Emergency Response to Hybrid Bus Incidents

BY THOMAS CRIST

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HYBRID ELECTRIC VEHICLE IS POWERED BY AN internal combustion engine with an electric motor. Propulsion can be by the engine, the electric motor, or both at any given time, depending on the system’s design.

These vehicles are becoming more and more common, especially since the oil price spikes of 2008. Most automotive manufacturers have at least one hybrid vehicle in their product line, and many bus and truck manufacturers are now producing hybrid models. As of December 2008, there were 279,847 hybrid vehicles in the United States.¹

Bus travel is much safer than most other forms of highway transportation,² but we still need to prepare for the inevitable. As ridership of public transportation continues at record levels,³ accidents involving buses have the potential for becoming mass-casualty incidents and for involving

Educational Objectives

On completion of this course, students will

1. Describe the differences between a Hybrid Bus and a conventional bus.
2. Describe how to safely de-energize the high voltage electrical system.
3. Describe what different firefighting strategies may be necessary in fighting a fire involving a hybrid bus.
4. Describe the concerns that may arise during the extrication process.

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1. Overall view of the bus, showing roof bulge. (Photos by author unless otherwise noted.)
2. Roofline “Hybrid Electric” lettering.
3. Rear “Hybrid Electric” lettering.
4. Rear and side “Hybrid Electric” lettering.

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many other problems because of the buses’ larger size. Training and preparation now will help us to deal more effectively with incidents in the future.

**BACKGROUND**

Suffolk County, New York, recently put into service four hybrid diesel-electric buses serving the busy Route 110 corridor. Among the reasons for this are the following:

- Fuel cost savings are expected to be as much as 35 percent.
- It will help lessen our dependence on foreign oil.
- There will be lower exhaust emissions and pollutants.
- It’s the “green” thing to do and sets an example.

The buses purchased by Suffolk County are manufactured by the Gillig Corporation. In addition to a full line of conventional buses, Gillig has been making hybrid buses for about seven years. The hybrid vehicle industry is an emerging technology with few standards. Although this article gives information specific to the Gillig Hybrid Buses in use in Suffolk County, it will also provide general safety and operating guidelines for other similar vehicles.

**ARE HYBRID BUSES JUST BIG HYBRID CARS?**

In recent years, we have become familiar with hybrid-electric automobiles and the measures necessary to safely operate around them when they are involved in emergency situations. The concept of both types of vehicles is the same. A combination internal combustion engine and an electric motor are teamed up to power the vehicle. Power for the electric motor is stored in a battery pack with various electronic controls in place to regulate the power.

Some differences between a car and a bus are that everything is heavier and bigger in a bus. The internal combustion engine is diesel and runs continuously when the vehicle is operating, not as in some hybrid cars. The Gillig Hybrid Bus has roof-mounted batteries and a power inverter.

**IDENTIFICATION**

Many outward appearances of the bus look like other transit buses on the road. The distinctive roof bulge (photo 1) may be the first clue that this vehicle is different. Although other alternative fueled buses may have a similar roof bulge (compressed natural gas-powered vehicles), any roof bulge indicates to emergency responders that something is different here. The most obvious indicator will be the lettering “Hybrid Electric” along the roofline and at the rear of the vehicle (photos 2-4). As these vehicles become more and more common and the controls are more integrated into the “normal” vehicle controls, even the operator may not know how the vehicle is powered.

**SYSTEM DESIGN**

The Gillig Hybrid Bus is powered by an Allison Electric Drive (AED). The AED is a bolt-on system sold to manufacturers by Allison Transmission Corporation. The system includes battery pack, inverter, control system, and Allison E40 transmission with integral electric motors (photo 5).

(6) The roof-mounted energy storage system. (7) The roof-mounted dual power inverter module. (8) The underneath view of the E40 transmission with orange-colored, high-voltage cables.
It is a parallel hybrid system that can run the internal combustion engine and electric motors at the same time. The smaller-than-usual diesel engine is similar in size to that found in large-size pickup trucks and uses the electric motors to supplement power when needed. During braking or downhill runs, the vehicle uses regenerative braking to use the electric motors as generators and recharge the batteries. There is no need to plug in the vehicle for charging.

There are two hybrid control modules that process information from sensors and control the AED system. Since electric motors provide full torque at all times, these buses are programmed for Soft Start and use the diesel engine when starting off and then supplement power with the electric motors as needed. The system can be programmed to operate as a strictly electric vehicle within tunnels or heavily populated areas to reduce the presence of diesel fumes.

In addition to the standard, automotive 12-volt battery system, there is a roof-mounted battery pack that supplies power for the electric motors (photo 6). The Allison E" System™ uses nickel metal hydride (NiMH) batteries in the Energy Storage System (ESS), or what we commonly call the battery pack. The ESS consists of 240 NiMH modules grouped in 40 subpacks. Each subpack is mounted in a separate housing. Combined voltage can be as much as 900 volts, depending on the state of charge, but is typically 650 volts. The weight of the ESS is about 900 pounds, which may make the vehicle slightly top heavy and should be a consideration in vehicle-stabilization procedures. The batteries are disconnected when the ESS cover is removed, but this should be done only by qualified technicians wearing the proper protective equipment.

The roof-mounted dual power inverter module (DPIM) (photo 7) converts the battery direct current (DC) to three-phase, alternating current (AC). During braking, it reverses and converts AC current to DC to recharge the batteries and provide a load to slow the vehicle.

The Allison E'40 transmission looks like other large vehicle transmissions on the exterior with the exception of the high-voltage cables from DPIM connecting directly to the transmission (photo 8). These cables have the distinctive, orange covering similar to what we find in other hybrid/electric vehicles. The Allison transmission has two electric motors built in to augment the engine power and recharge the ESS.
**EMERGENCY PROCEDURES**

Initial stabilization of a bus involved in an accident should begin immediately for the safety of the emergency responders, vehicle occupants, and onlookers. Naturally, a vehicle involved in a minor fender bender will require less stabilization than an overturned vehicle. Stabilization steps will vary according to the condition of the vehicle and your initial size-up. If the vehicle systems are compromised, chock the wheels to prevent the vehicle's moving before accessing the vehicle. If the driver is incapacitated and unable to open the doors, reach through the window and use the control on the console to the driver's left (photo 9). Alternately, if the engine is shut off, you can open the accessory air tank drain valve behind a hatch below the driver's window. This will release air pressure on the door and allow you to push it open (photo 10). Place the transmission in neutral, and set the parking brake (photo 11).

Secure the vehicle power according to the manufacturer's recommendations by turning off the ignition and battery disconnect switch. This bus uses a keyless ignition and has a rotating ignition switch to the left of the driver's seat (photo 12). Turning the switch to "OFF" will shut down the diesel engine and the ESS. The 12-volt battery disconnect switch is on the exterior, driver's side near the front of the bus. Open the small door, and move the ‘T’-handle down (photo 13), removing all 12-volt power. Conveniently, a padlock is provided to lock the battery switch in the “OFF” position and prevent unauthorized reenergizing of the electrical system. Either of these operations will shut off the DPIM and disconnect the ESS high-voltage power.

If it is not possible to access the ignition switch and the battery-disconnect switch, you can shut down the engine and DPIM at the rear run box in the rear engine compartment (photos 14, 15). Move the three-position, Ignition Select switch to the “ENGINE KILL/OFF” position.

If any operations include going under the vehicle, crib the entire vehicle in numerous places. These vehicles have an air suspension that can drop the vehicle to within five inches of the ground if air pressure is lost (photos 16, 17). Keep in mind that the loss of air pressure at one wheel without sufficient cribbing may cause the vehicle to lean and place excessive loads on other cribbing. More cribbing is better in this case.

**EXTRICATION**

Extrication procedures are no different from those of conventionally powered buses, provided you remain aware of the high-voltage systems. Do not cut into the ESS, the DPIM, or any of the high-voltage cables that run from the roof, down the right, rear corner inside the engine compartment, and to the transmission. Over the years, dirt, paint, and maintenance may cause the orange covering to be less noticeable.
This vehicle is heavily constructed, so your usual extrication tools may be difficult to use or may be ineffective. Fortunately, the open floor plan of a transit bus may mean that passengers will not be entrapped within the vehicle; you may have to provide access to the passenger compartment only for patient removal.

If the doors are inoperative or inaccessible, you can gain access through the windshield or side windows. Keep in mind that all windows are laminated glass, similar to that found in most car windshields, and window punches won't work. Most side windows are designed for emergency exit and can be removed from inside the vehicle (photos 18, 19), or you may remove the side window and windshield glass using a reciprocating saw or an extrication glass-removal tool. If the vehicle has overturned, the roof has two emergency exit hatches (photos 20, 21).

An engine compartment fire may expose high-voltage wiring, but firefighting will not result in electrocution, since the high-voltage wiring is not connected to the vehicle chassis or the ground. A firefighter would have to contact both high-voltage cables at the same time to receive a shock. The hybrid control modules continuously monitor the system and will deenergize the wiring if there is a fault or a short circuit in the high-voltage cables. Of course, eliminating any contact with the high-voltage cables by any means is always the best course of action. A short circuit can cause high heat or fire in the ESS. Extinguish a fire involving the ESS with an ABC dry-powder extinguisher or large amounts of water. Small quantities of water could temporarily act as an accelerant. Consider cooling the surrounding area and allowing an ESS fire to burn out.

**DAMAGE TO THE ESS**

Damage to the ESS can occur if the vehicle hits an overpass or a tree branch or if the vehicle overturns. *Do not* touch the orange cables or open or attempt to disconnect the ESS. Shut down the electric systems, as previously explained, using the ignition and battery-disconnect switches.

**HAZMAT**

The vehicle has a 90-gallon diesel fuel tank. Normal intervention techniques can be used to prevent environ-
mental damage and fire risk of spilled diesel fuel. The fuel tank has a unique, dry break filler neck connection that prevents fuel from spilling even if the cap is off and the vehicle is overturned (photo 25).

The batteries are classified as UN Number 2800 (3). Batteries, Wet, Non-Spillable and can be handled according to Emergency Response Guidebook Guide 154 for Toxic and/or Corrosive Substances. Most of the electrolyte is absorbed into the construction of the batteries, so if the ESS is damaged, fluid leakage should be minor. Treat damaged batteries that are leaking electrolyte as hazardous waste, which should be managed by a company specializing in that type of waste.

The electrolyte is an alkaline solution of potassium hydroxide and can burn the eyes and skin. Contact with zinc, aluminum, tin, and other materials can cause a reaction that produces toxic or flammable gases. In case of skin contact, flush the area with plenty of water, and seek medical attention.

If minor leakage occurs, wipe up with a towel, or neutralize with vinegar or another diluted acid (4) while wearing rubber gloves, safety glasses, and SCBA.

Reading this article and passing it along to other emergency responders are the first steps in preparing for a successful conclusion to an incident involving hybrid buses. The next step should be meeting with the bus operators in your area to see what kinds of vehicles they are operating and what emergency procedures are specific to them. Ongoing training on emerging technology will help prepare you for the situations you are called to handle.

ENDNOTES
1. HybridCars.com, Bradley Berman, editor.

Author’s note: Thanks to Ron Gambini, vice president of fleet maintenance for Educational Bus Transportation, Inc., for his assistance and allowing me access to the vehicle and to all of the employees, who were extremely helpful.
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COURSE EXAMINATION

1. A hybrid vehicle uses a combination of power sources to propel the vehicle.
   A) True
   B) False

2. Hybrid vehicles are all built the same due to national standards.
   A) True
   B) False

3. This course gives information specific to Gillig Hybrid Buses and general information for incidents involving other models.
   A) True
   B) False

4. Power for the electric motor is:
   A) Provided by an on-board generator.
   B) Supplied by a plug-in power cord.
   C) Stored in a high-voltage battery pack.
   D) Not necessary.

5. Clues that may indicate that a vehicle is not conventionally powered include:
   A) “Hybrid Electric” lettering or nameplates.
   B) A colorful paint scheme.
   C) An unusual roof “bulge”.
   D) Both A and C are correct.

6. The high-voltage battery pack is located:
   A) Behind the rear seat.
   B) On the roof.
   C) Between the frame rails.
   D) In the engine compartment.

7. Voltage in the battery pack can be up to:
   A) 300 volts.
   B) 600 volts.
   C) 900 volts.
   D) 1200 volts.

8. Placement of the battery pack may:
   A) Lead to the vehicle being top heavy.
   B) Cause it to be damaged by low branches.
   C) Make it difficult to de-energize.
   D) Both A and B are correct.

9. The high voltage power cables are what color?
   A) Red
   B) Yellow
   C) Orange
   D) Stripped

10. Initial stabilization of the vehicle involved in an emergency should include:
    A) Place the transmission in “Neutral”.
    B) Set the parking brake.
    C) Turn the ignition switch off.
    D) All of the above.

11. The high voltage power can be shut off by:
    A) Either turning off the ignition switch, activating the battery disconnect switch, or turning the rear run box switch to the “Engine Kill/Off” position.
    B) Cutting the orange cables.
    C) Setting the parking brake.
    D) Opening the passenger doors.

12. Loss of vehicle air pressure may result in:
    A) The bus rolling.
    B) The suspension dropping to within five-inches of the ground.
    C) Inability to shut off power.
    D) The engine starting automatically.

13. The 12-volt battery disconnect switch is located:
    A) In the engine compartment.
    B) Outside, below the drivers’ window.
    C) In front of the driver.
    D) Inside the battery pack.
14. Extrication may be:
   A) Easier since there is more room to work.
   B) Faster since you will be able to get more people through one opening.
   C) More difficult due to the heavy construction of the vehicle.
   D) Not necessary since buses don’t get into accidents.

15. Cutting into the battery pack, the power control module, and the high voltage cables:
   A) Should be done with hydraulic cutters.
   B) May be done after the ignition is turned off.
   C) Should never be done.
   D) Should not be done unless you are wearing heavy gloves.

16. A shock from the high voltage power system is:
   A) Unlikely since a firefighter would have to contact both cables at the same time to provide an electrical path.
   B) Unlikely because the voltage is too low to travel far.
   C) Likely at any time.
   D) Likely unless you are standing on insulating material.

17. The windows on this vehicle may be removed by:
   A) Breaking them with a window punch.
   B) Cutting them with a glass saw.
   C) Disassembling them from the outside.
   D) Using a Halligan tool to remove them.

18. The onboard fire extinguisher system may:
   A) Be automatically activated and will shut down the ignition and high voltage electrical power.
   B) Be manually activated and will shut down the ignition and high voltage electrical power.
   C) Be manually activated from the engine compartment.
   D) Both A and B are correct.

19. A fire involving the battery pack:
   A) May be extinguished by using an ABC type dry powder extinguisher.
   B) May be extinguished by using large quantities of water.
   C) May be allowed to burn out while protecting the surrounding area.
   D) All of the above are correct.

20. More information about the vehicles in use in your area can be obtained from:
   A) Online training forums.
   B) Trade magazines.
   C) Local bus operators.
   D) All of the above are correct.

21. Hybrid vehicles are:
   A) Becoming more common.
   B) Becoming less common.
   C) Have not changed.
   D) Are not a concern to emergency responders.

22. One major reason for using a hybrid diesel/electric design is:
   A) It can attain higher speeds.
   B) It is cheaper than conventional construction.
   C) Fuel cost savings may be as much as 35%.
   D) Passengers find it more comfortable.

23. Damage to the battery pack may cause a large spill of acid.
   A) True
   B) False
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