

# **MODULE III: VEHICLE SYSTEMS AND SAFETY FEATURES**

## **TERMINAL OBJECTIVE**

*The students will be able to describe the operation of HEV and EV systems.*

## **ENABLING OBJECTIVES**

*The students will be able to:*

- 1. Define terms related to HEV and EV systems.*
  - 2. Compare and contrast HEVs and EVs.*
  - 3. List major components of HEV systems.*
  - 4. List major components of EV systems.*
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## DEFINITIONS

### Hybrid Electric Vehicle (HEV)

A vehicle that has both an internal combustion engine (ICE) and electric motor(s).

### Plug-In Hybrid Electric Vehicle (PHEV)

A vehicle that has both an ICE and electric motor(s) and can recharge its batteries from an external electric power source.

### Electric Vehicle (EV)

A vehicle which uses only electric motor(s) for propulsion.

## VEHICLE TYPES

### Hybrid Electric Vehicles (HEVs)

#### Full Hybrid

All Hybrids use batteries and electric motors to reduce demand on the internal combustion engine (ICE). Allows better fuel economy. ICE can shut down when not needed. Full Hybrids can drive short distances on electric power only (silent movement hazard). For response purposes, treat all Hybrids the same.

#### Plug-in Hybrids (PHEVs)

A hybrid vehicle that allows the battery to be charged via an external electric power source. This increases the battery charge, increases the range of the vehicle; reduces the dependence upon the gasoline engine

These vehicles have the same hybrid system and components as a full hybrid. The ability to charge the vehicle from a charging station is added in order to charge the battery to a greater extent. Examples: 2012 Ford Escape and Toyota Prius will be available as PHEVs as well as full Hybrid Electric Vehicles

### Electric Vehicle (EV)

Electric motors are the only means of propulsion. Vehicle must be charged by external power source. Example – Nissan Leaf.

#### Extended Range Electric Vehicle (EREV)

Electric motors provide the propulsion. When the battery is low, a gasoline generator provides electricity for the motor. For an emergency response, treat as a PHEV with a gasoline engine, a high voltage battery and electric propulsion, and possible external power.

## HEV, PHEV AND EV VEHICLE COMPONENTS

### Standard components.

An internal combustion engine and 12 volt battery are components of the HEV, PHEV and EV like they are in conventional vehicles. The 12 volt battery can be located in various locations around the vehicle. Common locations are the trunk, cargo department, under the hood. Less common locations are the front wheel well and under the second row seats.

### High voltage battery

#### NiMH

There two battery types. The first is a NiMH (nickel-metal hydride). This is most common in existing hybrids but less common in newer vehicles. Electrolyte consists of sodium and potassium hydroxide. The electrolyte is an alkaline material.

#### Lithium Ion

The Lithium Ion battery is the most common in electric vehicle and they will be used more in the future hybrids. There are many different chemical variations in this batteries. The Lithium Ion battery in electric and hybrid vehicles is different from Lithium Ion batteries in home electronics.

#### Small Cell series

High voltage batteries are made of many small, low voltage cells. Small cells wired in series to multiply the voltage. Example: Four 1.5 VDC batteries in a series equals 6 volts.

#### Location of Batteries in HEVs and PHEVs

Generally batteries in HEVs and PHEVs are located in the rear of the vehicle. In SUVs and Trucks they are sometimes located under 2<sup>nd</sup> row seating. In sedans they are located in the trunk or cargo area.

#### Location of batteries in EVs

EV batteries are larger and of higher voltage than P/HEV batteries. Usually they are located on the underside of the vehicle.

### Service disconnects

Recommendations for use and required safety equipment vary by manufacturer, consult appropriate ERG before using service disconnect. They are located on the battery. They cut off the battery from the high voltage system..

### **Inverter/Converter**

Located under the hood. Found in vehicles using AC drive motors. Converts DC from HV battery to AC to run motor. Converts AC from regenerative braking back to DC to charge HV battery. Dangerous to penetrate cover with tools. Capacitors inside can store voltage for a period of time. If damaged, capable of rapid energy discharge that can cause severe injury.

### **DC/DC Converter**

Takes the place of the alternator. Converts DC from high voltage battery to 12 VDC to run vehicle's low voltage systems. In some models the DC/DC converter is housed in the inverter/converter module.

### **EV/HEV Cabling**

Color coded to voltage:

Low voltage: < 30 volts

(Often Red or Black, but can be of any color except orange)

Intermediate: 30-60 volts

(Usually Yellow or Blue)

High Voltage: > 60 volts

(Orange)

### **Medium/High Voltage Cabling**

Medium and high voltage cable should be considered highly dangerous.

For the purposes of this program, treat blue cables the same as high voltage orange.

They are located between the high voltage battery, high voltage components and the electric motor. They are typically routed along the underside of the vehicle and under the hood.

If a cable is compromised or damaged, the system is designed to detect the damage and shut down.

For safety, ALL high voltage cable must be considered energized during response operations.

### **Electric motors**

In P/HEVs the electric motors provide propulsion in some models. Start and stop the ICE when not needed.

Recharge HV battery through regenerative braking and ICE.

In EVs the electric motors provide propulsion and recharge HV battery through regenerative braking.

### **Regenerative Braking**

Regenerative braking is a process used to capture energy from braking and help recharge the high voltage battery. During braking, wheels turn the electric motor, making it act as a generator and produce electricity. This electricity is routed to high voltage battery to increase its charge. If towed in overhaul it can damage HV system.

### **Safety Systems**

P/HEVs and EVs are equipped with safety systems that are designed to immediately shut down the high voltage system in the event of a crash impact, airbag deployment, damage to the high voltage cabling, or short circuit. Still, always treat the HV systems as energized for maximum safety.

### **Charging Port (PHEVs and EVs).**

Charging ports are used to connect a charging cord to the vehicle. The charging components actually reside on the vehicle itself. The charging unit is an interface between the power supply and the vehicle.

## **CHARGING STATIONS**

### **Charging Station Levels**

#### Level I

1. 120v
2. 8-16 hours

#### Level II

1. 240v
2. 3-8 hours

#### Level III

1. 480v

2. 20-30 minutes

### **Level I Charging Station**

A charging system utilizing 120VAC power. It uses a standard household plug. It is the slowest rate of charging of the three levels. This can accompany the vehicle and be used to charge it anywhere there is access to an outlet.

### **Level II Charging Station**

Level II utilizes 240VAC power. It can be a fixed installation or portable unit. It is faster charging than Level I systems. Typically 3-8 hours depending on the size of the battery

### **J1772 Plug and receptacle**

The J1772 plug is SAE standardized for Level I and Level II charging. It is a multi pin communication link between the charger and the vehicle which conducts current and relays charge status. It shuts down charging when the battery is “full”. It prevents the vehicle from moving when plugged in.

### **Level III Charging Station**

Currently provides 480 VDC directly to the battery. A new standards for this type of charger are being developed, so this is likely to change. This is the fastest charging system. Due to wiring requirements, availability and expense it will likely be in commercial sites only.

## **MODULE SUMMARY**

There are several different types of P/HEVs and EVs. Each one has specific components related to its electrical identity. Familiarity with the types, components and differences will facilitate emergency operations.





**Activity 3.1**  
**HEV, PHEV and EV Components**

**Purpose:**

To identify common components and their functions used in HEVs, PHEVs and EVs.

**Directions to Students.**

1. You will be shown a slide of a common component found in HEVs, PHEVs and EVs.
2. As a component is shown, quickly discuss it and decide on the name of the component and its function. Your answer must address both.
3. If called on, share your answer with the class. Be prepared to discuss and justify your answer.

