



## PRELIMINARY HYBRID TRAINING HYBRID SAFETY & BASICS

With over 350,000 hybrid vehicles on U.S. roads it is almost a certainty that a percentage of these will find their way into aftermarket repair shops. Hybrid vehicles differ from a conventional gas or diesel powered vehicles which pose a threat to the technician that will repair them.

This threat is in the form of very high voltage, the voltage level in these vehicles can be anywhere from 144 to 650 volts which presents a new level of risk for the technician.

Training and safety equipment is an absolute must without exception, because for the first time the technician is working on a vehicle that can cause injury or death.

Even driving one of these vehicles requires special attention because when these vehicles are in electric only mode, they make no noise. Therefore it is possible to run someone over because they did not hear you and you thought they would get out of the way because we take that for granted with conventionally powered vehicles.

These vehicles also have “Engine Stop/Start technology which means the engine stops and starts back up on its own which poses a hazard for the technician whose hands may be in the way.

Certain makes like Toyota have what is called a smart key which can start the engine without even being in the car. All that’s necessary is to get close enough so the vehicles transponder signal is pick up by the key fob.

Once the vehicle is disabled, do not push the around the shop on its wheels, these vehicles have regenerative braking which means they generate electricity when the wheels are turning, use dollies

Once you have hybrid training and proper safety equipment it is important to recognize a hybrid vehicle when it comes into the shop, some hybrid badging is subtle so look for hybrid identification on the vehicle. If you open the hood you will see orange cables, that tells you have a hybrid vehicle.

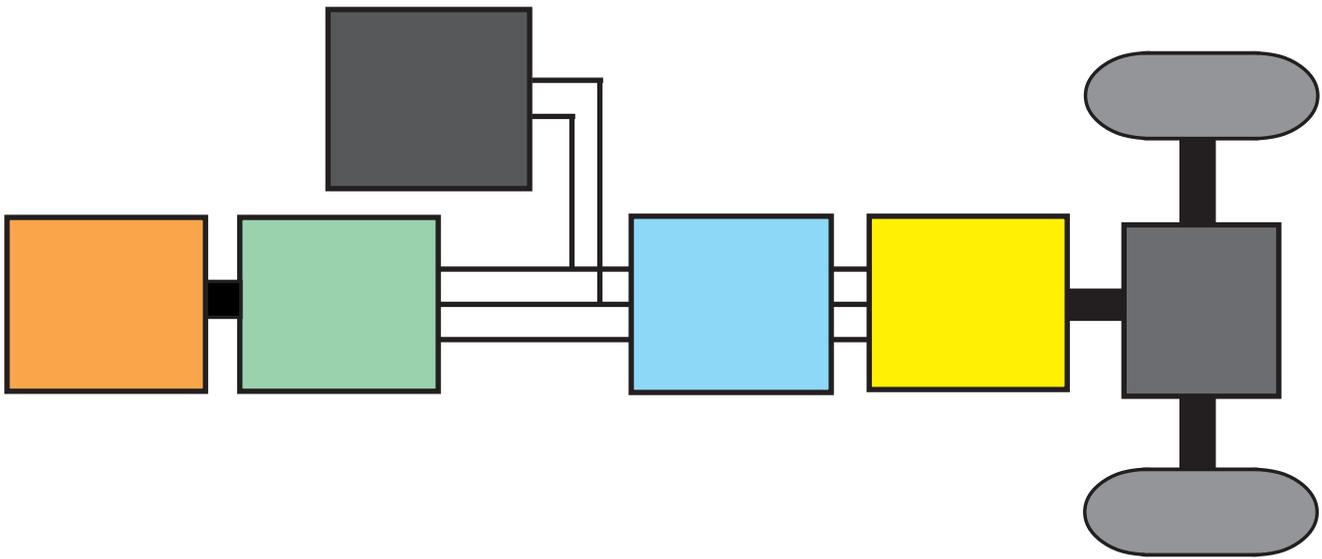
The following is a list of hybrid vehicles currently on the road, there will be many more to come.

|                        |                        |
|------------------------|------------------------|
| Toyota Prius           | Chevy Volt             |
| Toyota Highlander      | Cadillac Escalade      |
| Toyota Camry           | Saturn Vue Green Line  |
| Lexus RX400h           | Saturn Aura Green Line |
| Lexus GS 450h          | Ford Escape            |
| Lexus LS600hL          | Mercury Mariner        |
| Lexus RX 450h          | Ford Fusion            |
| Lexus HS 250h          | Mercury Milan          |
| Honda Insight          | Mazda Tribute          |
| Honda Civic            | Nissan Altima          |
| Honda Accord           | Infiniti M33           |
| Honda Fit              | Dodge Durango          |
| Chevy Silverado PHT    | BMW 1 Series           |
| Chevy Silverado 2 Mode | BMW X6                 |
| Chevy Tahoe 2 Mode     | BMW 7 Series           |
| GMC Sierra             | Mercedes Benz S400     |
| GMC Yukon              | Mercedes Benz ML450    |
| Chevy Malibu           | Volkswagen Touareg TSI |

***ASSUME NOTHING, IT COULD SAVE YOUR LIFE!***

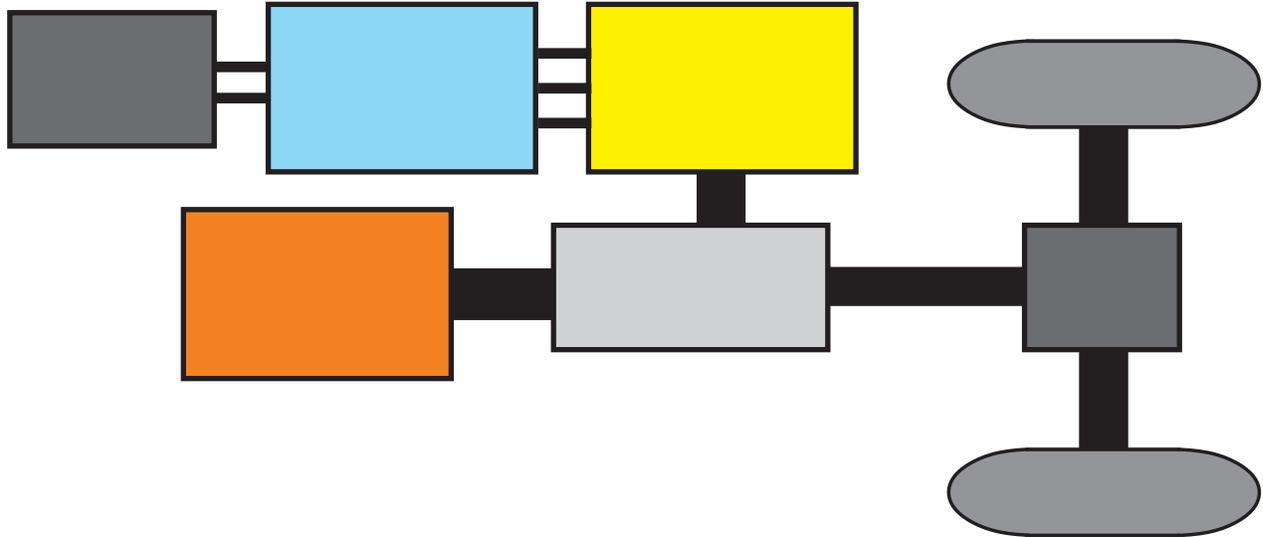
**AUTOMATIC TRANSMISSION SERVICE GROUP**

## SERIES HYBRID

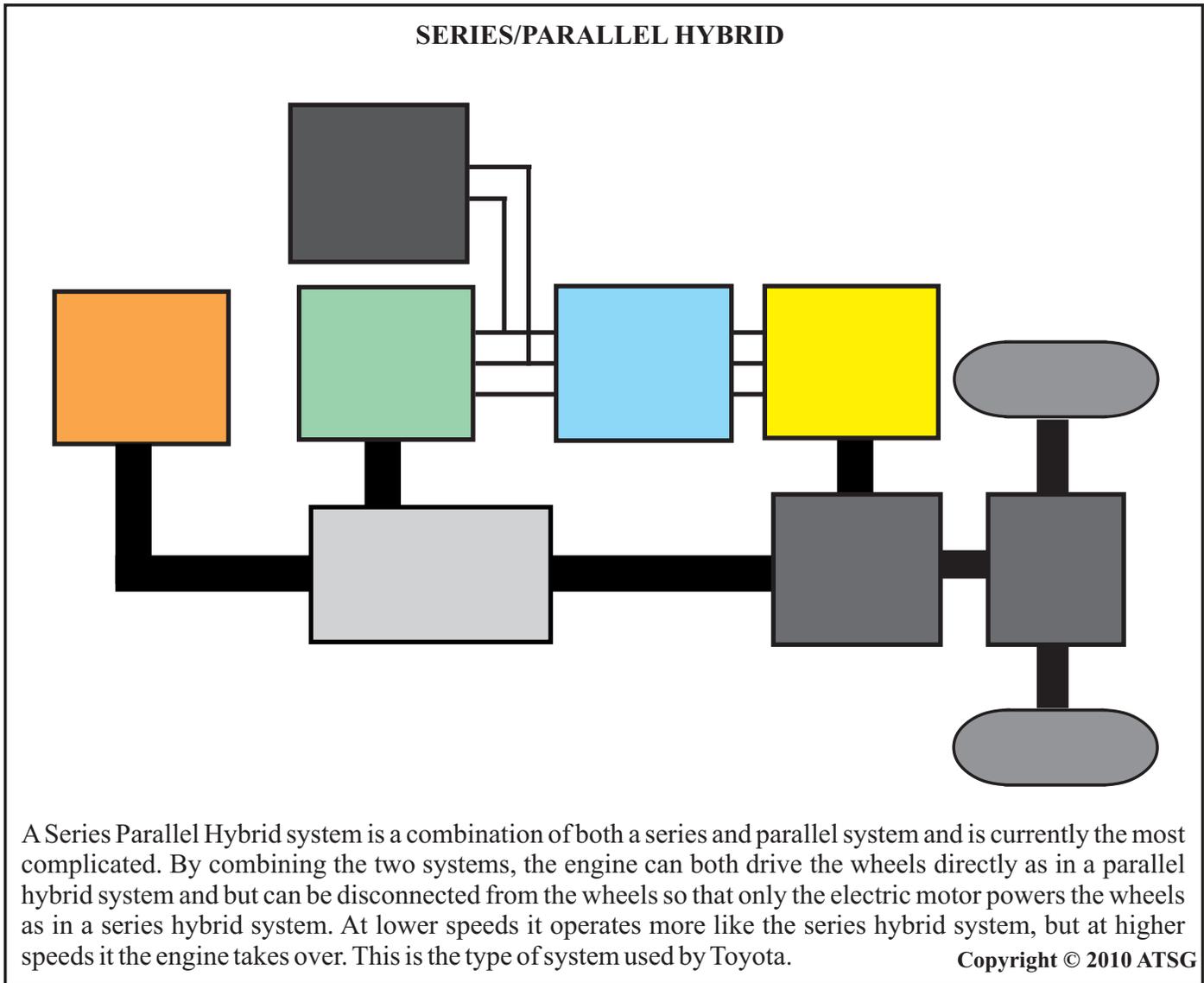


In a Series Hybrid equipped vehicle, the electric motor is what gets the wheels turning. The motor receives electric power from a generator run by a gasoline engine. A computer determines how much power comes from the battery pack or engine/generator. Both engine the engine/generator and regenerative braking recharge the battery pack. This is the type of system used in the Chevy Volt. Copyright © 2010 ATSG

## PARALLEL HYBRID



In a Parallel Hybrid equipped vehicle, both the engine and the electric motor generate the power that drives the wheels. Computer controls and a transmission allow these components to work in conjunction with each other. the electric motor and regenerative braking recharge the battery pack. This is the type of system used in Honda Hybrids. Copyright © 2010 ATSG



## HYBRID TERMINOLOGY

**ECVT - Electronically Controlled Continuously Variable Transmission**  
**EM - Electric Motor**  
**HEV - Hybrid Electric Vehicle**  
**HV - High Voltage**  
**ICE - Internal Combustion Engine**  
**kW - Kilowatt**  
**Li-ion - Lithium Ion Battery**

**MG - Motor Generator**  
**MH - Mild Hybrid**  
**NiMH - Nickel-Metal Hydride**  
**PSD - Power-Split Device**  
**SG - Starter Generator**  
**SOC - State of Charge**

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## HYBRID SAFETY REQUIREMENTS

The number of hybrid vehicles that are currently on the road and those that will be in the near future can pose a genuine threat to technicians that call the ATSG Help Line for technical assistance on servicing and repairing these vehicles.

What does an electric chair have in common with a hybrid vehicle?

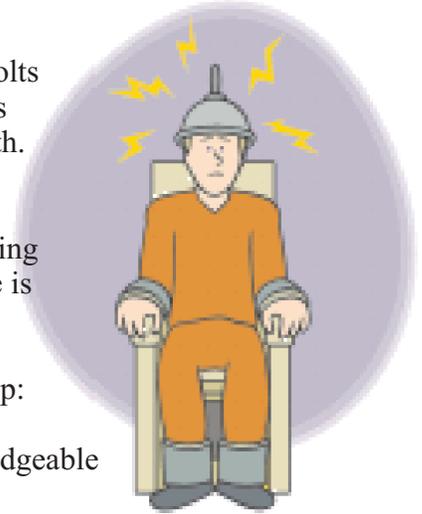
***Both can kill you!***

These vehicles have battery packs that can deliver between 144 and 330 volts to the hybrid's electric motors. This voltage can be bumped up to 650 volts by the inverter, certainly more than enough to cause severe injuries or death.

Therefore, in order to protect all parties involved in technical assistance as well as the technician working on one of these vehicles, ATSG is establishing a "required criteria" program that must be satisfied before a hybrid vehicle is touched.

The following list of safety requirements ***must*** be met by the repairing shop:

- Formal Hybrid Vehicle Training. Seek out professional classes by knowledgeable instructors. This is #1 on the list for a good reason.
- Hybrid vehicle identification. A hybrid vehicle may appear to be an ordinary vehicle, look for the common identifiers that let you know this is a hybrid vehicle....***Never Assume that it's not!***
- When road testing a hybrid vehicle, be mindful of pedestrian safety. When operating on electric motors only, these vehicles run silent. Someone stepping into the path of the vehicle you are driving may not hear you coming. ***Especially if that person is blind!***
- **ALWAYS** pay close attention to all hazard warning labels.
- Beware of ORANGE or BLUE colored cables, these are the high voltage lines. Before going near any of the high voltage components, locate and turn OFF the high voltage battery "disconnect switch". Wait 5 to 15 minutes for the capacitors to discharge before touching anything, Then **VERIFY** with CAT III voltmeter, that the voltage level has dropped below 12 volts.
- Make certain the vehicle ignition key is OFF and removed from the ignition switch and put in a safe place away from the vehicle. The vehicles use "stop/start" engine technology, if the key is left in the ON position and your hands are in contact with rotating components, the engine could start up at any time. Make certain the "ready lamp" in the instrument cluster is off.
- Before actual work begins, the work area should be secured by cones or yellow "caution" tape. This will prevent a coworker from turning the system back on. Only one technician should be designated to work on a hybrid vehicle at any given time.
- Before disassembly of any component, special gloves **MUST** be worn that are at least class "O" and are rated to 1,000 volts.
- These gloves must be tested before and after each use to insure that no damage has occurred to them, electricity can find its way through a pin hole. Check them by trapping air inside each glove and look and listen for leaks, this is an OSHA requirement.
- **NEVER** use gloves that are past their expiration date, they should be replaced immediately.
- These gloves are not meant to withstand sharp objects or other severe usage, they will be damaged. There are leather gloves that go over them to prevent damage to the insulating gloves.
- Do not assume that the high voltage circuits have no voltage, check them with a CAT III voltmeter that is rated for 1,000 volts. The meter leads must have the same rating. Immediately replace any lead that has damaged insulation.



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**HYBRID SAFETY REQUIREMENTS...continued**

- Try to limit the amount of metal items you wear when working on or near high voltage components such as jewelry, belt buckles and wrist watches.
- **NEVER** use AC voltage powered test equipment when probing high voltage circuits and NEVER pierce any high voltage cables.
- Use only approved insulated tools when working on high voltage components even if the system is off.
- Be certain to torque to specifications, any high voltage connection. Loose connections can cause high resistance in the circuit and could cause catastrophic damage when there is high amperage behind it.
- Once the vehicle is in the midst of the repair process, it should not be moved until repairs are complete. If the vehicle must be pushed to some other location in the shop with the drive axles in place, the technician **MUST** once again check for the presence of high voltage within the hybrid system. When the vehicle is pushed with the drive axles installed, the motor rotor is turned and will generate electricity into the system. These vehicles are equipped with regenerative braking which also creates electricity in the hybrid system.
- If any repairs are required that cause the technician to be in proximity with the electric motors rotor, he or she should be aware that this component is an extremely strong magnet and can cause death to someone who has a pacemaker.
- Be extremely careful of the hybrid batteries, they contain electrolyte that is far more corrosive than 12 volt battery electrolyte, it can dissolve human tissue, wear protective clothing. Spills should be handled in accordance with protocols for hazardous materials.
- If you intend to ship expired hybrid batteries back to the manufacturer for disposal, you must be DOT HazMat certified.
- Always be conscious of fire hazards and have approved fire extinguishers in prominent locations throughout the shop.
- Be very careful when working on a hybrid vehicle that has been in an accident. The hybrid system does not share its ground with the body, this could change as a result of collision damage.
- In the event that a hybrid or electric vehicle is equipped with Lithium Ion batteries, be aware that these batteries must remain cool, if these type of batteries are allowed to overheat, they can burst into flames. Some such equipped vehicles may use the HVAC system to keep these batteries cool. The AC system in these vehicles **MUST** be totally operational.

**ALL SAFETY REQUIREMENTS FOR HYBRID VEHICLE REPAIR LISTED HERE MUST BE MET...IT COULD SAVE YOUR LIFE!**

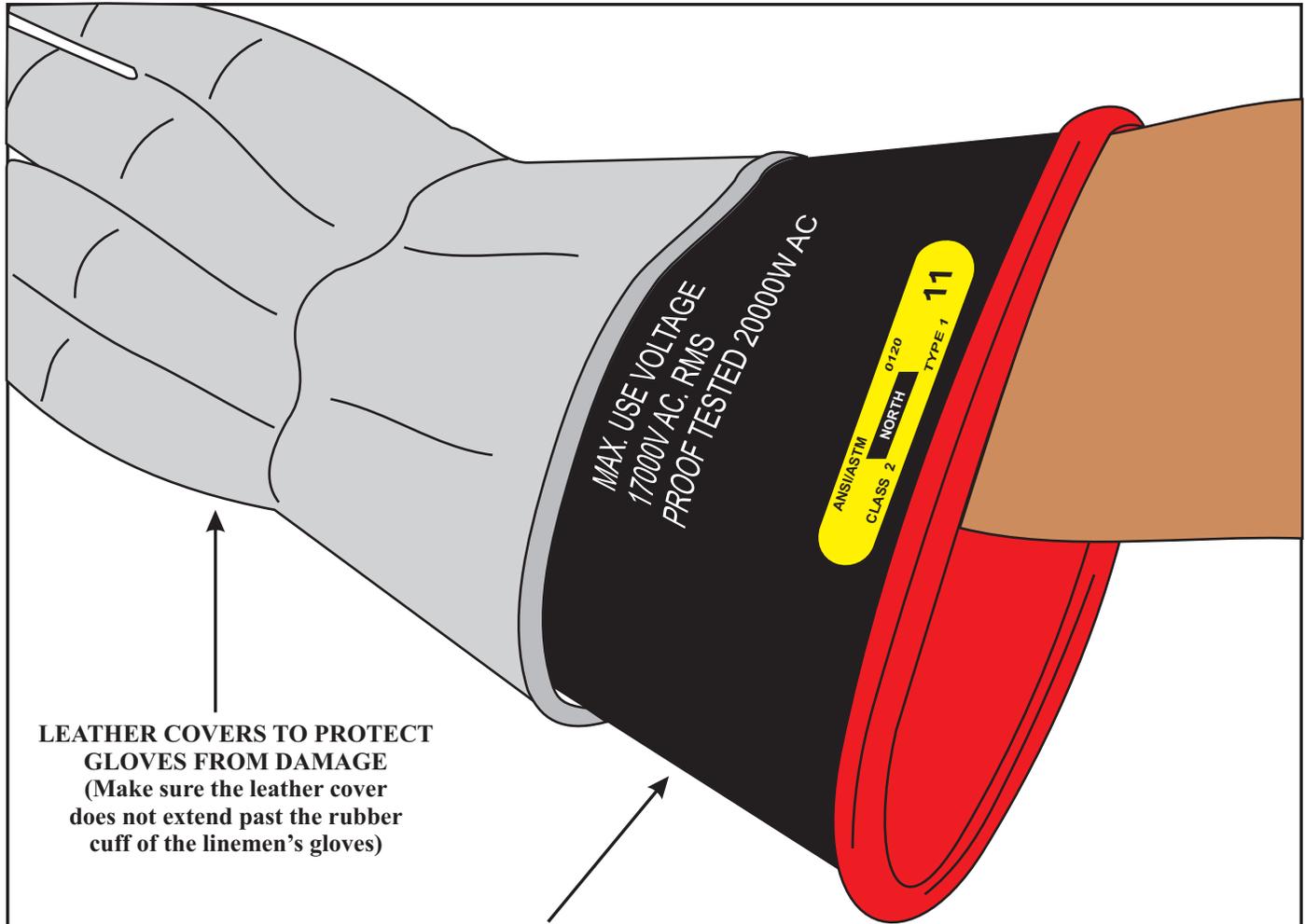
The threshold at which DC voltage becomes dangerous can be as low as 50 to 60 volts, since hybrid systems currently carry anywhere from 144 to 336 volts, it's more than enough to deliver a lethal shock. In most cases you cannot receive a shock by just touching the body of a hybrid vehicle because the hybrid system does not ground to the frame or body, the hybrid system is isolated from the rest of the vehicle. However, care should be taken if the vehicle was in a collision.

It is the **ORANGE** cables that carry the lethal amount of voltage. In some vehicles they are encased in orange conduit.

The **BLUE** cables or conduit can carry anywhere from 42 volts to 201 volts, the latter being a voltage supply to the electric AC compressor.

Conduit that is **PLAIN** in color will carry the 12 to 14 volt circuits which is powered by a 12 volt battery.

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**LEATHER COVERS TO PROTECT GLOVES FROM DAMAGE**  
(Make sure the leather cover does not extend past the rubber cuff of the linemen's gloves)

**LINEMEN'S GLOVES AT LEAST CLASS 0 RATED TO 1000 VOLTS**

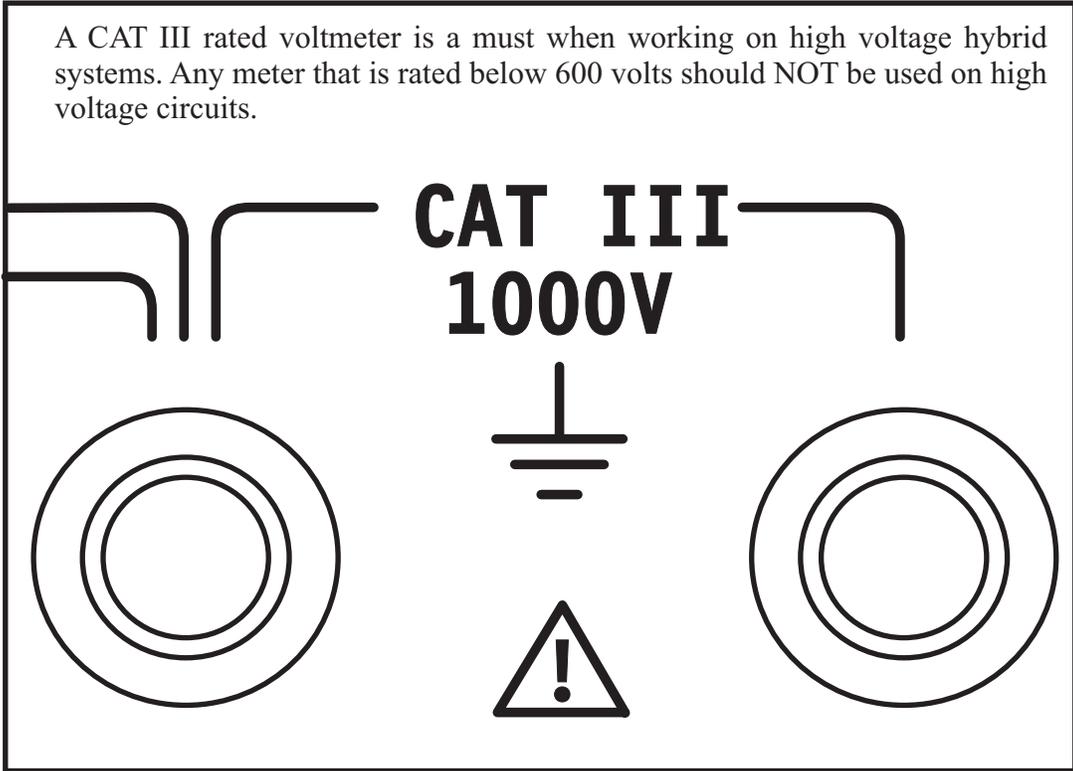
One of the most important pieces of equipment to protect the technician are linemen's gloves, these gloves must be at least class zero and rated to 1,000 volts.

The technician should also have leather glove protectors to prevent damage to the rubber gloves. Electricity can find its way through a pin hole, the leather covers are meant to prevent this from happening.

The best way to check the rubber gloves for pinholes is to roll the gloves so air is trapped in side them and then submerge them in water and watch for leaks. OSHA Standards require testing prior to each use, any damaged gloves should be discarded immediately.

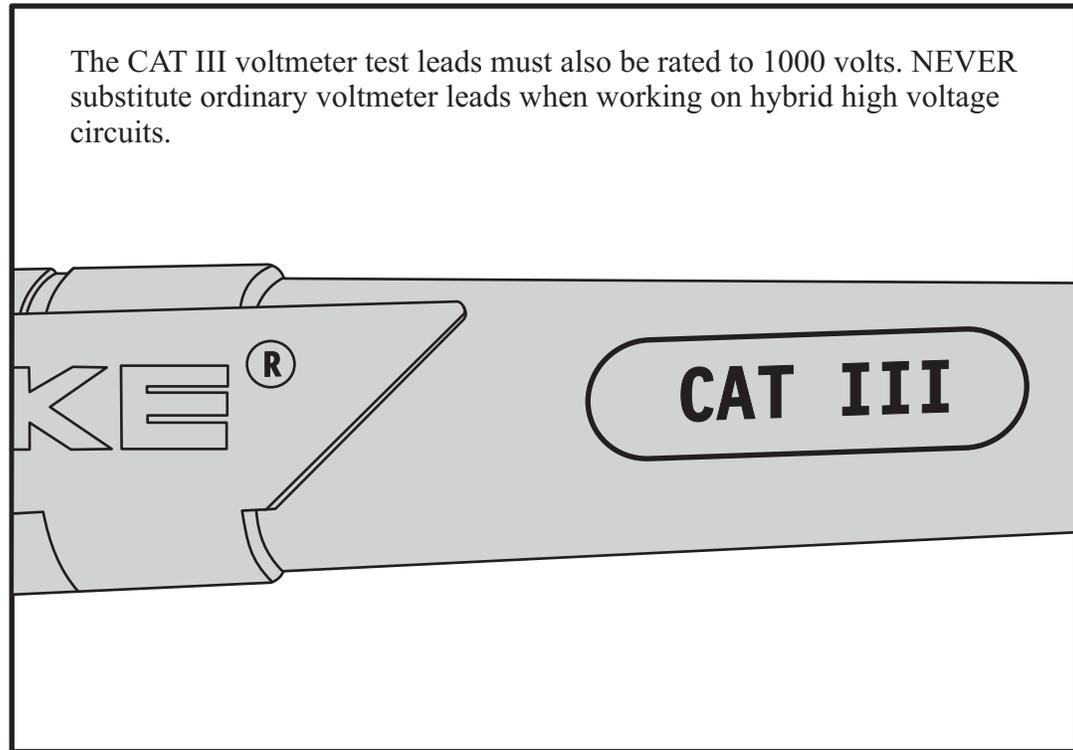
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A CAT III rated voltmeter is a must when working on high voltage hybrid systems. Any meter that is rated below 600 volts should NOT be used on high voltage circuits.



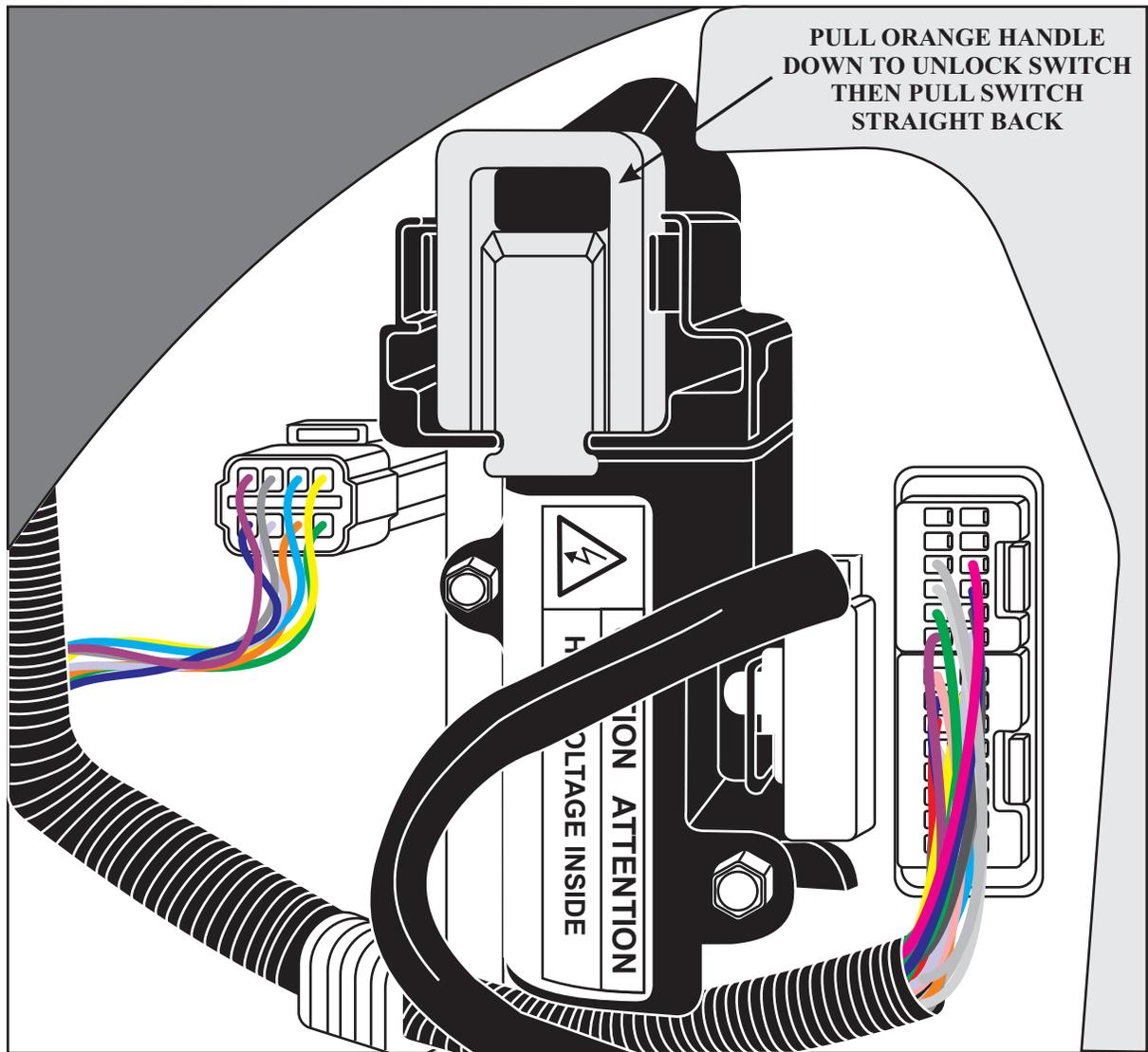
The diagram shows a voltmeter with two test leads connected to terminals. The text "CAT III 1000V" is prominently displayed above the meter. Below the meter, there is a ground symbol (three horizontal lines of decreasing width) and a warning symbol (a triangle with an exclamation mark). Two circular symbols, representing eyes or safety glasses, are positioned on either side of the ground and warning symbols.

The CAT III voltmeter test leads must also be rated to 1000 volts. NEVER substitute ordinary voltmeter leads when working on hybrid high voltage circuits.



The image shows a close-up of a test lead. The lead is grey with a black tip. The letters "KE" with a registered trademark symbol (®) are visible on the side. A rounded rectangular label on the lead contains the text "CAT III".

## TOYOTA PRIUS BATTERY DISCONNECT SWITCH

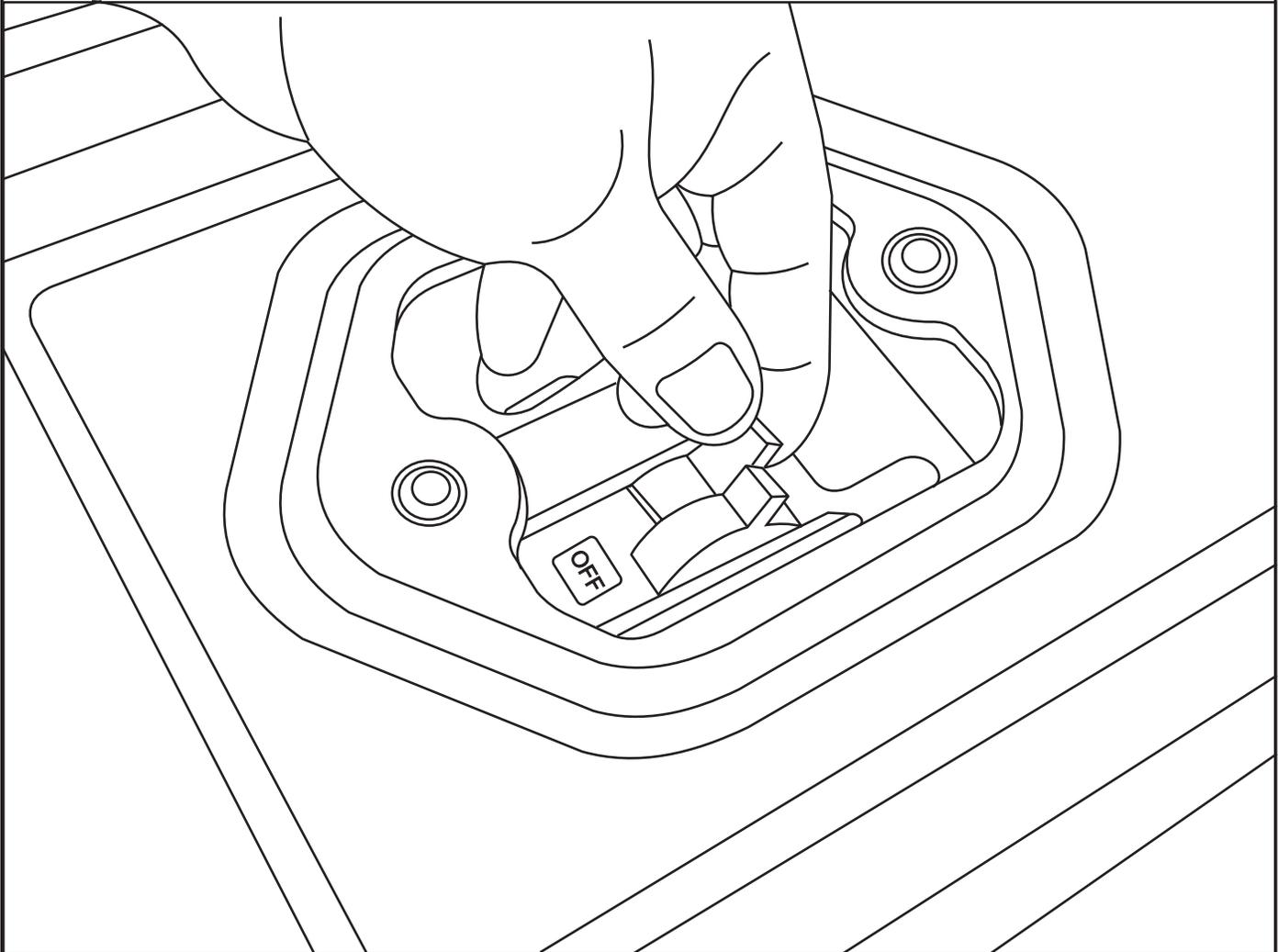


To remove the battery disconnect switch in a Toyota Prius, Remove the key from the ignition and put it in a different safe location, especially if it is a Smart Key. Open the trunk and remove the liner on the drivers side. Pull the orange handle down to unlock the switch, then pull it straight back until it comes out. Put this in your toolbox for safety. Wait 5 to 15 minutes for the capacitors to discharge, then check the orange cables to insure they less than 12 volts on them with your CAT III rated voltmeter.

***REMEMBER TO WEAR YOUR INSULATED GLOVES UNTIL YOU ARE SURE THERE IS LITTLE OR NO VOLTAGE ON THE HIGH VOLTAGE CIRCUITS!***

***CAUTION: EVEN THOUGH THE CAPACITORS ARE DISCHARGED, THE HYBRID BATTERY PACK IS ALWAYS LETHAL!***

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**HONDA INSIGHT & CIVIC BATTERY DISCONNECT SWITCH**

**INSIGHT:** To remove the battery disconnect switch in a Honda Insight, Remove the key from the ignition and place in a different safe location. Next, remove the rear deck carpet then the 2 small screws that hold the small access panel, (it says “UP” on it), Remove the access panel and the RED switch cover and turn the switch OFF. Wait 5 to 15 minutes for the HV capacitors to discharge and then using your CAT III voltmeter, check the HV circuits to make certain the voltage level is below 12 volts.

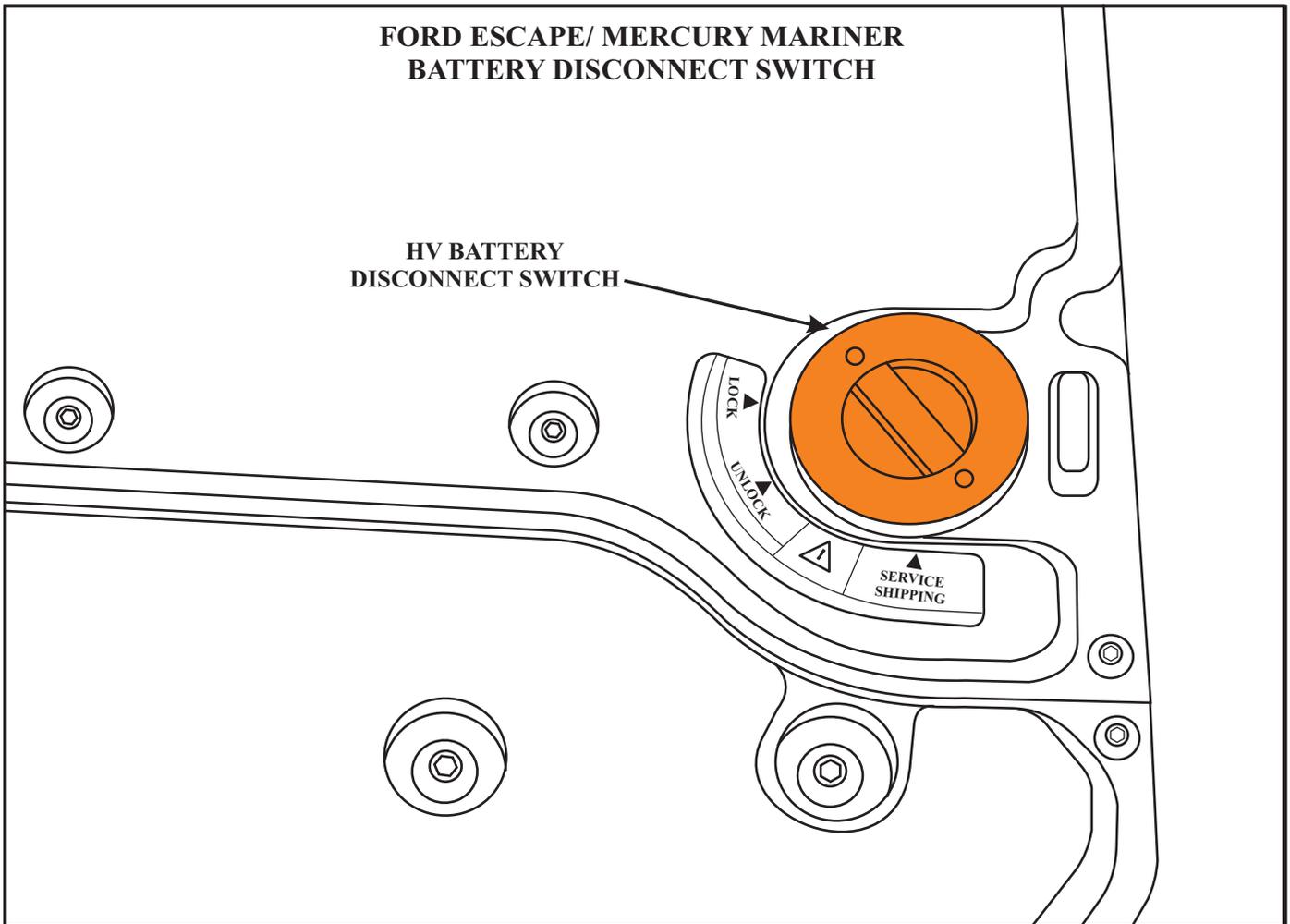
**CIVIC & ACCORD:** Remove the back seat upper cushion and follow the above mentioned procedure.

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## FORD ESCAPE/ MERCURY MARINER BATTERY DISCONNECT SWITCH



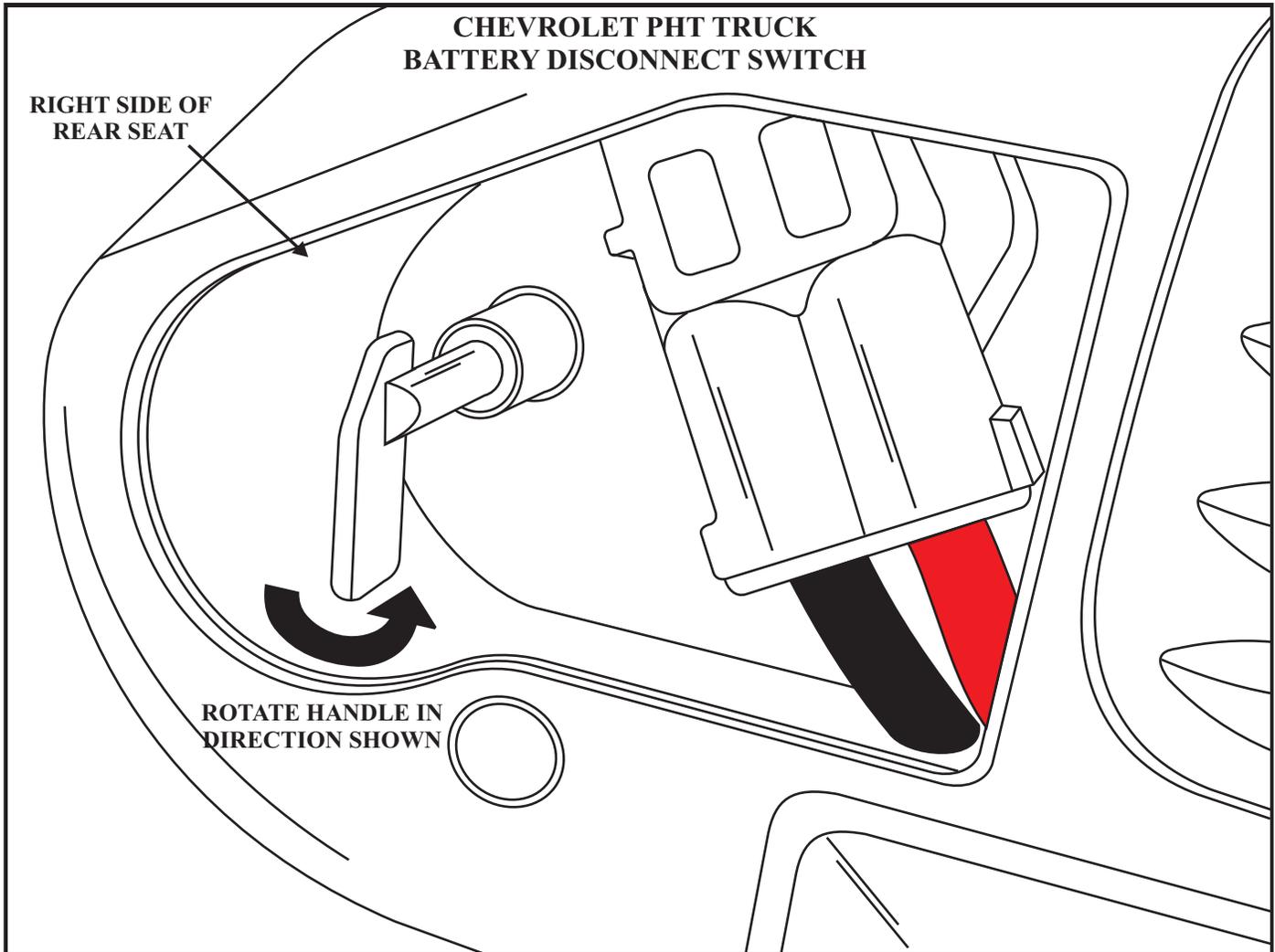
To remove the battery disconnect switch in a Ford Escape or Mercury Mariner, remove the key from the ignition and place in a different safe location. Next, locate the ORANGE cover in the battery pack cover and rotate the cover to the “UNLOCK” position and pull it out. **DO NOT STICK YOUR HAND OR DROP ANYTHING IN THE HOLE, THE 336 VOLT BATTERY PACK IS BELOW THE OPENING!**

Next, replace the cover in the “SERVICE SHIPPING” location. Wait 5 to 15 minutes for the HV capacitors to discharge and then using your CAT III voltmeter, check the HV circuits to make certain the voltage level is below 12 volts.

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To remove the battery disconnect switch in a Chevy PHT, remove the key from the ignition and place in a different safe location. Next, lift the bench part of the rear seat. Next, Locate the GREEN handle behind the triangular cover at the right end of the HV battery box and rotate it clockwise until it stops. Next, wait 5 to 15 minutes for the HV capacitors to discharge and then using your CAT III voltmeter, check the HV circuits to make certain the voltage level is below 12 volts.

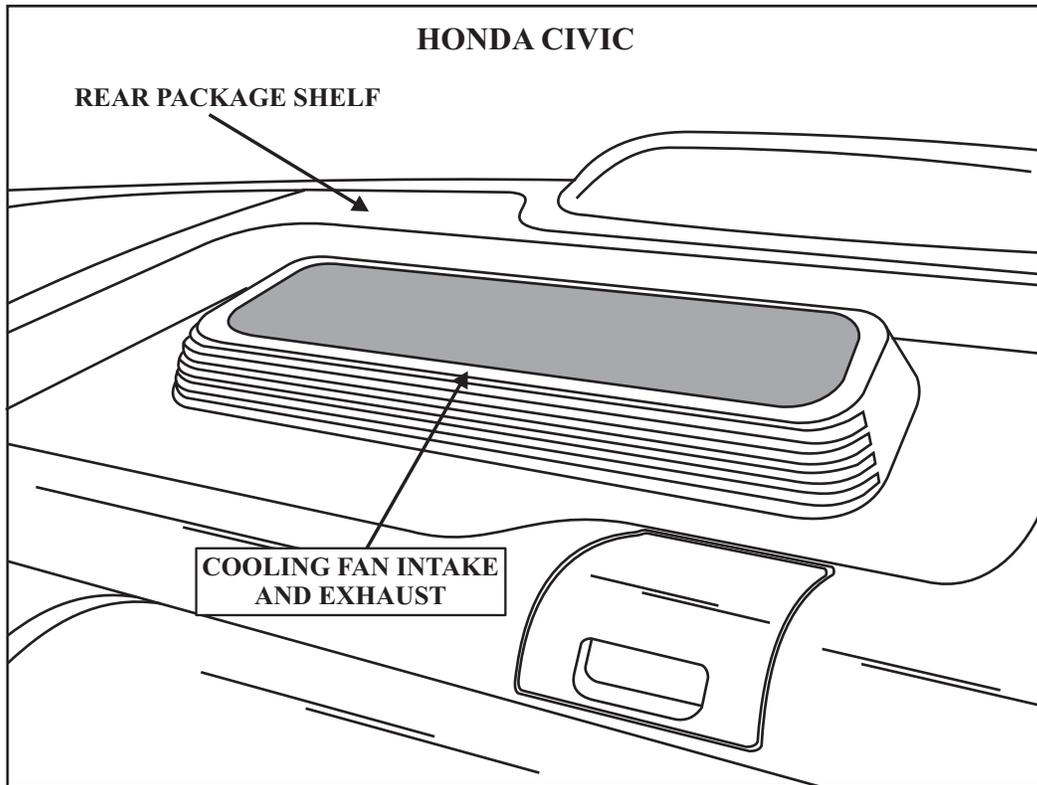
**This vehicle is equipped 120 volt, 20 amp power outlets, Just like the ones in your house or shop, treat these with the same respect!**

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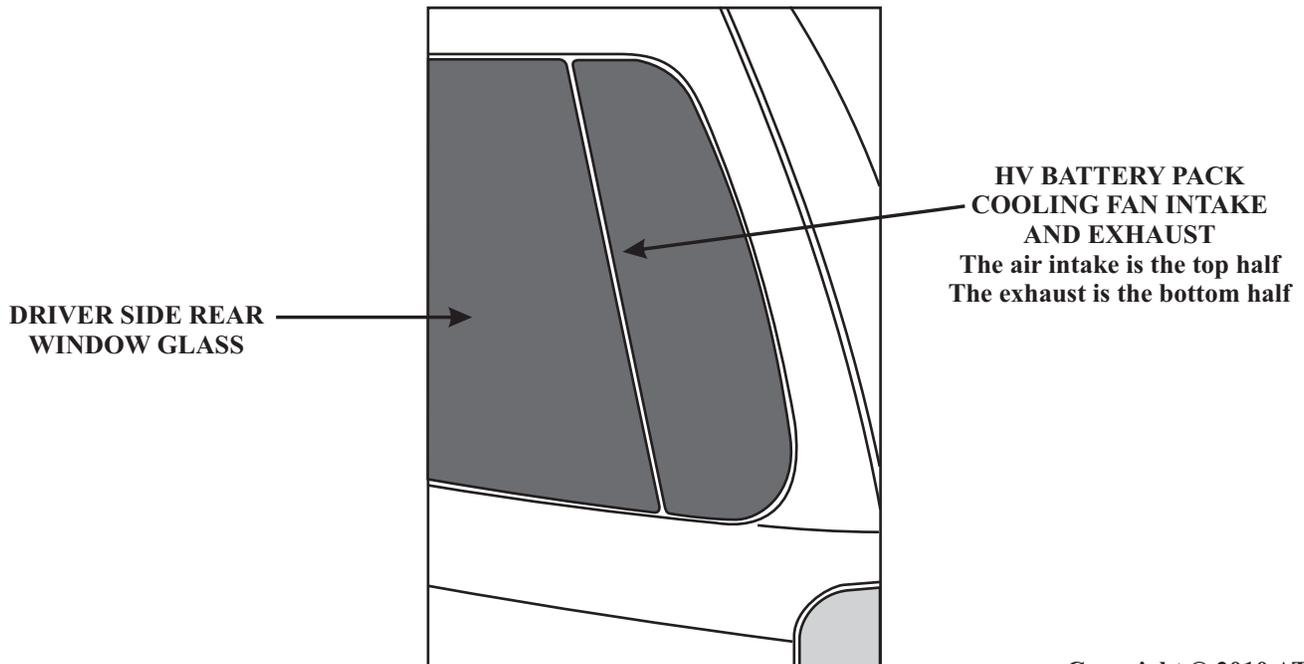
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## HV BATTERY PACK COOLING SYSTEMS



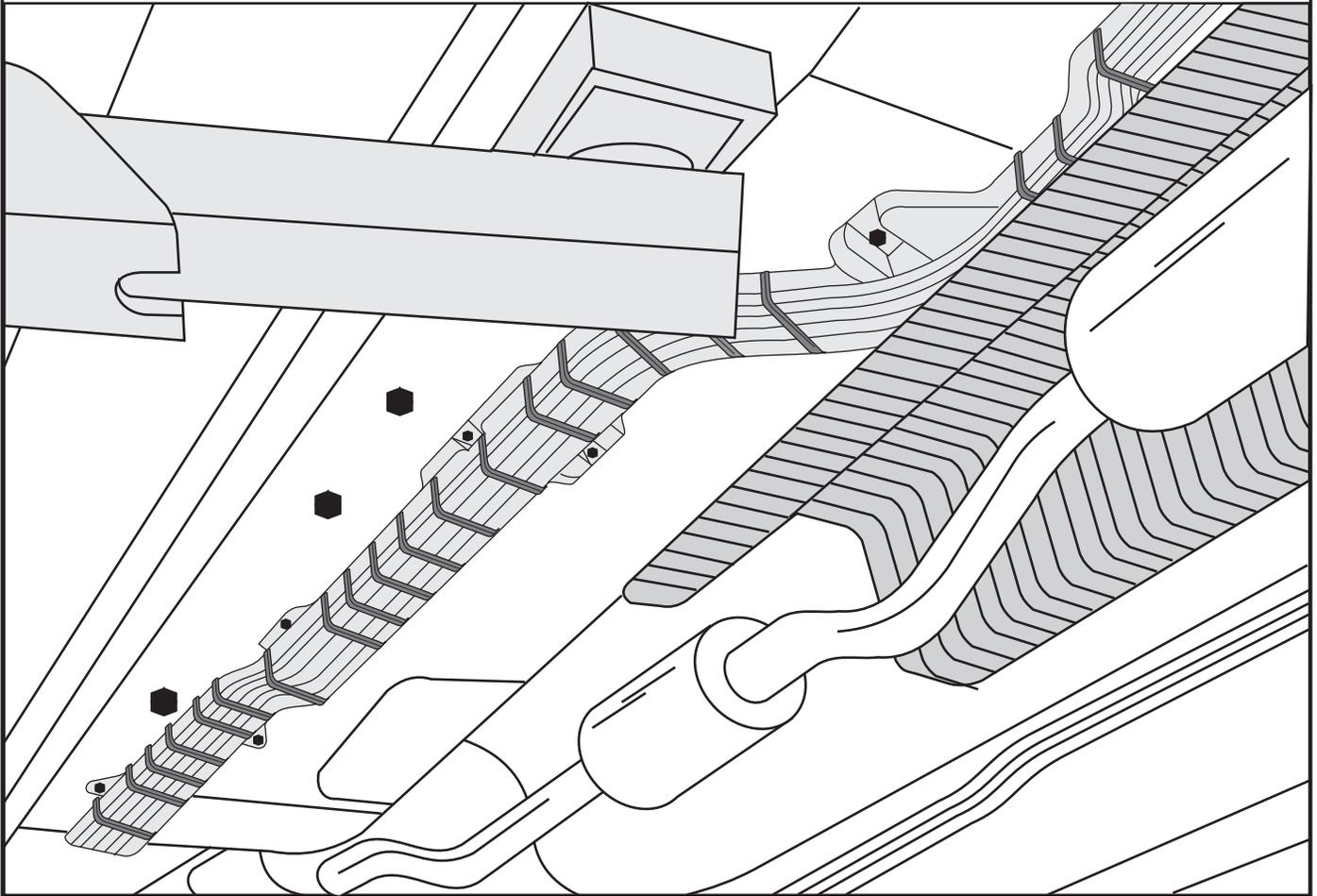
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## FORD ESCAPE & MERCURY MARINER



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## HOIST & JACK SAFETY



In most of the current hybrid vehicles on the road at the present time, HV battery packs are located in the rear of the vehicle while the hybrid controls are up front. This means that the high voltage cables that run from the battery pack to the hybrid controls are routed underneath the vehicle.

Therefore special care must be taken when setting the hoist pads or a floor jack so this equipment does not contact and crush the high voltage cables.

***THIS WOULD HAVE CATASTROPHIC RESULTS TO BOTH THE VEHICLE AND THE PERSON OPERATING THIS EQUIPMENT!***

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