

AR&D

Automotive Research and Design

Technology and Training Since 1987



HEV Tip of the Month

Q: Is it safe to work on an HEV when it is wet or standing in water?

A: An HEV system does not reference its electrical system to earth ground, thereby making it safe to perform diagnostics and/or repair.

Fuel Update

The cost of gasoline is falling! The average price of unleaded fuel is \$3.68 per gallon in the United States!

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So, Your Customer Wants to Purchase an Out-of-Warranty (Used) Hybrid Vehicle – What Items in the High Voltage System Should You Check???

If your service business includes customers that are currently or planning to own a hybrid vehicle it will be important for you to begin developing a strategy on what elements of the High Voltage (HV) system you will want to target for determining the State-of-Health (SOH) and the process by which you will accurately determine the SOH. Determining an accurate SOH is vitally important when/if your customers intend on purchasing a used hybrid vehicle. Although the typical SOH checks of the engine, fuel, ignition, brake, etc. systems which are important, these systems in the automotive service realm are known quantities.

Engine compression, fuel pressure/volume, ignition oscilloscope, brake inspections, etc. tests have been performed in the automotive field for decades and reside in the DNA of any quality service business. However, hybrid and electric vehicle HV systems provide new challenges for the automotive service industry where new skills and tools provide the conduit for accurate SOH measurements. Some examples or requests you receive to perform Hybrid Electric Vehicle (HEV) a SOH inspection could come in many forms:

- When your customer requests that you inspect an (HEV) **prior** to a purchase
- Another service business requests that you perform an HEV SOH on behalf of one of their customers (i.e., sublet, referral, consultation, etc.)
- A local municipal or commercial fleet
- A local dealer that is acquiring a vehicle on a trade-in and needs to know the actual condition of the HV system.

Although there could be other scenarios, the aforementioned four (4) examples provide the majority of the situations in which you could become involved in a HV system physical and operational inspection.

What HV Systems Are Checked As Part Of The SOH?

There are four basic high voltage systems that need consideration for determining SOH:

- Electric transaxle/transmission
- HV Rechargeable Energy Storage System (i.e., Battery Pack)
- Power Inverter & Motor Control System



We have seats available in two of the remaining HEV TTT courses for year 2011.

[Click here](#) for registration info



FEATURED CLASS

5-Day Train The Trainer
at
Peninsula College in Port Angeles, WA
July 5-15, 2011

Click [here](#) for registration information

To view the complete 2011 and 2012 training schedules, [click here](#).

AR&D has two satellite schools we schedule HEV TTT courses to support summer availability.

HEV News

[Suzuki To Roll Out Plug-in 'Swift' in the UK](#)

[Ford Triples Hybrid Production](#)

[Toyota and the Longest Hybrid Parade?](#)

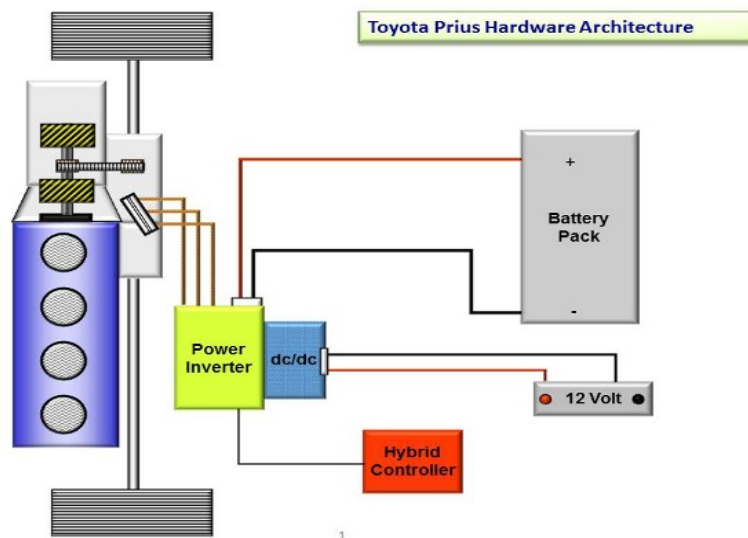
[Mini E Study Reveals that Second Car is Key to Avoiding Range Anxiety](#)

[Nissan Pulls Plug on Altima Hybrid](#)



AR&D will be attending the the Automatic Transmission Rebuilders Association Powertrain Expo at the Las Vegas Hilton on October 27-31! Click on the photo above to download a FREE PASS into the Trade Show!

- Accessory Power Module (i.e., dc-dc Converter) System.



These systems are the core of the HV system and need a thorough examination before you can confidently inform the customer the HV system SOH. The electric air conditioning compressor system could be considered as a fifth system SOH inspection but, not all HEVs have an electric compressor. However, if a vehicle is equipped with this type of compressor system, it could also be added to the SOH inspection list.

What Is The Basic SOH Inspection Process?

The inspection process will always begin with a visual inspection of the system and a quick view of the vehicle data with a scan tool in the stall and on a short road test. If any diagnostic trouble codes (DTC) are found in the system these issues must first be addressed prior to any additional inspection of the system. It should be noted here that serial data (i.e., scan tool) data is very helpful if a HV systems problem is **near-chronic or catastrophic**. However, you should be aware of how the DTC illuminate the Malfunction Indicator Lamp (MIL).

Vehicle manufacturers will make every attempt to ensure that the MIL does not illuminate until it is **absolutely necessary**. The reason for this is that anytime the MIL is illuminated this likely means a trip to the dealer. This also means that the manufacturer will be paying a warranty claim. Therefore, it is advantageous for the manufacturer to keep MIL illumination as a minimal event.

The MIL is only required to be illuminated if there is an emission or safety related problem with the system. Other DTC and serial data is optional. Therefore, the scan tool may or may not be of assistance in locating issues. This is especially true when the issues are not-chronic but, causing vehicle driveability concerns. Therefore, different techniques must be implemented to accurately determine HV systems SOH. Accurate is the operative word here when the cost of HV components can range from ~\$800.00 to greater than \$8,000.00.

With more than 25 years experience developing, testing, and training engineers/technicians on hybrid, electric, and fuel cell vehicles, this is our recommendation for determining the SOH of a HV system:

- **Electric Transaxle/Transmission** – the most expensive components in the electric transaxle/transmission are the electric motor-generators (i.e., electric machines). Therefore, the AR&D recommendation is to use a motor circuit analysis tester such as the AT33EV (ALL-TEST Pro®) to locate stator winding faults (turn-to-turn short, phase-to-phase short, phase-to-ground short, open, stator insulation SOH, winding insulation SOH, etc.) and test rotor magnet or rotor bar SOH.
- A motor circuit analysis tester uses dc resistance, impedance, inductance, capacitance, phase angle, current-to-frequency ratio, and insulation testing to provide accurate testing results. This type of testing is vitally important. Ohmmeters, milli-ohmmeters, ammeters, voltmeters, and insulation testers are inferior and inadequate methods of testing electric machines and will yield inconclusive results. Unless extensively trained, oscilloscopes can fool



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We provide you with equipment specifically designed to analyze and diagnose Hybrid and Electric Vehicle Systems.

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The All Test Pro® 33EV is the most powerful tool to analyze and diagnose any 3-phase motor-generator on an a hybrid or electric vehicle. Click on the photo above to learn about its functions and how to use them.

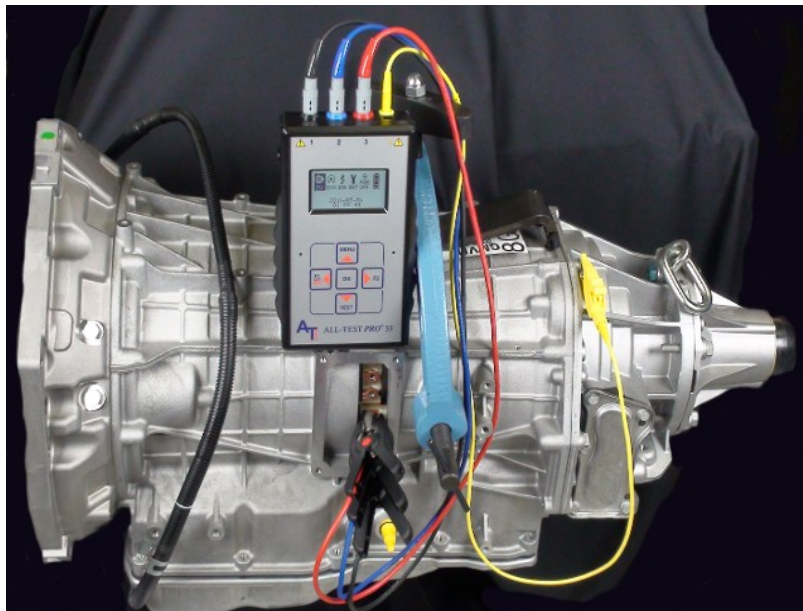
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even the most experienced engineer/technician when testing for electric machine SOH.

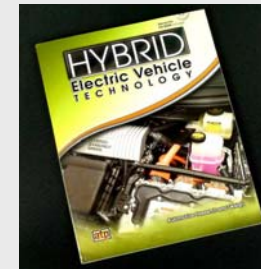


- **Battery Pack** – although some scan tools will provide limited battery module testing, the test results only provide a high level SOH on some (not all) of the battery modules. The scan tool can provide high level information about battery module ? voltage information (i.e., battery terminal voltage variances between module groups) but it is inconclusive as to ALL battery module power and energy levels.
- With the cost of battery packs ranging from ~\$2,500.00 to \$10,000 it is vitally important that you accurately determine battery module and battery pack SOH. Therefore, the only accurate method of determining battery module / module group SOH is to use a battery discharger that will load the batteries to test both power and energy. Power and energy measurement are the battery industry metrics for testing batteries. Using power and energy testing will identify battery modules that are:
 - just beginning to fail
 - are in a “moderate” failure condition
 - pre-chronic failure condition, or
 - have entered into a chronic failed state



This is similar to a doctor performing a series of tests (in a specific sequence) to determine the SOH of a patient. This type of testing is performed using a microprocessor controlled data acquisition system to acquire and display the data with an easy to interpret signature. Many colleges are now teaching this method in their advanced automotive programs with great success. Fleets and the aftermarket have shown great interest in how battery pack SOH can be determined using power and energy testing.

Power and energy testing is the only reliable method of testing and rebuilding battery packs (i.e., using battery module replacement, module matching, battery pack leveling, and battery



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WEBINARS

To support increased demand in the educational & aftermarket industries, we will be adding webinars to our training products (September 2011), providing you the opportunity to interact with the instructor. For a listing of webinar topics and descriptions [click here](#).

Currently, we provide e-Learning training modules through our partner NAPA. For more information [click here](#)

pack conditioning) to ensure the battery pack will provide trouble-free performance. High quality commercial battery discharger units for use in the automotive aftermarket are available for those businesses that have interest in the next automotive frontier.

- **Power Inverter Module** – inverts battery/generator direct current (dc) electrical power to 3-phase electrical power and transmits this power to the 3-phase electric machines that are internal or external of the transaxle/transmission. The Power Inverter Module (PIM) is the most difficult component of the HV system to diagnose due to the constantly varying amplitude and frequency of its waveforms. Since automotive electric propulsion systems are torque-controlled it makes analyzing and diagnosing the PIM more difficult. To complicate matters, an engineer / technician must be able to determine whether an operational or performance problem is due to a PIM or electric machine (i.e., transaxle / transmission) problem.
 - Therefore, the method that AR&D has been teaching engineers/technicians for several years is to first eliminate the electric machines as a possible problem area prior to testing the PIM. This method is preferred so that any irregularities in the 3-phase oscilloscope waveform can be attributed only to the PIM (or its inputs) and not to the electric machines. This is analogous to ensuring that a 12 volt battery has an acceptable SOH condition prior to testing a cranking motor. In an HEV system this process technique will eliminate a complex and costly variable (i.e., the electric machines) in the diagnostic equation.
 - Once the electric machines are eliminated as a possible problem variable it is a simple matter of analyzing and interpreting the PIM 3-phase electric machine waveforms on an oscilloscope to determine if any of the control systems or high power switching transistors are malfunctioning.
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- **Accessory Power Module / dc-dc Converter** – has replaced the traditional generator (i.e., alternator) on an HEV. It is the simplest and, by far, the least complicated HV component. It merely receives electrical energy from the high voltage bus (e.g., 300 volts dc) and reduces it to 14 volts or, some dc-dc converters can also boost 14 volts to ~300 volts. Testing the dc-dc converter is simple; simply use the same methods for it as the automotive industry has been using to test a traditional belt-driven generator by using a carbon-pile load. If for any reason it is suspected that the dc-dc converter is operating normally, and there is audible electrical noise in the electrical system, an oscilloscope can be used to analyze the dc-dc converter waveform to determine if there is excessive voltage (not current) ripple.

Now you know the process. It's simplicity is the element that makes it elegant. Most technicians could complete this process on an HEV in less than four (4 hours). The actual time that an engineer/technician is actually testing or analyzing data is less than 30 minutes. Most of the time is consumed in preparing (disassemble and reassemble) the vehicle for the testing. This type of HEV analysis opens the door to many, many business opportunities in the aftermarket.

Next Month: Predictive Maintenance: *How the Aftermarket can Capitalize on Servicing Hybrid Vehicles (multi-series newsletter).*

To view previous newsletters, access our newsletter [archive](#)

*Until next time remember - knowledge is **POWER***



AR&D Tech Team

Contacting AR&D:

www.autoresearchanddesign.com

Email: arandd@ix.netcom.com

Phone: 586.718.9469

Fax: 586.983.3709

Automotive Research and Design

34337 Fontana Drive
Sterling Heights, MI
48312
US

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