

Automotive Technology 6th Edition

Chapter 94 Hybrid Safety & Service Procedures

Opening Your Class

KEY ELEMENT	EXAMPLES
Introduce Content	This Automotive Technology 6th text provides complete coverage of automotive components, operation, design, and troubleshooting. It correlates material to task lists specified by ASE and ASEEducation (NATEF) and emphasizes a problem-solving approach. Chapter features include Tech Tips, Frequently Asked Questions, Case Studies, Videos, Animations, and ASEEducation (NATEF) Task Sheets.
Motivate Learners	Explain how the knowledge of how something works translates into the ability to use that knowledge to figure why the engine does not work correctly and how this saves diagnosis time, which translates into more money.
State the learning objectives for the chapter or course you are about to cover and explain this is what they should be able to do as a result of attending this session or class.	Explain learning objectives to students as listed below: <ol style="list-style-type: none"> 1. Correctly use appropriate personal protective equipment (PPE). 2. Discuss the safety interlock system and loss of insulation in a hybrid electric vehicle. 3. Safely de-power a hybrid electric vehicle. 4. Explain hazards while driving, moving, and hoisting a hybrid electric vehicle. 5. Perform routine vehicle service procedure on a hybrid electric vehicle and understand the HEV's unique service requirements.
Establish the Mood or Climate	Provide a WELCOME , Avoid put downs and bad jokes.
Complete Essentials	Restrooms, breaks, registration, tests, etc.
Clarify and Establish Knowledge Base	Do a round robin of the class by going around the room and having each student give their backgrounds, years of experience, family, hobbies, career goals, or anything they want to share.

NOTE: Lesson plan is based on 6th Edition Chapter Images found on Jim's web site @ www.jameshalderman.com

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NOTE: You can use Chapter Images or possibly Power Point files:

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1. SLIDE 1 CH94 HYBRID SAFETY & SERVICE PROCEDURES

Check for **ADDITIONAL VIDEOS & ANIMATIONS**
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Crossword Puzzle (Microsoft Word) (PDF)
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Videos

2. **SLIDE 2 EXPLAIN FIGURE 94–1** Appropriate personal protective equipment (PPE) must be worn whenever working on or around a hybrid vehicle high-voltage system, including high-voltage gloves with protective leather gloves to protect rubber from being cut or pierced.
3. **SLIDE 3 EXPLAIN FIGURE 94–2** Whenever working around the high-voltage circuit, it is recommended that one hand be kept in a pocket to prevent possibility of a high-voltage shock passing through the body.

WARNING: Touching circuits or wires containing high voltage can cause severe burns or death.

DISCUSSION: Have students talk about importance of using leather gloves over insulated gloves. Remind them that when purchasing leather gloves, they must be large enough to fit over insulated safety gloves. What should be done before each use of gloves?

4. **SLIDE 4 EXPLAIN FIGURE 94–3** Checking rubber lineman's gloves for pinhole leaks.

WARNING: Cables and wiring are orange in color. High-voltage insulated safety gloves and a face shield must be worn when

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carrying out any diagnostics involving high-voltage systems or components.

SAFETY Have students talk about need for safety precautions when working around & with hybrid electric vehicles. Both hybrid electric vehicles & all-electric vehicles use high-voltage circuits that cannot be touched without protection.

DEMONSTRATION: Show students materials necessary to create a "High Voltage: DO NOT TOUCH" sign that can be placed on roof of HEV that is being stored.

DISCUSSION: Discuss CAT III-rated DMM. Why is a CAT III-certified DMM required for taking measurements on HEVs? FIGURES 90-4 & 5

DEMONSTRATION: Using a CAT III DMM, show students how to check a floating ground to identify a high-voltage leak. FIGURES 94-4 & 5

DISCUSS FREQUENTLY ASKED QUESTION:

Is It the Voltage Rating That Determines the CAT Rating? Yes and no. Voltages stated for the various CAT ratings are important, but the potential harm to a technician due to energy level is what is most important. For example, some CAT II-rated meters may have a stated voltage higher than a meter that has a CAT III rating. Always use a meter that has a CAT III rating when working on a hybrid electric vehicle. • SEE FIGURES 94-4 AND 94-5.

5. **SLIDE 5 EXPLAIN FIGURE 94-4** Be sure to only use a meter that is CAT III-rated when taking electrical voltage measurements on a hybrid electric or electric vehicle.
6. **SLIDE 6 EXPLAIN FIGURE 94-5** meter leads should also be CAT III-rated when checking voltages on a hybrid electric vehicle.

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DISCUSSION: Discuss identifying colors used for high voltage cables. What does blue or yellow plastic conduit mean? What does orange plastic conduit mean?

DISCUSSION: Discuss insulation testers (Fluke 1587). When is an electrical insulation tester used?

HANDS-ON TASK: Have the students wear insulated and leather gloves while trying to take a voltage reading using a CAT III DMM. Ask students to share their experience with the task.

ON-VEHICLE ASE EDUCATION TASK: Identify location of hybrid vehicle high-voltage circuit disconnect (service plug) location and precautions.

DEMONSTRATION: DEMO de-powering procedure on a Hybrid Electric Vehicle

Use a cooking timer with a bell alarm or some other audible signal as a way to know when the 10-minute waiting period for HV battery shutdown has passed.

DISCUSSION: Have students talk about when high voltage system needs to be de-powered & when it doesn't. When servicing a system that may contain high voltage, how can you be sure of whether or not it needs to be de-powered?

HANDS-ON TASK: Supervise students as they de-power vehicle.

7. SLIDE 7 EXPLAIN FIGURE 94-6 HV disconnect plug has two small terminals used to signal HV controller that the safety/service plug has been removed.
8. SLIDE 8 EXPLAIN FIGURE 94-7 An insulation tester showing where the meter leads should be attached and where to select the voltage level to be used to test the insulation (usually 1,000 volts). The resistance between

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the insulated HV circuit and ground should be higher than one million ohms (1.0 to 2.2 MΩ).

EXPLAIN TECH TIP: *Silence Is NOT Golden:* Never assume vehicle is shut off just because engine is off. When working with a Toyota or Lexus hybrid electric vehicle, always look for **READY** indicator status on dash display. The vehicle is shut off when **READY** indicator is off.

The vehicle may be powered by:

1. The electric motor only.
2. The gasoline engine only.
3. A combination of both the electric motor and gasoline engine.

Vehicle computer determines mode in which vehicle operates to improve fuel economy and reduce emissions. Driver cannot manually select mode. • **SEE FIGURE 94-8.**

9. **SLIDE 9 EXPLAIN FIGURE 94-8** Ford Escape Hybrid instrument panel showing vehicle in park and the tachometer on “EV” instead of 0 RPM. This means that the gasoline engine could start at any time, depending on the state of charge of the high-voltage batteries and other factors.

WARNING: Power remains in high-voltage electrical system for up to 10 minutes after the HV battery pack is shut off. Never touch, cut, or open any orange high-voltage power cable or high-voltage component without confirming that high voltage has been completely discharged

DEMONSTRATION: Show jump starting procedures on HEV. Review safety procedures for connecting & disconnecting jumper cables. Can jump box or jumper cable from another vehicle be used on high-voltage HV battery pack?

EXPLAIN TECH TIP: *High Voltage Is Insulated From the Vehicle Body:* Both positive and negative HV power cables are isolated from metal chassis, so

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there is no possibility of shock by touching metal chassis. This *design is called a floating ground*. A ground fault monitor continuously monitors for HV leakage to metal chassis while the vehicle is running. If a malfunction is detected, vehicle computer illuminates master warning light in instrument cluster and hybrid warning light in LCD display. HV battery pack relays automatically open to stop electricity flow in a collision sufficient to activate SRS airbags.

DEMONSTRATION: Using a CAT III DMM, show students how to check a floating ground to identify a high-voltage leak

DEMONSTRATION: Show procedure for moving & storing HEV waiting for parts to arrive.

HANDS-ON TASK: Have the students describe safety precautions that should be taken to work on HEVs. Grade them on thoroughness and a clear understanding of dangers that HEVS present and how those dangers can be addressed.

HANDS-ON TASK: Review importance of separating the keys from a hybrid vehicle to prevent an accidental start-up that could lead to personal injury. Have students create a metal lock box or research the cost of purchasing one.

ON-VEHICLE ASE EDUCATION TASK: Identify high-voltage circuits of hybrid electric vehicles and related safety precautions.

ON-VEHICLE ASE EDUCATION TASK:) Identify hybrid vehicle A/C system electrical circuits

DISCUSS FREQUENTLY ASKED QUESTION:
How Do You Keep Engine Running on a Hybrid?

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There are times when service technician or a vehicle inspector needs to bypass idle stop feature and to keep engine running, such as:

- Checking A/C pressures on a unit that has an engine-driven A/C compressor
- Attempting to get engine (ICE) up to operating temperature in order to check for proper operation of the cooling system
- Safety inspection of the exhaust system.

The mode to keep ICE running can often be done using a scan tool, such as Snap-on Solus Ultra being used on a Lexus RX 450h hybrid. • **SEE FIGURE 94-9.**

This mode is called the

- Service mode
- Maintenance mode
- Inspection mode

Most vehicle manufacturers warn to not drive the vehicle while in this mode because many of the torque limiting factors are also disabled, which could cause damage to the powertrain components if driven aggressively. • **SEE CHART 94-1** for the method to use to keep the ICE operating and to prevent the idle stop mode without using a scan tool

10. **SLIDE 10 EXPLAIN** FIGURE 94-9 To enter inspection mode, select this feature on a scan tool and follow the on-screen procedure.



DISCUSSION: CHART 94-1Hybrid engine service mode chart. This procedure is needed to be followed if the technician or safety inspector requires that the internal combustion engine (ICE) needs to be kept running and prevented from entering stop/start (idle stop) operation.

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11. **SLIDE 11 EXPLAIN FIGURE 94–10** Jump starting a 2001–2003 Toyota Prius using a 12-volt supply to boost the 12-volt auxiliary battery in the trunk.
12. **SLIDE 12 EXPLAIN FIGURE 94–11** underhood 12-volt jump-start terminal on this 2014 Toyota Prius has a red plastic cover with a “+” sign. The positive booster cable clamp attaches directly to vertical metal bracket.

DISCUSS FREQUENTLY ASKED QUESTION:

When Do I Need to De-Power the High-Voltage System? During routine service work, there is no need for a technician to de-power HV system. The only time when this process is needed is if service repairs or testing is being performed on any circuit that has an orange cable attached. These include:

- A/C compressor, if electrically powered
- HV battery pack or electronic controller’s electric power steering system usually operates on 12 volts or 42 volts and neither is a shock hazard. However, an arc is maintained if a 42-volt circuit is opened. Always refer to service information if servicing electric power steering system or any other system that may contain high voltage.

WARNING: Even if all of above steps for **DE-POWERING** are followed, there is still a risk for electrical shock at high-voltage batteries. Always follow OEM instructions exactly and wear high-voltage gloves and other specified personal protective equipment (PPE).

DISCUSS FREQUENTLY ASKED QUESTION: *Will the Heat from Paint Ovens Hurt High-Voltage Batteries?* Nickel-metal hydride (NiMH) batteries may be damaged if exposed to high

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temperatures, such as in a paint oven. The warning labels on hybrid vehicles specify that battery temperature not exceed 150° F (66° C). Therefore, be sure to check the temperature of any paint oven before allowing a hybrid electric vehicle into one that may be hotter than specified. Check service information for details on the vehicle being repaired.

11. SLIDE 11 **EXPLAIN** FIGURE 94–12 Using a warning cover over the steering wheel helps others realize that work is being performed on the high-voltage system and that no one is to attempt to start or move vehicle.
12. SLIDE 12 **EXPLAIN** FIGURE 94–13 lock box is a safe location to keep the ignition keys of a hybrid electric vehicle while it is being serviced.

SAFETY Gather materials necessary for the students to create a **“High voltage—Do not touch” sign** that can be placed on roof of HEV that is being stored.

DEMONSTRATION: Show how to **identify lift points** for HEV from on-line service information. Using a floor jack/lift, raise vehicle and have the students take note of **areas of concern** on vehicle:

HANDS-ON TASK: create a **“High voltage—Do not touch” sign** that can be placed on the roof of a hybrid vehicle that is being stored..

13. SLIDE 13 **EXPLAIN** FIGURE 94–14 Insulated tools, such as this socket set, provide an additional margin of safety to the service technician when working around high-voltage components and systems.

EXPLAIN TECH TIP: **High-Voltage Battery SOC Considerations:** NiMH batteries do not store well for long lengths of time. After a repair job, or when the HV system has been powered down by a technician and powered up again, do not be surprised if a warning lamp lights, diagnostic trouble codes are set, and MIL is illuminated. If everything was done correctly, a couple road tests

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may be all that is required to reset MIL. The HV battery indicator on dash may also read zero charge level. After a road test, HV battery level indicator most likely displays proper voltage level.

14. SLIDE 14 **EXPLAIN** FIGURE 94–15 high-voltage wiring on this Honda hybrid is colored orange for easy identification.
16. SLIDE 16 **EXPLAIN** FIGURE 94–16 scan tool display showing two hybrid-related faults in this Ford Escape hybrid.

DISCUSSION: Have the students review the eight-step diagnosis procedure. Is diagnosing a hybrid electric vehicle different from diagnosing any other type of vehicle?

HANDS-ON TASK: Have students lift an HEV supervised by the instructor

DISCUSSION: Have students talk about cooling system service for HEVs. What considerations for servicing an HEV cooling system may differ from those for servicing ICE cooling system?

DISCUSSION: Have the students discuss servicing the air conditioning of an HEV. What does the service technician need to know about the air conditioning compressor on HEV

DISCUSSION: Have the students talk about the regenerative braking system and base brakes used on hybrid electric cars. Why do base brakes on HEVs often get stuck or function incorrectly?

ON-VEHICLE ASE EDUCATION NATEF TASK:

Describe the operation of HEV regenerative braking system

DISCUSSION: Have the students discuss rolling resistance. How does replacing tires affect fuel economy?

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QUESTION



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ON-VEHICLE ASE EDUCATION TASK: Identify hybrid engine service precautions.

DISCUSSION: discuss oil changes for HEVs. Why do most hybrid electric vehicles require either SAE 0W-20 or SAE 5W-20?

DISCUSS CASE STUDY: A Bad Day Changing Oil

A shop owner was asked by a regular customer who had just bought a Prius if the oil could be changed there. The owner opened hood, made sure the filter was in stock (it is a standard Toyota filter used on other models), and said yes. A technician with no prior knowledge of hybrids drove warmed-up vehicle into service bay. The internal combustion engine never started, as it was in electric (stealth) mode at time. Not hearing engine running, technician hoisted vehicle into the air, removed drain bolt, and drained oil into the oil drain unit. When the filter was removed, oil started to fly around shop. The engine was in “standby” mode during the first part of oil change. When voltage level dropped, the onboard computer started engine so that HV battery could recharge. The technician should have removed key to keep this from happening. Be sure that the “ready” light is off before changing the oil or doing any other service work that may cause personal harm or harm to the vehicle if engine starts.

Summary:

- **Complaint**—technician was not aware that the hybrid vehicle was not off when changing the oil.
- **Cause**—“ready” light was still on when the technician started to change the oil.

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- **Correction**—technician learned that all hybrids need to be shut off because just because the engine is not running, it does not mean that vehicle itself has been turned off.

17. SLIDE 17 **EXPLAIN** FIGURE 94–17 Always use the specified viscosity of oil in a hybrid electric vehicle, not only for best fuel economy, but also because of the need for fast lubrication because of the engine (idle) stop feature.

DISCUSS FREQUENTLY ASKED QUESTION:
Is the Radiation From a Hybrid Dangerous? No.
While there is a changing magnetic field surrounding any wire carrying an electrical current, the amount of electromagnetic radiation is very low. • SEE FIGURE 94–18.

18. SLIDE 18 **EXPLAIN** FIGURE 94–18 radiation emitted from a hybrid electric vehicle is very low, as shown being measured in units of milligauss.

19. SLIDE 19 **EXPLAIN** FIGURE 94–19 This 12-volt battery under the hood on a Ford Fusion hybrid is a flooded-cell-type auxiliary battery.

DISCUSSION: Have the students talk about auxiliary battery service. What is the proper charger to use when recharging an AGM battery? Can this charger also be used on regular lead acid battery?

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20. SLIDES 20-32 **OPTIONAL EXPLAIN HV GLOVE**

DEMONSTRATION: Show the students how to inspect, test, and store HV safety gloves and leather protectors.

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DISCUSSION: Have the students discuss the storage and care of safety gloves. What kinds of materials and products can damage rubber gloves?