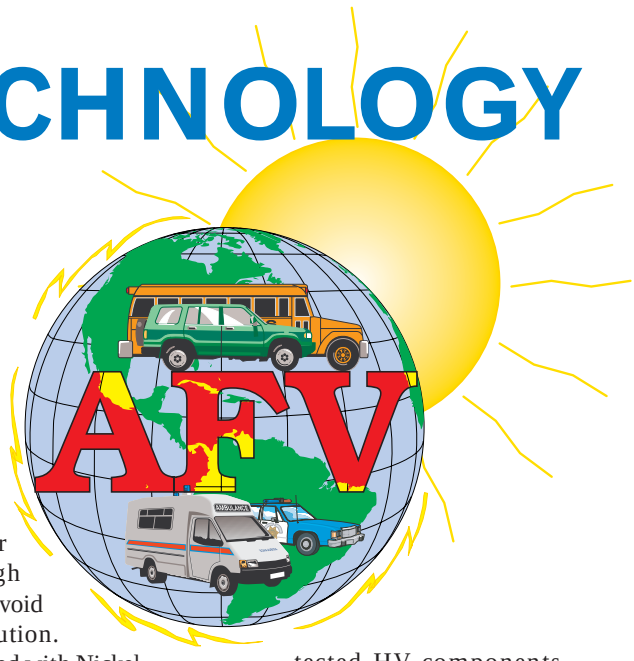
ALTERNATE FUEL TECHNOLOGY

Service Hybrid Electric Vehicles – Safely!



Editor's Note: *In this installment, part 16 of a continuing series on Alternate Fuels, AFVs, and Advanced Vehicle Technology, author Bob Rodriguez offers tips to automotive technicians considering servicing hybrid electric vehicles.*

With record high prices for crude oil, and at the pump, consumers are placing record numbers of orders for gas saving light-duty hybrid electric vehicles (HEVs). But how prepared are shops when it comes to servicing these?

Technician A says general automotive knowledge and skill may be sufficient when performing routine maintenance on hybrid electric vehicles.

Technician B says that specialized training is needed when performing service on high voltage systems on hybrid electric vehicles.

Who is right?
(A) A only
(B) B only
(C) both A and B
(D) neither A nor B

Of course, the correct answer is C. As with any vehicle, hybrids need routine LOF service, tire rotation, alignment, brakes etc. On the other hand, servicing high voltage battery packs, hybrid drive systems and motor electronics introduces new challenges for technicians. If you're unfamiliar with hybrids, you may want to review our basic information covered previously in *ASE TechNews* articles.[1]) In this article, we'll discuss more need-to-know about hybrid systems and components in HEVs from Toyota, Honda, General Motors and Ford. The general outline presented here does not replace authorized HEV factory training, but it will help you get started.

The Nature of Hybrids

For improved fuel economy and emissions, hybrids use specially designed tires and wheels, "slippery" body styles, regenerative braking, engine start/stop features, etc. Hybrid gasoline engines (ICEs) feature electronic throttle controls, variable valve timing, lean burn combustion designs, and more, making them more complex, and challenging! Despite the sophisticated nature of hybrid systems, technicians should be qualified for routine hybrid vehicle service. Don't expect to see belts and pulleys under the hood, however, as space is often dominated by hybrid drive and electrical components.

Scan tools are a fact of life in today's service bay, helping us "see" into the world of invisible electronics and diagnose problems. "The scan tool will remain the mainstay of the technician's arsenal, for analyzing and diagnosing a hybrid and [its] electric power system."[2] You'll not only be accessing familiar engine data—Engine RPM, MAP/MAF, injector pulse width, etc.—but also comparable data about the electric drive components: Encoder Signal, Current Sensor, Pedal Position, Commanded Current, Phase Faults, Slip %, and more.[3] To interpret such arcane data, specialized HEV training is a must, and numerous training providers now offer it (see Winter/Spring 2004 *ASE Tech News*).

Components

Yes, hybrid systems and components are unique. These include the 3-phase AC drive motor(s), the (final) drive unit with reduction gearing, the AC (alternating current) power inverter, the DC/DC inverter, the starter/generator and its control module, a continuously variable electronic transmission (CVET), electric or electro-hydraulic power steering, a high voltage battery pack, special cooling systems, high voltage cables and connections, safety and cutoff switches, electric air conditioning compressor… the list goes on.

The electric drive motor(s)—either induction (IM) or permanent magnet (PM) type—partially or totally propels the vehicle using high voltage 3-phase alternating current. The power inverter changes the battery pack's high voltage DC into 3-phase AC for the drive motor(s), and the motor controller supplies the motor varying amounts of AC and voltage (in both directions) to determine vehicle speed and direction as requested by the motorist. Much like a torque converter slips to add torque when vehicle load increases, the electric motor uses "slip angle" to multiply torque. The drive/gear reduction unit is coupled to the motor shaft and reduces high RPM to useable axle RPM.

In most HEVs, small low-voltage Nickel-Metal Hydride battery "modules" are wired in series to produce the battery pack's high DC output voltage. NiMH battery temperatures are controlled, as are other power electronics devices. A DC/DC converter supplies 12 volts for conventional automotive devices. In the case of GM's hybrid pickup, three 12-volt lead acid batteries are wired in series and stored in an energy storage box (ESB) under the passenger seat, and a 42-volt starter/generator keeps them charged. In all hybrids, emergency disconnects enable high voltage systems to be isolated (see images). Sensors monitor what's happening in all areas for load management and safety.

Before servicing even non-high voltage related systems, technicians should follow OE procedures if shutting off the vehicle's high voltage components.

While perhaps at first intimidating, black (inflatable) lineman's gloves rated for 1000 volts should be worn whenever servicing the high voltage system to avoid shock or electrocution. Chemicals associated with Nickel-Metal Hydride batteries are caustic and will react with certain metals or liquids. Safety goggles, rubber aprons, and other gear is required when working with or around such batteries.

In An Emergency

As with any new technology, there's a lot of mystique about hybrid vehicle safety. HV battery packs, 3-phase AC, converters, inverters, controllers… all present new challenges and concerns for today's technicians. But there's no need for alarmist reactions. The fact is, with redundant safety systems and well-protected HV components and wiring, hybrids have an excellent safety record. As with natural gas, propane and hydrogen fueled vehicles, safety sensors, fuses, switches and shutoff devices protect vehicle owner and technician alike.

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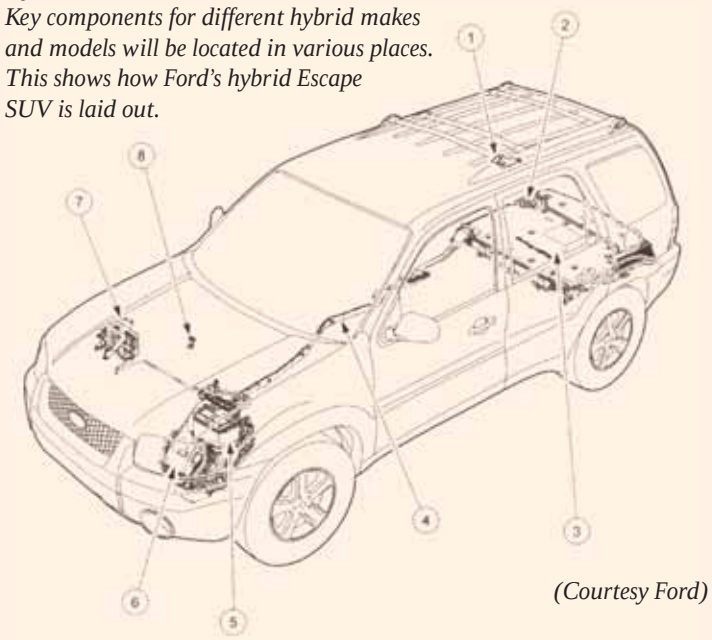
1 *For PDF files of previous ASE TechNews AFV articles, contact the author at ASE.*
2 *Automotive Research and Design Company, Detroit, Mich. < arandd@ix.netcom.com >*
3 *Ibid*

Schematic of Components on the 2005 Ford Escape Hybrid Electric SUV
Key components for different hybrid makes and models will be located in various places. This shows how Ford's hybrid Escape SUV is laid out.



(Courtesy Ford)

Key to components:
1. *Rear Inertia Switch – disconnects high voltage system and fuel pump in the event of a collision.*
2. *High Voltage Service Disconnect Switch – orange handled battery disconnect switch under carpet.*
3. *High Voltage Battery – 300+ volts (250 x 1.3 volt sealed Ni-MH modules connected in series).*
4. *High Voltage Wiring – orange colored wiring connects HV battery to Electronically Controlled Continuously Variable Transmission (ECVT); ECVT to DC/DC Converter.*
5. *12 Volt DC Battery – lead acid 12 VDC service battery provides power to the vehicle and accessories.*
6. *ECVT – contains the drive motor, the starter/generator, and electronics.*
7. *DC/DC Converter – provides 12 VDC to charge the service battery and run 12 V accessories.*
8. *Front Inertia Switch – disconnects high voltage systems and fuel pump in the event of a collision.*

HV shutoff devices

The best way to prevent high voltage/current from flowing in a hybrid electric vehicle is to simply turn off the key, disconnect the negative 12 VDC battery cable, or turn off switches as shown here.

Toyota Prius
In the trunk, remove the 3 clips holding the upper left portion of the trunk side cover. Toyota advises to use rubber lineman's gloves to pull this (partially hidden) orange handled plug.

Ford Escape SUV
In the rear of the vehicle under the right side carpet, locate this handle and rotate it to the "service shipping" position; then lift it out.

Chevy Silverado/ GM Sierra pickup
Under the rear passenger seat, remove the marked cover on the Energy Storage Box; turn the green Service Disconnect Switch to horizontal for power off.

Honda Civic
It's better to remove the main fuse (#1) in the driver's side underhood fuse box. If that's not possible, remove the rear seat cushion and back; remove the metal switch cover (marked "up") and flip down the Battery Module Switch behind the red locking cover.

Part of a continuing series on alternate fuel vehicles and advanced vehicle technology.
If you have comments or questions, contact ASE's Bob Rodriguez at 703-669-6634 or **brodriguez@asecert.org**.

Hybrid Vehicle Service

(continued from page 5)

One example is GM's hybrid pickup with its 120 AC auxiliary power outlet (APO) provision. Ground fault detection and a "high voltage interlock loop" continuously monitor the 120 volt AC wiring harness' integrity; a fault automatically shuts off the utility circuit's power

Summary

There is no need for skilled automotive technicians to fear hybrid electric vehicles. That said, anyone going beyond "routine" vehicle maintenance on hybrids should get authorized training, so why not get started? We'll see many more gasoline (and diesel) electric hybrids pretty soon, all leading the way to the hydrogen fuel cell vehicle (FCV), which is itself another form of hybrid. "Learn more to earn more" to service the new and increasingly popular breed of hybrid electric vehicles.

A Word to First Responders...

Hybrid OEMs go out of their way to provide the industry with first responder information contained in Emergency Response Guides (ERGs) available on the Internet.[a] Familiarity with ERG procedures protects both motorists and rescue personnel in the event of a hybrid vehicle mishap.

In accordance with OEM procedures, if an HEV is involved in a collision, first turn off the ignition key. This shuts down the high voltage supply. Next, stabilize the vehicle, and as required, further isolate the high voltage system using the HV shutoff devices (see photos). You may also want to neutralize the SRS system(s) by disconnecting the 12 VDC battery negative (or both) cables.

In an emergency, accessing HV shutoff compartments behind seats or in trunks may not be an option. Emergency personnel using saws / jaws to extricate victims must be familiar with respective ERG guidelines. High voltage (50 volts or higher) systems are isolated from the grounded 12-volt on-board system, and HV cables are orange for easier identification. HV cables are typically routed along frame rails or down the vehicle mid-section—but certainly not in vehicle doors as some have mistakenly asserted—but in any case, orange cables should **not** be cut. According to GM, "Today's 'rip and tear' techniques to gain [vehicle] entry are less effective and potentially dangerous. Access is often much easier than it appears. A more appropriate adage is to 'Try before you pry.' Avoid cutting the vehicle until all electrical systems have been deactivated and isolated. Cutting into the areas of the vehicle prior to disconnecting and isolating the electrical energy sources may cause an electrical arc and/or personal injury."[b]

First responders should also know that some vehicles (not just hybrids) may use dual-stage steering column air bags or side-curtain airbags which use pyrotechnic or gas propelled actuators in the A, B or C pillars... not the kinds of things you'd want to cut into.

Always refer to the OEM Emergency Response Guides for the most accurate and up-to-date information.

Editor's Note: The Inter-Industry Conference on Auto Collision Repair (I-CAR) also offers training and information for emergency responders on proper procedures for disabling high-voltage systems. Visit **www.i-car.com**.

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[a] *Hybrid vehicle emergency response guides (ERG) can be found at these Internet websites:*
- *Ford: http://www.fordtechservice.dealerconnection.com/vdirs/quickref/ guide-escape.pdf*
- *GM: http://www.gmstc.com/courses/EMT%20PHT.pdf*
- *Honda: http://eaglefirecompany.org/emergencyservice/Honda%20ERG%20Civic%20Hybrid.pdf*
- *Toyota: http://www.toyota.com/web/vehicles/prius/safety/prius_erg_2.pdf*

[b] *General Motors' ERG, see above.*