# Course Length: 3-days

## Predictive Maintenance Course Overview:

The Predictive Maintenance course is designed to instruct the student in how to determine High Voltage system component State-of-Health (SOH) for the purpose of analyzing and diagnosing or, tracking the performance of a hybrid electric vehicle (HEV) propulsion system. The SOH includes analysis of Electric Machines (motors/generators), Power Inverter system, Energy Storage (Battery Pack) system, and the dc-dc Converter. A Predictive Maintenance program at any educational institution or service facility permits a vehicle to be trended over time so that a statistical prediction can be implemented to provide an accurate analysis on the operational reliability and durability of an electric propulsion system. Components in the system can be tracked to analyze the commencement of a possible failure or end-of-life prediction before it becomes catastrophic. Predictive Maintenance can also be used strictly as an analysis (diagnostic) method to measure the current status of the electric propulsion system components without tracking component performance over time. Multiple lab vehicles will be used to perform all of the SOH tests on the high voltage systems and/or components. This course is an advanced step in HEV analysis, diagnostics, and repair.

Some of the areas of where Predictive Maintenance analysis can be used in the college classroom and/or in the field of HEV repair:

- SOH check before a prospective buyer purchases a hybrid/electric/fuel cell vehicle
- Customers with "out-of-warranty" vehicles that want to know of any impending or eminent repair possibilities
- Trend/track the SOH of customer HEV systems.....a service that dealers don't provide
- Ensure that any analysis and diagnosis of the HEV systems have empirical (statistical) analysis that removes subjectivity from the analysis
- Reduces or eliminates unnecessary part replacement of expensive components and the associated labor costs
- Partner with used car businesses to provide an analysis on a prospective trade-in or sale
- Offer customers a once-per-year "SOH Check-up"
    - Results are documented and graphed to visually show customer the vehicle high voltage system health status

## Course Objectives:

At the completion of this course attendees will be able to perform and/or complete the following analysis tasks:

- ✓ Perform High Voltage battery module charging
- ✓ Perform High Voltage battery discharging
- ✓ Analyze battery data to determine the battery pack SOH
- ✓ Perform Power Inverter waveform capture
- ✓ Analyze Power Inverter waveforms to determine SOH
- ✓ Perform Electric Machine (motors/generators) rotor and stator tests
- ✓ Analyze Electric Machine data to determine the SOH
- ✓ Perform a dc-dc Converter output test
- ✓ Analyze dc-dc Converter output data

## Tools and Equipment that will be used in this course:

- High Voltage Charger
- High Voltage Discharge Unit
- Data Acquisition (DAQ) unit
- Laptop Computer (to analyze data from DAQ)
- Carbon Pile unit
- Digital Storage Oscilloscope
- Special Electric Machine test equipment
- Serial Data (scan) tool
- DVOM
- Insulation Tester
- Electrical Safety Gloves

## Equipment required at hosting facility to support on-site PM Training Course:

- Current Probes ….Fluke I310s or equivalent
  - Quantity = 6 (must have in multiples of 3)
- Carbon Pile (VAT 60) or equivalent
  - Quantity = 3
- DVOM
  - Quantity = 5
- Insulation Meter….Fluke 1587 or equivalent (or students could bring their own meter)
  - Quantity = 4
- Class 0 Electrical Gloves
  - Minimum 1 pair for each vehicle (5 + pairs total)
  - Gloves must have (or maintain) current test certification
- Utility Carts – approximately 36”L x 26”W x 40”H with one shelf (or small benches on wheels) to hold charging and discharging equipment, laptop, and data acquisition equipment
  - Quantity = 2
- Each participant MUST bring their own scan tool
  - There must be at least one (1) OEM scan tool (NOT GENERIC) for this class!

## Vehicles needed at hosting facility to support on-site PM Training Course:

- **Minimum of 5 Cars to include:**
  - Three …..Toyota Prius
  - Two …….consisting of Honda Civic (and/or) GM Tahoe Yukon

## Facility requirements to support on-site PM Training Course:

- **Classroom (preferably in U-Shape)**
  - Projector to support PowerPoint presentation (and extension cord)
  - 2 Tables in front of classroom to support instructor materials
  - White Board and Easel
- **Garage or Shop area to support hands-on activities on vehicle**

***Note:*** *The AR&D Instructor will bring all other specialty equipments, tools, and supplies to support the training class (if the facility has not purchased these kits prior to the event)*