisles

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).

3.20.6 Aisles (Commuter Coach)

The aisle between the seats shall be no less than 14 in. wide at seated passenger hip height.

3.20.7 Passenger Assists

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 95th-percentile male and the 5th-percentile female standee. 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 the other without losing support.

3.20.8 Assists

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 NHTSA Drawstring Test.

3.20.9 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 and the vertical assist and the assists on the wheel housing or on the front modesty panel.

3.20.10 Vestibule

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.

3.20.11 Rear Doorway(s)

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.

3.20.12 Overhead

Except forward of the standee line and at the rear door, a continuous, full-grip, overhead assists 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. Overhead assists shall simultaneously support 150 lbs. on any 12 in. length. No more than 5 percent of the full grip feature shall be lost due to assist supports.

3.20.13 Passenger Doors

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

3.20.13.1 Front door

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

3.20.13.2 Rear Door(s)

Curbside doorway centerline located forward or rearward of the point midway between the front door centerline and the rearmost seat back. (As applicable) for commuter coach.

3.20.14 Door Glazing

The upper section of both front and rear doors shall be glazed for no less than 45 percent of the respective door opening area of each section. The lower section of the front door shall be glazed for no less than 25 percent of the door opening area of the section. Door glazing shall be easily replaceable. The front door panel glazing material shall have a nominal ¼ in. thick laminated safety glass conforming with the requirements of ANSI Z26.1 Test Grouping 2 and the recommended practices defined in SAE J673.

3.20.15 Door Projection

3.20.15.1 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 curb side mirror when the doors are fully open.

3.20.15.2 Interior

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

3.20.16 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 lbs. 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.

3.20.17 Door Control

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

3.20.18 Accessibility Provisions

Space and body structural provisions shall be provided at the front or rear door of the bus to accommodate a wheelchair loading system.

3.20.19 Loading System for 30 to 60 ft. Low-Floor and High-Floor Buses

An automatically controlled, power-operated ramp system and/or high-floor lift shall be compliant to requirements defined in 49 CFR Part 38, Subpart B, §38.23c and 49 CFR 571.403 (FMVSS 403) shall provide

ingress and egress quickly, safely and comfortably, both in forward and reverse directions, for a passenger in a wheelchair from a level street or curb.

Front door location of loading system, flip-out design ramp with no less than a 6:1 Slope. The wheelchair loading system shall be located at the front or rear door being capable of deploying to the ground at a minimum 6:1 slope.

3.20.20 Wheelchair Accommodations

Two (2) locations, as close to the wheelchair loading system as practical, shall provide parking space and securement system compliant with ADA requirements for a passenger in a wheelchair.

3.20.21 Passenger Stop Request/Exit Signal

A passenger “stop requested” signal system that complies with applicable ADA requirements defined in 49 CFR, Part 38.37, shall be provided. At each wheelchair passenger position and at priority seating positions, additional provisions shall be included to allow a passenger in a mobility aid to easily activate the “stop requested” signal.

An auxiliary passenger “stop requested” signal shall be installed at the rear door to provide passengers standing in the rear door/exit area a convenient means of activating the signal system. The signal shall be a heavy-duty push button type located in the rear door vicinity. Button shall be clearly identified as “passenger signal.”

3.20.22 Signal Chime

A single “stop requested” chime shall sound when the system is first activated. A double chime shall sound anytime the system is activated from wheelchair passenger areas.

Exit signals located in the wheelchair passenger area shall be no higher than 4 ft. above the floor. Instructions shall be provided to clearly indicate function and operation of these signals.