Alternative Fuel Vehicle Safety (ALT05e)

Textbook

I-CAR®

Version: 16.1

ALT05e-STMANi-E

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Introduction

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Obligations To The Customer And Liability

The collision repair industry has an obligation to correctly repair the customer's vehicle. Collision repairs must be performed using:

- recommended or tested procedures from vehicle makers, I-CAR, and other research and testing organizations.
- quality replacement parts and materials.
- repair processes and parts as written and agreed upon in the repair order. If items on the repair agreement are not consistent with the repair order, it can be considered fraud.

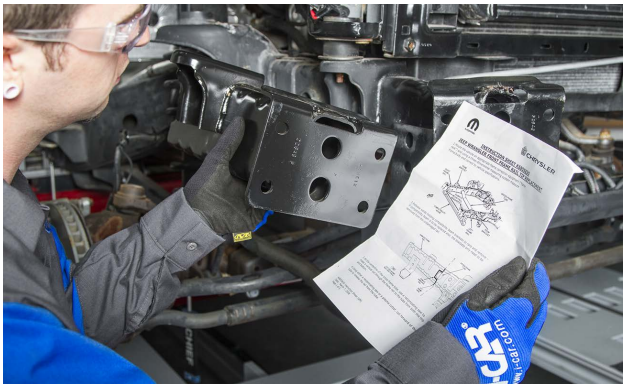
Performing proper collision repairs requires using parts and procedures that keep remaining warranties intact.

Collision repairs must restore:

- safety.
- structural integrity.
- durability.
- performance.
- fit.
- finish.

Throughout the damage analysis and repair process the repairer and insurer must:

- communicate with each other.
- maintain constant communication with the customer.
- be in agreement with each other and the customer on how repairs will be performed.
- inform the customer of any changes in the repair plan from the original repair agreement, and explain the changes and why they have to be made.



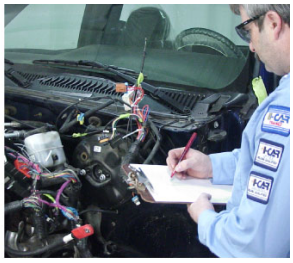
To reduce liability:

- make sure that all repairs are performed thoroughly, correctly and as listed in the damage report.
- follow proper procedures.
- have documentation of required repairs with detailed record keeping available for customers.

Technicians are considered the experts and are expected to be knowledgeable on how to perform a quality repair.

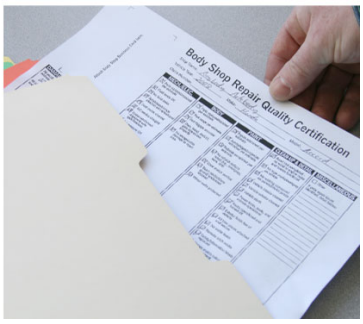
Liability insurance that covers the repair facility may not always cover all damages. For example:

- the policy may not cover faulty repairs, leaving liability responsibility completely on the facility.
- a shop owner may find that repair facility liability coverage may not cover the full amount awarded in a lawsuit. The shop owner would have to pay the difference.



It is difficult to reduce the risk of liability exposure. The part that the repairer can control is the chance of being found at fault. Chances can be minimized by:

- using recommended or tested procedures from the vehicle makers, I-CAR, or other research and testing organizations.
- using quality replacement parts and materials that restore fit, finish, durability, and perform at least as well as the original.
- keeping thorough records.



Keeping thorough records includes more than recording the date, mileage, and pre-existing damage. Record keeping also includes:

- making sure all notes are legible.
- verifying the repairs that were made or not made.
- having the customer sign a waiver for repairs that they do not want performed. Repairers must determine their liability on not repairing safety systems such as restraint and anti-lock brake systems.
- keeping computer printouts or worksheets on file showing wheel alignment readings or vehicle dimensions before and after repairs.
- keeping scan tool printouts and records of computer codes for airbag, anti-lock brake, emission, and powertrain control module (PCM) systems.

- attaching the OEM or other tested procedure printout to the vehicle repair order.
- keeping receipts for all sublet work performed.

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Module 1 - Approaching A Damaged Electric Vehicle

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Identification

Learning objectives for this module include:

- identifying an electric vehicle.
- finding sources of information on electric vehicles.
- identifying hazards when working around electric vehicles.
- identifying safety equipment required when working around electric vehicles.

HV = High Voltage
HEV = Hybrid Electric Vehicle
PHEV = Plug-In Hybrid Electric Vehicle
EV = Pure-Electric Vehicle
DC = Direct Current
AC = Alternating Current
V = Volt

Download the Common Acronyms handout in PDF format. This handout lists and identifies the common acronyms used when discussing alternative fuel vehicles. These acronyms will be used throughout this course. The handout also defines basic terms used when discussing hybrid-electric vehicles and pure-electric vehicles.

Refer to Identifying An Electric Vehicle #1 in the presentation for an activity on methods to identify an electric vehicle.

Refer to Identifying An Electric Vehicle #2 in the presentation for an activity on methods to identify an electric vehicle.

Refer to Identifying An Electric Vehicle #3 in the presentation for an activity on methods to identify an electric vehicle.

Kia Soul EV

This nameplate is on the Kia Soul EV.

Honda Insight

This nameplate identifies the 2010 Honda Insight as a hybrid.

The blue shadow around the Lexus emblem indicates a hybrid.

The first way to help determine if the vehicle being approached is an EV or HEV is to look for the emblems or nameplates. These include:

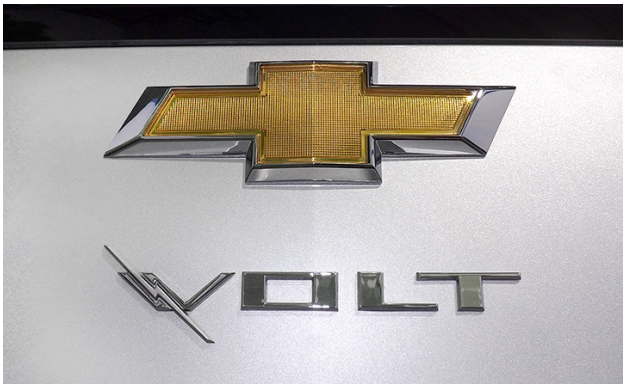
- the words electric or EV for a pure-electric vehicle. These are commonly found on any exterior panel such as the fender, deck lid, and doors.
- the word hybrid for an HEV. These are also commonly found on any exterior panel such as the fender, deck lid, and doors.
- a blue shadow around a Toyota, Lexus, or Volkswagen emblem. These are commonly found on any exterior panel including the hood. Hyundai also uses a blue background on its emblem if the vehicle is an EV or HEV.

For the purposes of this course, an emblem is the vehicle make emblem, such as the Lexus "L" or Chevrolet bowtie. Nameplates include model names and other attaching identifiers such as "Hybrid," "Electric," or "RX-350h."

The small "h" at the end of the model name indicates a Lexus hybrid.

The small "e" on this Volkswagen Golf nameplate indicates an electric vehicle.

The "E" in "E=ENERGI" signifies an electric vehicle.

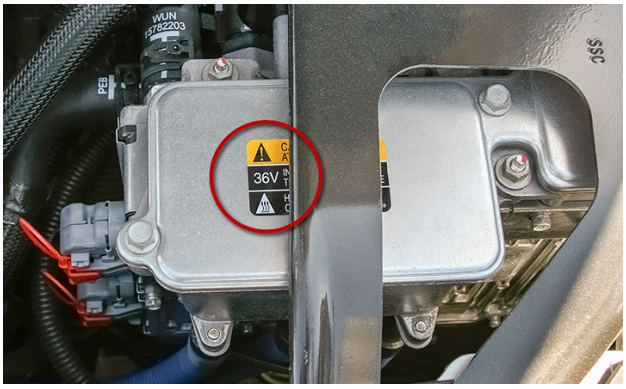


The name "Volt" is enough to identify this as an electric vehicle.

Other emblem or nameplate information include the:

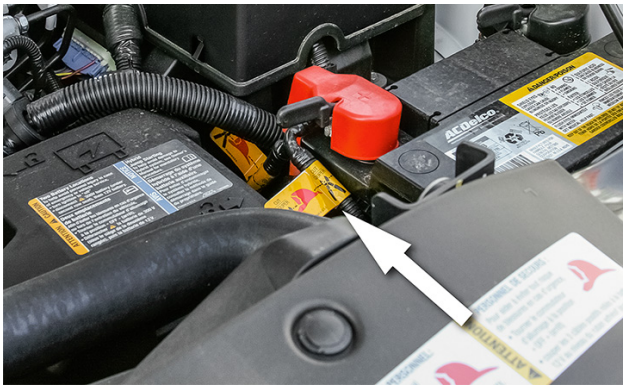
- small letter "h" after a Lexus model number such as "L600h."
- letter "e" before the model name such as "e-GOLF."
- separated "E" in the Ford Fusion "E=NERGI" on the plug-in Fusion HEV.
- model name of a dedicated HEV such as the Toyota "Prius" and Chevrolet "Volt."

The word "hybrid" on the underhood cover panel is a common indicator.



This label, underhood on a GM belt / alternator starter (BAS) hybrid, warns of 36 volts being fed to this part.

Emergency personnel are told the quickest way to cut the power to avoid personal injury.



The yellow tape with the fire hat image marks the spot to cut through the cables.

The next best place to look for identifiers of an EV or HEV is underhood, where there is typically labeling that may include:

- the word "hybrid" or other identifier on the engine cover.
- warning decals on the underside of the hood and any HV part.
- a first responder label calling attention to the cut tape label on the 12-volt battery cable to disconnect the 12-volt battery, thus disabling the HV system. There may be more than one cable that must be cut. Emergency responders are directed to cut through all the cables, as leaving one uncut will still supply 12 volts. The 12-volt system controls the HV system.
- a yellow first responder cut tape label on the 12-volt battery cable, showing where a first responder should cut to disconnect the 12-volt battery.

Ford Escape Hybrid

This label in the trunk on a Ford Escape Hybrid indicates the presence of the HV battery and to consult the service manual.

Lexus RX450h

This "high voltage" label on the inside of the trunk on a Lexus RX450h also shows a drawing of the service disconnect.

Honda Accord Hybrid

This label, noting that high temperatures may damage the onboard HV battery, is on the driver B-pillar on Honda HEVs.

Chevrolet Malibu BAS Hybrid

The word "hybrid" may be indicated on the instrument panel even when the vehicle is not powered, such as on this 2008 Chevrolet Malibu BAS Hybrid.

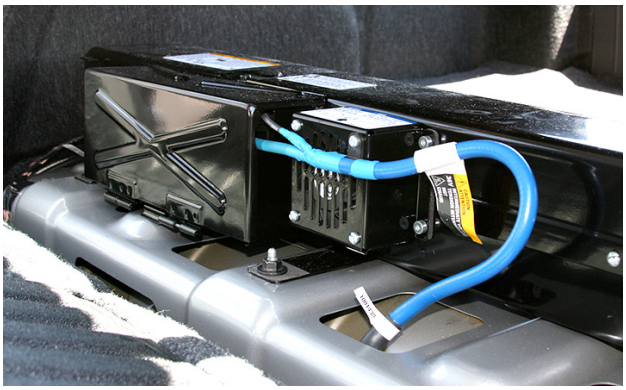
Other labeling identifying the vehicle as an EV or HEV may include:

- warning labels on or near the HV battery itself.
- warning labels on other locations. For example, there may be labels in the trunk in the area of the battery. Honda electric vehicles have a sticker on the driver side B-pillar warning to avoid high temperatures in a spraybooth because of the onboard HV battery.
- a hybrid logo on the instrument cluster even when it is not powered.

Volkswagen e-Golf

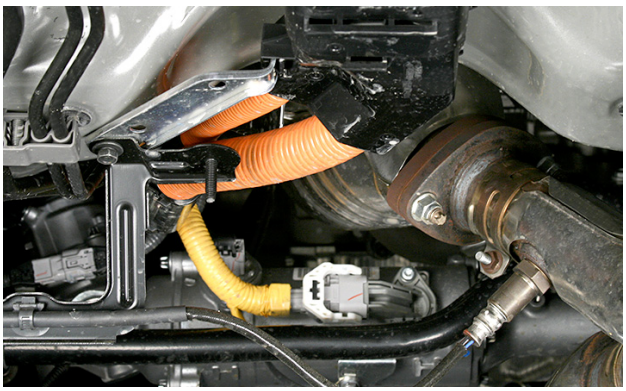
The bright orange cables underhood on this 2015 Volkswagen e-Golf indicate the possible presence of HV.

Chevrolet Malibu BAS Hybrid



GM uses blue for the 36-volt intermediate voltage on this 2008 Chevrolet Malibu BAS Hybrid.

Lexus RX400h



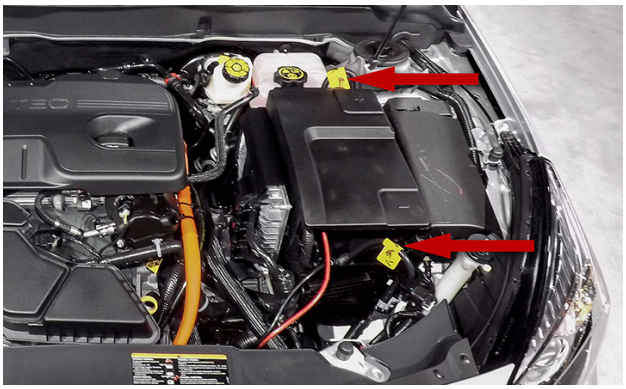
The yellow cables on the underbody of this Lexus RX400h show the presence of intermediate voltage for the power steering assist.

Cable color is another method of helping determine an HEV or EV, as:

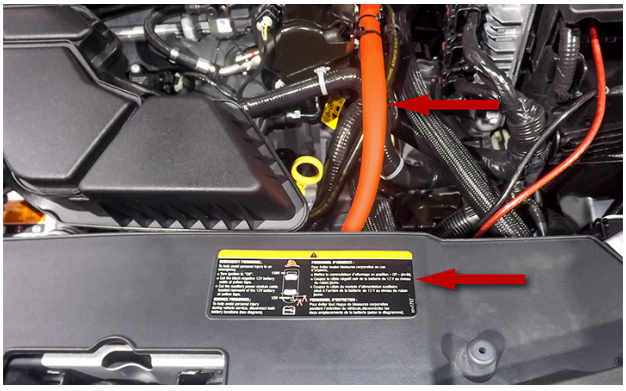
- low voltage is typically colored black. GM, for example, specifies a range up to 30 volts DC and 15 volts AC for low voltage.
- cables that carry HV have sheathing that is universally colored bright orange. Look for bright orange sheathing on underhood cables. Some vehicle makers, including Ford and Honda, use orange-colored sheathing for all voltage levels higher than 12 volts.
- there are cables on HEVs and EVs that carry intermediate voltage, and these may be colored blue or yellow. GM vehicles with the BAS system, specifically the 2007 - 2010 Saturn Vue and Aura Hybrids and the Chevrolet Malibu Hybrid, have a 36-volt battery pack with blue cables. GM considers voltage from 30 - 60 volts DC intermediate voltage and colors those cables blue. On Toyota and Lexus vehicles, intermediate voltage cables are yellow.

Color cannot be used alone to determine voltage levels. Color is just an indicator. Warning labels and service information are a better guide for the presence of high and intermediate voltage.

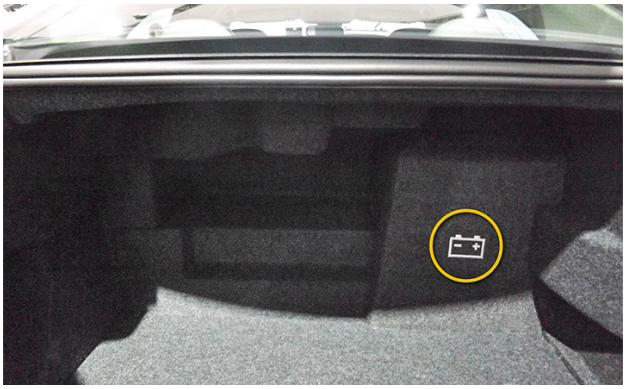
The word "eco" by the Malibu nameplate is the only external identification on any of the GM eAssist vehicles.



Underhood, there are yellow emergency responder cut tape labels indicating onboard HV.



The underhood orange cable and label are warnings to emergency responders on the presence of HV.



There is a battery icon in the trunk.

The "Auto Stop" on the instrument panel shows this vehicle is equipped with stop / start technology.

There are four GM vehicles, produced first in 2012, that have HV batteries onboard but no exterior emblems or nameplates indicating this. These include the:

- Buick LaCrosse and Regal eAssist.
- Chevrolet Malibu and Impala eAssist. The Impala eAssist version was only offered in 2014, and only about 2,000 were sold.

One of the eAssist models, the Chevrolet Malibu eAssist, has the word "eco" in a green box by the exterior nameplate, indicating the classification. The eAssist Malibu was discontinued in model year 2014.

These vehicles are equipped with a 130-volt lithium-ion battery in the rear. With no exterior nameplates, other than the "eco" word on the Malibu, the vehicles can be identified by:

- a bright orange cable underhood which is connected to a starter / generator.
- yellow first-responder cut tape labels around the 12-volt cables, also underhood.
- a battery icon in the trunk area.
- an "Auto Stop" position and economy gauge at the bottom of the speedometer or tachometer.
- warning labels on top of the radiator core support and the battery itself.

Ford C-Max Energi

This is a standard configuration charge port on the Ford C-Max Energi plug-in electric vehicle.

Nissan Leaf

The charge port on the pure-electric Nissan Leaf is behind a flip-up door in the front.

Nissan Leaf

This is a closeup view of the charge port on the pure-electric Nissan Leaf, with the standard port on the right and fast-charge port on the left.

Volkswagen e-Golf

The charge port on the pure-electric e-Golf is behind a sliding door in the front, and has the standard port on the left and fast-charge port on the right.

EVs and PHEVs have a charging port, often behind a door resembling a fuel-filler door. The port is used to plug in the charger connected to a 220- or 110-volt electrical source. The charge port is in varied locations, such as:

- on the left side fender on the 2014 Ford C-Max Energi HEV.
- a front flip-up door on the 2014 and newer Nissan Leaf pure-electric.
- a sliding front door panel on the 2015 Kia Soul EV.

There is a standard configuration of the charging port on all EVs, per a standard set by the Society of Automotive Engineers (SAE) in 2012. Charging standard J1772 assures that no matter what EV or PHEV, a roadside charging plug will fit. This is not the case for fast-charging ports that some EVs and PHEVs offer in addition to the regular charging port. There are currently several configurations but no standard for fast-charging ports.

VIN POSITIONS 5, 6 AND 7	VEHICLE
P0L	Fusion SE Full Hybrid
L2L	MKZ Hybrid Full Hybrid
P0P	Fusion SE Energi Plug-In Hybrid
P0R	Fusion Titanium Full Hybrid
P0S	Fusion Titanium Energi Plug-In Hybrid

SAMPLE VIN: 3FADP0L30AR100001

Fusion Hybrid FWD

Ford Motor Company indicates their HEVs in the 5th through 7th positions of the VIN.

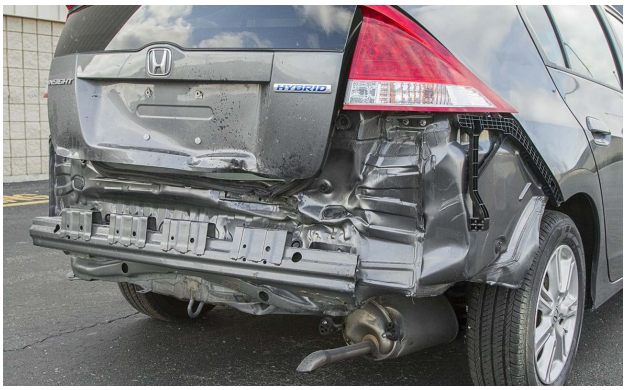
The vehicle maker may indicate on the VIN whether the vehicle is an EV or HEV. Examples include:

- Ford, which uses the 5th, 6th, and 7th VIN positions to identify the hybrid line. For example, the Ford C-Max Hybrid has "P5A" or "P5B" as the 5th through 7th characters and the C-Max Energi has "P5C" as the identifier for the plug-in model.
- Hyundai, which uses the number "4" in the 8th character of the VIN to indicate that the vehicle is an HEV such as the Sonata Hybrid.
- Toyota, which uses the first 6 to 8 alphanumeric characters in the VIN to indicate a hybrid. The 3rd generation Prius, for example, is identified with the first 8 alphanumeric characters "JTDKN3DU."

Using the VIN is not a universal method of identification. For example, Honda does not use the VIN to indicate an EV or HEV.

Information Sources

Honda Insight

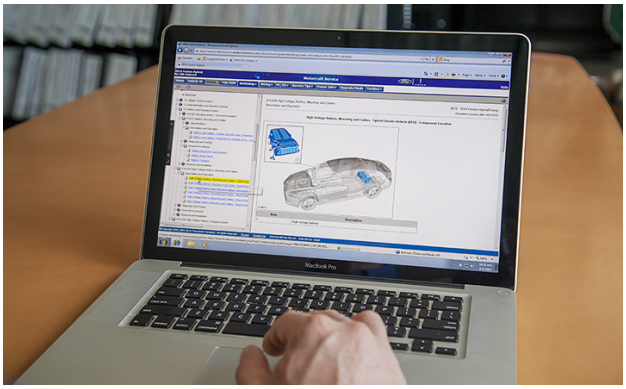


There are several sources of information available to identify the high voltage parts on this 2010 Honda Insight HEV.

When estimating a vehicle with electric technology, where should you go to find information?

- Vehicle maker service information
- Emergency response guides
- Dismantling guides

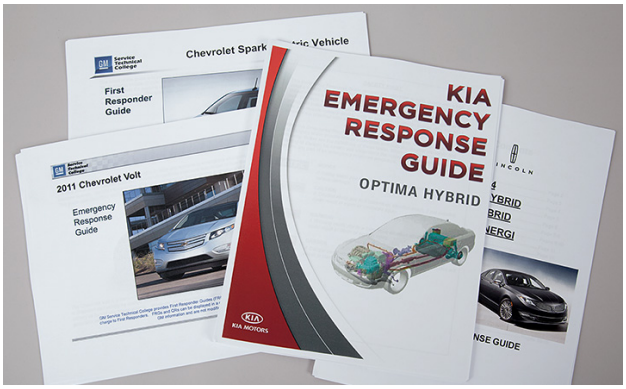
All of these can be found easily by going to the I-CAR Repairability Technical Support (RTS) Portal, i-car.com/RTS, under the Technical Knowledge banner, select OEM Information. Then select the vehicle maker of choice.



Vehicle service information will contain all the information that is needed on a specific alternative fuel vehicle.

Vehicle maker service information specific to the vehicle model and model year:

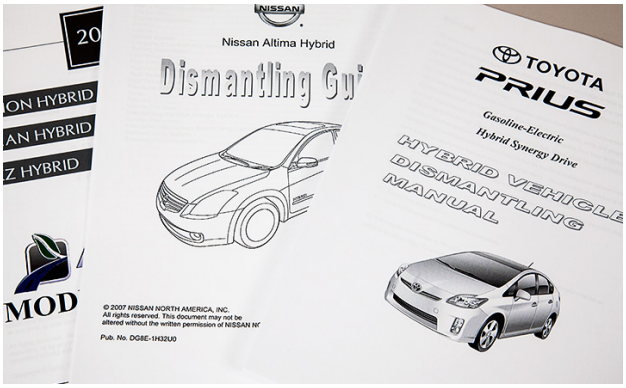
- is the best resource for repair information on any vehicle whether electric or not. All of the information is aimed at the repair technician.
- includes a description and operation of all systems and parts on that specific vehicle.
- identifies diagnostic information, procedures for replacing parts, and any special tools and equipment required for the specific vehicle.
- includes up-to-date technical service bulletins that may affect the repair of the vehicle.



Emergency response guides are free and contain valuable information on electric vehicles.

Emergency response guides (ERGs) are:

- free online publications that explain how to approach an EV or HEV.
- written by the vehicle makers for emergency responders to safely extricate someone from an electric vehicle, put out a fire, or other emergency situation.
- effective for the collision industry in that they include identification information and part locations and descriptions, among other information. HV disabling procedures are included, but the information may not include instructions for pulling the service disconnect, which is recommended before a vehicle is towed or doing collision repairs.
- linked off the I-CAR Repairability Technical Support website: i-car.com/RTS. On the RTS site select "Hybrid And Electric Vehicle Disable Search" from the left column. Select make, model and year of the vehicle. Find a link to the Emergency Response Guide.



Dismantling guides are free on vehicle maker websites and contain valuable information on alternative fuel vehicles.

Another resource from the OEMs is an online dismantling guide, which:

- is aimed at the recycling parts industry.
- is also free information on some vehicle maker websites. Not all vehicle makers have dismantling guides. Examples of those that do include Ford, Nissan, and Toyota.
- includes similar information as ERGs, such as safety precautions, identification information, and HV part locations.
- includes additional information such as HV part functions, vehicle operation, and methods for part removal. For example, instructions for removing parts to access HV parts, removing the battery pack, cleaning up battery electrolyte spills, and a tent sign indicating that the technician is working around HV are typically included.

Ford Motor Company has modifier's guides with their service information. These guides include information on what can be done and what cannot be done when modifying an HEV or EV for such uses as a police vehicle, taxi cab, or limousine. Again, much of this information is valuable for repair technicians working with HEVs and EVs.

Dismantling guides are linked off the I-CAR Repairability Technical Support website: i-car.com/RTS. On the RTS site select "Hybrid And Electric Vehicle Disable Search" from the left column. Select make, model and year of the vehicle. If there is a Dismantling Guide for that vehicle, there will be a link.

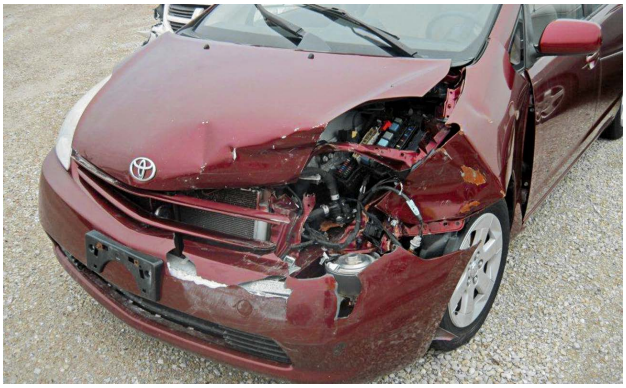
KPI Improvement Tip
Getting the dismantling information up front in the repair process will save the technician valuable time once the repairs have been started.

Hazards With Electric Vehicles

Refer to Module 2, Demonstration Video: Shocking Facts in the presentation for a

video demonstration of how you can get shocked from a battery.

Toyota Prius

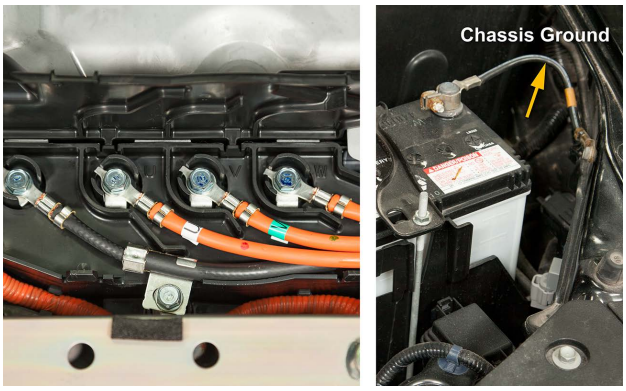


This Toyota Prius has front end damage.

When approaching an EV or HEV for doing an estimate, general safety considerations include:

- be aware that the collision may have compromised HV safety systems and present a potential HV electrical shock hazard.
- always assume that parts of the HV circuit are energized even though steps have been taken to disable the system. After a collision, anything is possible.
- do not wear metallic objects or jewelry. Do not have metal objects, such as mechanical pencils or tools, in pockets. A metallic object may fall from a pocket onto an HV part or connection and cause a short circuit.
- make sure skin is not wet and there is no moisture present on or around the vehicle.

Honda CR-Z

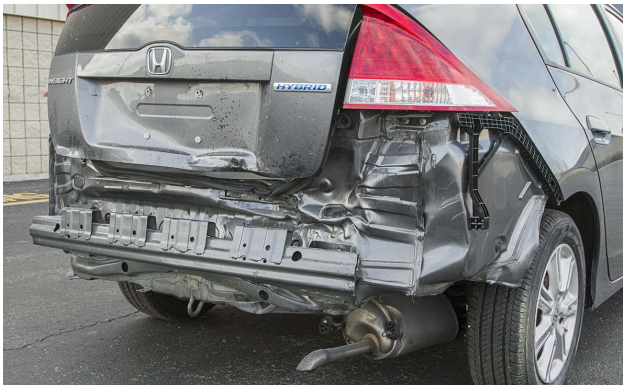


An HV battery (left) does not use a chassis ground like a 12-volt battery (right). This makes the HV system a floating system.

A high voltage system is referred to as a floating system, in that with:

- the 12-volt system, the negative terminal of the battery is connected to the chassis making it a common ground.
- an HV system, both terminals of the HV battery are connected directly to the HV parts via the HV cables and connectors. There is no common ground. The ground is floating.

Refer to Video: Floating System in the presentation. This video explains that the high voltage system is a floating system.



Refer to Activity: Damaged HV Parts in the presentation for different looks of the damage on this Honda Insight.

Honda CR-Z

The sediment on the underhood parts is a sure indication this 2010 Honda CR-Z has been flood damaged.

Flood-damaged HEVs and EVs might seem to pose a high safety risk, as water and electricity do not mix well. However, there is no electrocution danger to an occupant or rescue personnel from a vehicle that is submerged. HV batteries that have submerged will short circuit internally and lose their charge. Some instructions for working with flood-damaged HEVs and EVs include:

- not pulling the vehicle from water, if it is partially or fully submerged, until it is certain that the HV battery is completely discharged. Ford states that a submerged HV battery can produce fizzing or bubbling while it is being discharged, and once this reaction stops the battery is discharged.
- manually disable the HV system using one of the procedures described.
- draining the water from the vehicle, if possible.

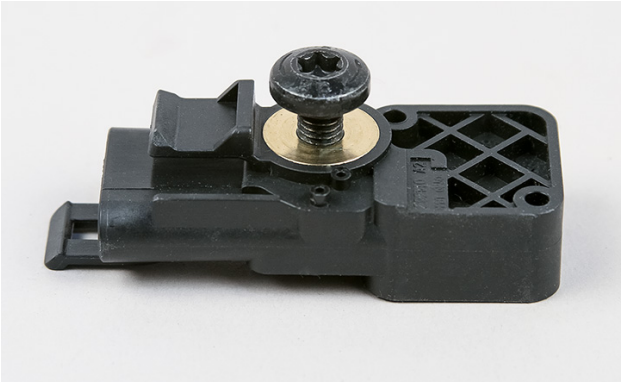
Honda Accord Hybrid

The highly visible cable sheathing and various warning labels are only part of the built-in safety underhood on this 2014 Honda Accord Hybrid.

Electric vehicles are not designed to be HV shock hazards for anyone that opens the hood. There are built-in safety features, such as:

- insulation and sheathing on the HV cables. HV current flows

through these cables, not through the metal vehicle body.
- various onboard sensors that shut off the HV if a problem is detected, such as a collision. For example, on the Honda Accord Hybrid, Plug-In Hybrid, and Acura RLX Hybrid, the passive restraints control unit uses information from the airbag impact sensors to stop the flow of current from the HV battery in the event of a collision.
- warning labels posted wherever there could be a potential for shock.
- multiple methods of disabling the HV system. The simplest is to turn off the ignition and remove the key. If it is a keyless ignition, the electronic key must be removed from the area.

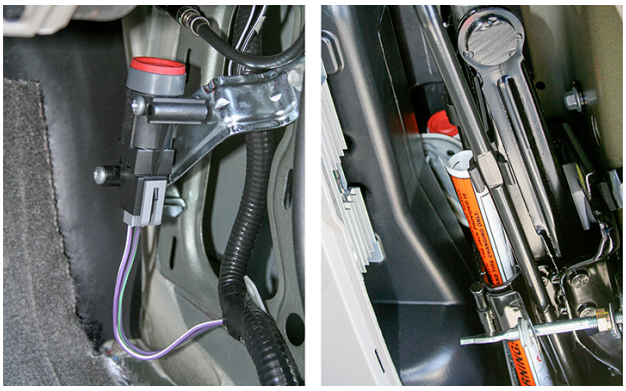


This is the HV Circuit Impact Detection Sensor, which is attached to the radiator core support on two-mode GM HEVs.

Some HEVs have a dedicated onboard sensor to automatically disable the HV in a collision. For example:

- GM two-mode HEVs have a HV Circuit Impact Detection Sensor located in the front of the vehicle, on the lower tie bar. The HV system is automatically disabled whenever there is an airbag deployment. This sensor detects offset front collisions that do not deploy the airbags, as the HV system can also be damaged by an offset front collision. The sensor sets a diagnostic trouble code (DTC) that requires a scan tool to clear. It does not have to be replaced if it is not damaged in the collision. It can be reset using the scan tool and reused.
- most Toyota and Lexus HEVs have a circuit breaker sensor mounted on the inverter which shuts off the HV in the event of a collision. If any circuit breaker has tripped, a DTC is set. The code must be cleared with a scan tool before the vehicle will start.
- the Ford Escape Hybrid has a thermal sensor on the HV battery to automatically disconnect the battery if the ignition is on and the HV battery exceeds 140°F.
- the Ford C-Max Hybrid and C-Max Energi PHEV have an HV interlock circuit that disables the HV whenever any HV connector is disconnected.

Ford Escape Hybrid



There are inertia switches in the front (left) and the rear (right) on the Ford Escape Hybrid.

Ford / Lincoln vehicles have an inertia switch that cuts off the fuel in a collision. The Ford Escape Hybrid has two inertia switches, one in the front and one in the rear. With these inertia switches:

- the front switch cuts off both the fuel and the HV in a collision. The rear inertia switch cuts off power to the HV contacts inside the battery case. When the powertrain control module (PCM) senses the loss of power at the contacts, the PCM shuts off power to the fuel pump. Therefore, the rear inertia switch also, indirectly, cuts off power to the fuel pump.
- the front inertia switch is located behind a service panel in the front passenger compartment in the right side footwell area.
- the rear inertia switch is located in the jack storage compartment in the right side of the cargo area.
- both switches can be reset with the red button on the top of each switch. The service information states to turn the ignition to LOCK and check for fuel leaks before pressing each reset button.

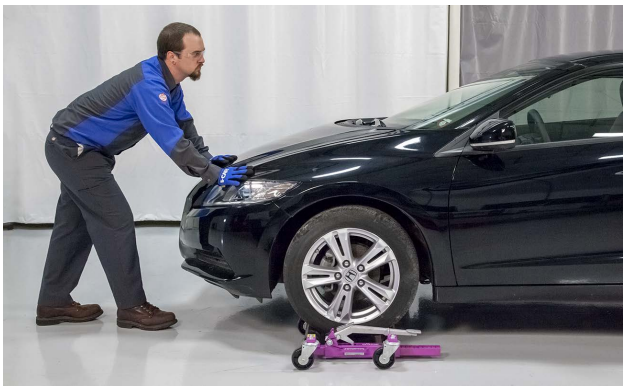
On the Ford C-Max Hybrid and C-Max Energi PHEV, both the fuel supply and high voltage are also cut off in a collision, but there is not a reset button on the switch itself. The systems are reactivated by cycling the ignition. The owner's manual is a good source for the reset process.

An electronic key can start the vehicle if it is in the vicinity.

EVs and HEVs equipped with an electronic key should be removed and kept the recommended distance away from the vehicle. This distance varies from 4 - 16 feet. If not, the vehicle could start without warning and there will not be any noise.

Disconnecting the 12-volt battery will also prevent unintentionally starting the vehicle.

Honda CR-Z



Use go-jacks or equivalent to move an HEV or EV so the drive wheels are not turning.

When servicing a damaged HEV or EV, do not push the vehicle with the drive wheels on the ground. Use wheel dollies to move the vehicle without turning the drive wheels. Moving the vehicle with the drive wheels on the ground:

- may generate electrical energy and charge the capacitors in the inverter.
- could start a fire if there is damage to an HV cable that shorts it to the vehicle chassis.

Working Safely

Equipment used to work safely around an EV or HEV includes a fire extinguisher, a DVOM that can read HV, alert signs, and electrical tape.

Additional equipment required to work safely with a damaged EV or HEV include:

- an HV DVOM with the proper test leads. Test leads used around HV parts should have finger guards to ensure that HV parts are not touched while probing with the test leads. A meter capable of reading megaohms may be used to check the insulating properties of the HV cable insulation.
- warning signs for the presence of HV. While the vehicle is at the repair facility, it should be signed as an HV vehicle to warn others.
- a multi-class, ABC-rated fire extinguisher. Class ABC fire extinguishers are suitable for use on ordinary combustibles, flammable liquids, and electrical fires.
- vinyl electrical tape for temporarily insulating bare HV cables. After disabling the HV system and testing for the presence of voltage, bare spots in HV cables

and cable ends can be temporarily insulated with vinyl tape until the cable can be replaced or the end reconnected.

Insulated lineman's gloves, protected by leather outers, are essential when working around HV connections.

Class 0, electrically insulating rubber gloves, or lineman's gloves, are a necessary safety item for technicians working around HV systems. These lineman's gloves:

- need to be worn for any tasks that require touching HV parts such as when disabling the HV battery using the service disconnect switch.
- need to be covered by protective leather outers to help protect from tears and contaminants. If the gloves have any holes or tears, they must be discarded. Leather outers do not come with the gloves.
- should be inflated before each use to ensure that no tears or holes exist. They may be inflated by blowing into them or by rolling them up from the open end. There are also commercial glove inflators that are made for this purpose. Even a tiny pinhole in the glove may expose the hand to electrical energy.
- cannot be used if they are wet. Lineman's gloves should always be completely dry.
- must be tested by a certified testing lab every six months to ensure no loss of insulating properties.
- should be stored in a clean, dry, cool location. The original box is a perfect storage location.

Refer to the Insulated Rubber Gloves And High Voltage Batteries article for more information on the proper use and care of electrically insulating rubber gloves.

Download the Insulated Rubber Gloves And High Voltage Batteries article in PDF format from the link on the presentation screen.

An electrolyte spill kit should include litmus strips to determine if the spill is acidic or alkaline.

Most HV batteries have a gel-type electrolyte which does not spill. However, it is possible that battery damage can result in some electrolyte leakage. Electrolyte from an HV battery is highly alkaline or caustic. Lead-acid batteries have electrolyte that is highly acidic.

Safety equipment required for cleaning up battery electrolyte spills include:

- litmus paper for checking the acidic or alkaline content of the suspected spill.
- neoprene rubber boots or shoe covers, as well as coveralls, suits, or aprons.
- alkali- and acid-resistant face shields or goggles. Eyes must be completely protected against accidental splashing of the electrolyte.

Electrolyte neutralizing solutions include boric acid (center) and water for an HV spill and baking soda or ammonia and water for a lead acid battery spill.

Electrolyte spills require neutralizing with a solution. The solution used depends on whether it is an alkaline or acidic spill. For an:

- alkaline spill, such as from an HV battery, neutralize with boric acid and water solution.
- acidic spill, such as from a 12-volt battery, neutralize with baking soda or ammonia.

Module Wrap Up

Topics discussed in this module included:

- electric vehicle identification.
- sources of information on electric vehicles.
- hazards when working around electric vehicles.
- safety equipment required when working around electric vehicles.

Module 2 - Alternative Fuel Vehicle Safety

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Diesel-Fueled Vehicle Considerations

Learning objectives for this module include:

- identifying considerations with diesel-fueled vehicles.
- identifying considerations with compressed natural gas (CNG) vehicles.
- identifying considerations with liquid petroleum gas (LPG) vehicles.

This is a GM bottle of diesel exhaust fluid.

Diesel-fueled vehicles are getting to be more popular in the U.S., as diesel is more fuel-efficient than gasoline. Since 2010, all diesel vehicles in the U.S. must be equipped with a system to inject a urea additive into the exhaust stream to reduce nitrogen oxide (NOx) emissions.

U.S. vehicle makers call the additive "diesel exhaust fluid" or DEF.

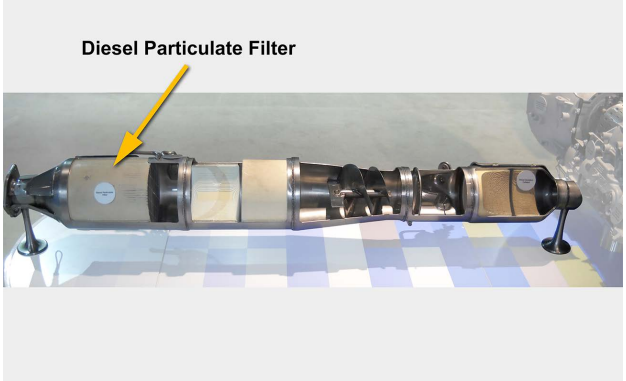
Vehicle makers recommend using the make-specific DEF, which can be purchased from the local dealership.

Jeep Grand Cherokee Diesel

Modern diesel vehicles sold in North America have a separate tank and filler port for the diesel exhaust fluid.

The DEF:

- requires a separate tank and filler port on the vehicle. The filler port may be in the trunk area, such as on the 2014 Chevrolet Cruze Diesel, or next to the diesel filler port, such as on many pickups.
- tank typically holds about five gallons of DEF and must be filled about every 10,000 miles.
- when the tank is near empty, a sensor signals the engine computer to limit the vehicle engine speed until the engine will not start at all.



This cutaway of a Ford F250 diesel exhaust shows that a diesel particulate filter is in a bulging area of the exhaust.

Since 2007, diesel-engine vehicles require a particulate filter in the exhaust. This diesel particulate filter:

- captures soot particles in the exhaust so they do not blow out into the atmosphere.
- when filled, automatically heats up to reduce the particulates to ash, which is vented. When this occurs, the particulates are harmful to breathe and the temperatures at the exhaust tip are high enough to cause burns.
- eventually must be replaced and disposed of as hazardous waste.

CNG Vehicle Considerations

Honda Civic Natural Gas

On the Honda Civic Natural Gas vehicle, there are nameplates identifying the fuel type.

Most vehicles fueled by CNG are conversions, but there is at least one CNG vehicle made by a vehicle maker. The Honda Civic Natural Gas vehicle has been publically available in some markets since 2005. The nameplate on the Honda Civic makes it clear it is a CNG-fueled vehicle.

CNG conversions can be identified by:

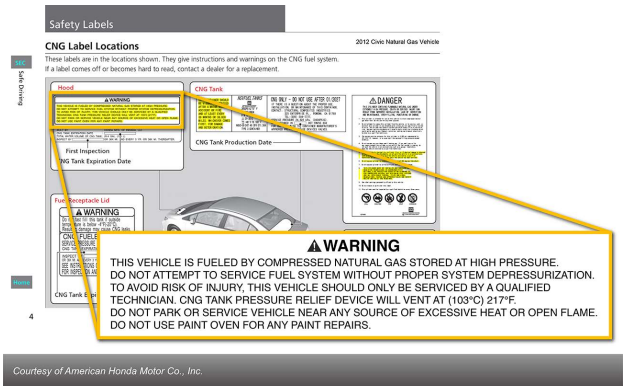
- a label inside the fuel-filler door, and there may be a decal.
- a fuel-filler valve instead of, or in addition to, a gasoline filler neck.
- stainless steel fuel lines, which may be covered with sheathing.

CNG requires a tank pressurized to 3,600 psi.

Hazards with CNG as a vehicle fuel include that CNG:

- is flammable and explosive, though not as much as gasoline.
- is a very dense gas when compressed at 3,600 psi, but lighter than air when released so the vapor rises when vented. This means there is more of a danger of fire at the ceiling level than the floor level.
- tanks have a thermally activated pressure relief device that opens if the temperature exceeds 216°F. Once activated, the relief device does not reseal. Gas vents out until the tank is empty.

Honda Civic Natural Gas



The labels on the Honda Civic Natural Gas clearly state the precautions to take with CNG.

For its Civic Natural Gas model, Honda specifies that only qualified technicians service the vehicle. For any collision repairs, Honda requires the CNG tank be removed at a qualified dealership before the vehicle even enters the repair facility. Labels on the vehicle specify to:

- not park the vehicle in an enclosed space after a collision.
- have the vehicle inspected and repaired by a trained technician.
- not use a spraybooth, which Honda refers to as a "paint oven," for any refinishing repairs.

After the CNG tank is removed and the CNG lines are purged, the vehicle can be repaired like a regular Honda Civic, then returned to the qualified facility to have the CNG tank reinstalled.

One of the requirements for a qualified facility, as stated in National Fire Protection Association (NFPA) code 52, is an approved flammable gas detection

system calibrated to the specific gas. In the event of a gas leak, the system must:

- emit an audible and visual alarm.
- automatically open vents to the outside.
- automatically shut off the facility heating system.

LPG Vehicle Considerations

The labels inside the fuel filler door show this vehicle should be fueled with LPG.

Most vehicles fueled by liquid propane gas (LPG) are conversions, so there is no official emblem or nameplate for identification. Therefore, a vehicle that is fueled with propane is identified by the:

- fuel-filler valve, instead of or in addition to, a gasoline filler neck.
- torpedo- or doughnut-shaped fuel tanks either in the cargo area, underside, or on the truck bed.
- copper fuel lines, which may be covered by a sheathing.

LPG tanks must be white or at least a light color, as dark colors could absorb enough heat to open the pressure relief valve.

Hazards with vehicles that use LPG as fuel are that:

- propane is a liquid state under pressure but immediately releases as a vapor when a pressure relief valve is opened.
- a mild temperature difference, such as moving the tank from a cold to a hot area, is enough to open the pressure relief valve. For this reason, propane tanks should not be painted any color other than white or a light reflective color. A dark-colored tank can absorb enough heat from the sun to open the pressure relief valve.
- propane vapor is heavier than air, so the vapors will hover near the floor if released.
- propane is highly flammable. Mixtures in the air as low as 2% will easily ignite and explode. Released vapors can form a flammable layer against the floor.

Ford Expedition Conversion

The tanks on this converted Ford Expedition make it clear that this is an LPG conversion.

Similar to a CNG-fueled vehicle, the vehicle cannot be brought into an enclosed space, such as a repair facility, until the LPG tank is removed and the fuel lines purged. This should be done by a qualified technician at an approved facility that does LPG conversions. For example, there are Ford dealerships qualified to convert F-series pickups to LPG using the Roush conversion kit.

The same fire code requirements apply to LPG as CNG. The repair facility must be equipped with an approved flammable gas detection system calibrated to LPG, which in this case must detect vapors hovering at floor level.

The fact that the pressure relief valve can open so easily makes it especially critical for the tank to be removed before any collision repairs.

Module Wrap Up

Topics discussed in this module included considerations with:

- diesel-fueled vehicles.
- compressed natural gas (CNG) vehicles.
- liquid petroleum gas (LPG) vehicles.

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