

## **HIGH VOLTAGE-POWERED VEHICLES**

The Mississippi School Bus Minimum Specification is the primary specification for all public-school buses in Mississippi pursuant to Mississippi Code Annotated Section 37-41-1. All applicable provisions of the Mississippi School Bus Minimum Specifications of school bus body and chassis shall be adhered to unless specifically mentioned in this section. This section and specifications listed in this section are for new electric school buses only and does not allow for the modification of any existing school bus.

### **Training For State Personnel, Local School District Personnel, and First Responders**

The vendor shall be required to provide training for state personnel, transportation directors/supervisors, bus shop foreman, school bus mechanics/technicians, bus driver instructors, bus operators, and first responders in the safe and efficient operation, inspection, repair, maintenance, and emergency response of the bus. This training may be provided at multiple locations around the state in response to local demands.

### **Compliance With FMVSS and SAE**

A high voltage-powered vehicle shall meet all Federal Motor Vehicle Safety Standards and all Society of Automotive Engineers standards that are applicable at time of manufacture.

### **Alternator**

The alternator shall meet the applicable state specifications in the School Bus Body and Chassis section. Alternately, the alternator functions may be performed by the Hybrid Drive System Batteries.

### **Battery(ies)**

#### *Low Voltage Battery*

The Low Voltage Battery shall meet the applicable state specifications in the School Bus Body and Chassis. Alternately, the Low Voltage Battery functions may be performed by the Hybrid Drive System Batteries.

#### *Hybrid Drive System Batteries*

- A. Energy storage for the Hybrid Drive System shall be protected from crash impacts and shall be encased in a non-conductive, acid-resistant compartment. This compartment must be well ventilated to preclude the possibility of hydrogen gas buildup. Energy storage shall be located in an area and in such a way as to provide ease of service.
- B. Batteries shall require automatic electrical isolation in the case of a vehicle crash.

- C. The Hybrid Drive System Batteries shall allow for a minimum storage of 28 kWh for charge depletion.
- D. The high voltage battery system integrity shall meet the specified spillage performance standards in accordance with test conditions specified in FMVSS No. 305 as applicable.

#### *Battery Management System*

- A. The Hybrid Drive System Batteries may be equipped with a system that allows the batteries to be charged via connection to the local electric utility, otherwise known as a Plug-in Hybrid Electric system. The plug connector shall make a conductive electrical connection and shall be an Apollo 200 AMP connector by BIW Connector Systems or approved equal.
- B. The Hybrid School Bus shall have equipment for monitoring the status of the batteries while the batteries remain on the vehicle. This equipment shall include the capability to balance the state of charge and monitor temperature of individual battery modules (if appropriate).

#### **Brakes, Service**

The Hybrid School Bus shall include a regenerative braking system that uses the motor and/or generator to slow the vehicle in conjunction with the service brakes while returning electrical energy to the Hybrid Drive System Batteries.

#### **Differential Ratio**

The Differential shall be compatible with the Transmission/Hybrid Drive System and provide for a minimum of 65 mph in highest gear.

#### **Engine Equipment**

- A. The hybrid system shall include a system that deactivates the engine when not in use, such as, at red lights, and reactivates the engine when needed for acceleration.
- B. The engine shall be equipped with system that electrically heats the engine to maintain minimum starting temperature. This system should be integrated with the Plug-in Battery Management System, if so equipped, and not require a separate electrical grid connection. The engine heater shall also heat the fuel filtration system. The engine heater shall be switched to allow this heating to be optional.

#### **Fuel System Capability**



The diesel fuel system shall be capable of operating with a 20 percent biodiesel blend (B20).

## High Voltage System

- A. High Voltage-Powered Vehicles: Buses utilizing a high voltage propulsion system (more than 48 normal volts) shall meet the requirements of FMVSS No. 305, *Electric Powered Vehicles: Electrolyte Spillage and Electrical Shock Protection*, except for the following:
  - 1. The propulsion power source (batteries, fuel cells, etc.) shall be located outside the passenger compartment.
  - 2. The propulsion power source enclosure shall be constructed to conform to the power source manufacturer's requirements and recommendations.
  - 3. Due to the much larger size and quantities of the propulsion power sources on larger vehicles, buses over 10,000 lbs. are permitted to exceed the 5.0-liter spillage constraint of Section S5.1, *Electrolyte damage from propulsion batteries* and the requirements to statically rotate the vehicle on its longitudinal axis posttest.
- B. Wire, cable, and conductor insulation in the High Voltage System shall provide adequate insulation for the voltage used and for ambient temperatures ranging from - 15°F to 120°F. All high voltage circuits shall be bright orange in color or otherwise labeled as HIGH
- C. VOLTAGE. All high voltage circuits shall provide adequate and automatic protection against electrical overloads caused by short circuits or other excessive current conditions through the use of fuses, circuit breakers, and ground fault interruption.
- D. Each door, cover, or other panel that affords immediate access to any high voltage area shall be plainly marked with a hazard warning label which shall read WARNING—HIGH VOLTAGE or DANGER—HIGH VOLTAGE. This label shall be located in a highly conspicuous place. All high voltage access areas shall be equipped with a lock or otherwise secured to prevent unauthorized access.
- E. The High Voltage System should be designed so that when the ignition switch is off, the propulsion motor is positively disconnected. All other accessories powered by the main propulsion battery circuit shall remain operable when the ignition switch is off.
- F. All buses shall be equipped with an additional manual or automatic switch or device independent of the propulsion motor disconnect controls that permits the positive disconnection of all circuits from the Hybrid Drive System Batteries. This

switch shall be operable from outside the vehicle. Each door or panel providing access to this switch shall be plainly marked to indicate that it is a main-power-disconnect switch or device.

### **Ignition System**

The ignition switch circuit shall be linked to the Battery Management System and will prevent driving the vehicle while it is connected to an external battery charging source.

### **Transmission/Hybrid Drive System**

- A. The Hybrid Drive System shall work in conjunction with the chassis engine to provide motive power to the bus. This system shall be automatically controlled requiring no intervention by the driver after it has been put in forward or reverse gear. Systems that require the use of a manual clutch or require the driver to shift through a progression of gears will not be accepted.
- B. The Hybrid drive controller/converter system shall incorporate a Ground Fault Interrupt(GFI) system that protects passengers and others from electrical shock if a shorted circuit or water intrusion situation occurs.
- C. The bus dash shall have an indicator light that indicates whether the bus is operating in Charge Depleting or Charge Sustaining mode. Charge Depleting is an operating mode in which the state of charge of the Hybrid Drive System Battery decreases as the bus operates. At a certain minimum state of charge, the bus becomes Charge Sustaining. Charge Sustaining is an operating mode in which the Battery Management System seeks to maintain or increase the state of charge of the Hybrid Drive System Battery. The Hybrid School Bus shall have the capability to operate in both modes.
- D. The Hybrid Drive System shall have a system for protecting system components from thermal damage due to electrical overload. This system should include temperature sensors at critical points and be capable of reducing Hybrid Drive System electrical power when necessary. The bus dash shall have a warning light that indicates when a Hybrid Drive System component exceeds a safe temperature.
- E. The warning light should illuminate prior to critical temperature to allow sufficient time to safely stop the bus.

### **BATTERY ELECTRIC VEHICLES (BEV)**

#### **BACK-UP ALARM**

BEVs shall be equipped with a back-up alarm to warn other vehicles and pedestrians when the school bus drive is placed in Reverse.



## **BATTERY(IES)**

### *Low Voltage Battery(ies)*

- A. The low voltage battery shall meet the applicable state specifications.
- B. At least one (1) low voltage battery will be installed to provide power to 12VDC circuits.
- C. A low voltage battery shutoff switch shall be installed in the vicinity of the low voltage battery compartment in an area not easily accessible to the driver or passengers. If behind an access door or panel, the location of the low voltage battery shutoff switch must be clearly labeled on the exterior of the door or access panel.

### *High Voltage Battery(ies)*

- A. High voltage battery assemblies shall be located in between or under chassis frame rails protected by a steel cradle.
- B. High voltage batteries shall have a main service disconnect that isolates the batteries and does not allow high voltage outside the battery pack.

## **BATTERY MANAGEMENT SYSTEM**

- A. The high voltage batteries shall be equipped with a system that allows the batteries to be charged via a connection to the local electric utility grid. This connection shall be a Combined Charging System (CCS) or SAE J1772, compatible with the charging equipment.
- B. The charging receptacle/port shall be mounted/located in accordance with manufacturer standards. The receptacle shall accommodate the minimum requirements for Level II AC charging DC fast charging.
- C. If the charging port is behind a door or an access panel, the door or access panel will be clearly labeled with the location of the charging port.
- D. Vehicles shall have on-board equipment to monitor and display battery health. This displayed information shall include but is not limited to:
  - 1. High voltage battery state of charge
  - 2. Motor temp
  - 3. Battery available range in miles
  - 4. Battery discharge and regeneration rates
  - 5. Battery health (temperature, battery cell balancing, as applicable, etc.)