

MODULE II: BASIC ELECTRICAL CONCEPTS AND HAZARDS

TERMINAL OBJECTIVE

The students will describe basic electric concepts that pertain to P/HEV/EVs.

ENABLING OBJECTIVE

The students will be able to:

- 1. Define basic electrical terms.*
 - 2. Compare and contrast AC and DC electricity.*
 - 3. Identify how electricity affects the body.*
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This module is designed to give you the basic electrical knowledge to understand the types of electricity found in hybrid and electric vehicles, as well as understand how it impacts emergency operations.

As emergency responders we need to understand the dangers behind the higher voltage electricity found in these vehicles, as well as how their electrical systems differ from what we are accustomed to seeing in residential or commercial applications.

Most of us are uneasy about dealing with electricity, because it can be dangerous, we can't see it, and most of us don't completely understand it.

DEFINING VOLTAGE CURRENT AND RESISTANCE

Voltage is defined as the electrical potential of a circuit. It can be compared to the PSI of water in a hose stream, or how much force, or power that is available to push the current. It is measured in Volts.

Current is a term used to describe the number of electrons moving past a fixed point in one second. In other words, it is the rate of flow of electrical current. Comparing it to the hose stream, you can picture it as the number of gallons per minute flowing through a hose. Current is measured in Amperes.

Resistance is a material's opposition to the flow of current electrons. Using the fire hose analogy, resistance can be compared to the friction loss in the hose, valves, or nozzle. Resistance is measured in Ohms.

DIRECT CURRENT VS. ALTERNATING CURRENT

Both Direct Current (DC) and alternating current (AC). can be found in hybrid and electric vehicles.

In a DC circuit, the current, or flow of electrons, moves in a single direction. Direct current is primarily found in devices powered by batteries and some industrial application.

In an AC circuit, the current switches directions, or alternates, back and forth many times per second. The number of times per second that the current reverses its direction is measured in hertz.

Alternating current is the type of electricity provided by the utility company to residential and commercial buildings.

UNDERSTANDING ELECTRICAL CIRCUITS

In order to better gauge the potential dangers of the high voltage electricity found in hybrid and electric vehicles, it is important to

understand the concept of an electrical circuit, or the path that electrical current will follow.

Whether, discussing direct current or alternating current, they both share a common element. With both AC and DC, there must be a completed path or circuit for the current to flow.

Using the hose line analogy again, if the bail on the nozzle is closed, no current is flowing. Once it is opened, the current flows. A switch creates a break in the circuit when “OFF”. Turning the switch “ON” completes the circuit, allowing current to flow.

Injury from electricity can occur when a person’s body becomes part of a circuit by completing a path for current.

DC Circuits

DC power sources have a positive and a negative terminal. Current flows from negative side of battery, through the circuit, to positive side of battery.

Therefore, contacting one side of the circuit will not result in an electric shock because the circuit is not completed. Contacting both sides will complete the circuit and can result in shock.

AC Circuits

Since the current in an AC circuit flows in both directions, there is no positive and negative like you find in DC circuits.

Instead, they have one or two live, or hot, conductors, a neutral conductor, and possibly a grounding conductor, or ground, depending on wiring.

Typically, when a circuit is completed current flows back and forth between the hot and neutral conductors. The ground serves as a safety measure, allowing excess energy to discharge in the event of a hazard or fault.

You might think that in order to receive a shock from an AC circuit, you would have to touch both the hot and neutral, but that isn’t the case, at least in typical AC circuits like those in a building. Because most AC circuits in the U.S. have an earth ground, if you were to touch just the hot side of the circuit, electricity would flow through you and back to the earth to complete a circuit.

AC Circuits in a Vehicle


Some P/HEVs and EVs use AC powered motors. High Voltage AC circuits in vehicles are isolated from the chassis and have no earth ground. Current does NOT seek earth ground. To get a shock, you must contact TWO points in the circuit. Contacting

only one should not create a circuit. Lack of ground reference equals “safe” to use water for fire suppression. Current will not follow hose stream.


UNDERSTANDING HOW ELECTRICITY AFFECTS THE BODY

The human body and PPE does provide some resistance to the flow of electricity. Voltage must be high enough to overcome resistance before it can enter your body. Environmental conditions, such as being wet, can greatly reduce resistance. Once resistance is overcome, amperage usually determines degree of damage.

Circuits in P/HEVs and EVs have both the voltage and amperage to be considered highly dangerous.



DC Current Effect on Humans ¹


Milliamps (1000 mA = 1 A)	OBSERVABLE EFFECT ²
240	<div style="text-align: center;">  </div> <p>Possible Ventricular Fibrillation</p> <p>Electrical Burns</p> <p>Can't let go</p> <p>Startle Reaction</p>
70	
40	
2	

Many models of EV/HEV generate current in excess of 100 Amps, or 100,000 mA


¹ Effect thresholds based on full grown adult physiology. Effects on smaller persons or children may occur at lower amperage.

² Personnel Protection Devices for Specific Applications, Electric Power Research Institute, Project 6850-02, Final Report, October 1999, prepared by Underwriters Laboratories Inc.

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AC Current Effect on Humans¹

Milliamps (1000 mA = 1 A)	OBSERVABLE EFFECT ²
833	<div style="text-align: center;">  </div> <p>Current Used by a 100 Watt Light Bulb</p> <p>Ventricular Fibrillation</p> <p>Electrical Burns</p> <p>Muscle Contraction (Respiratory Paralysis)</p> <p>Can't let go</p> <p>GFCI will trip</p> <p>Startle Reaction</p>
105	
70	
20	
6	
5	
.5	

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¹ Effect thresholds based on full grown adult physiology. Effects on smaller persons or children may occur at lower amperage.

² Personnel Protection Devices for Specific Applications, Electric Power Research Institute, Project 6850-02, Final Report, October 1999, prepared by Underwriters Laboratories Inc.

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As you can see from these charts, DC and AC electricity have different danger thresholds, but hybrid and electric vehicles systems can operate in excess of 100 Amps, or 100,000 milliamps, well beyond human danger range, especially in wet conditions. This is why it is so important that you be aware of the potential dangers and always take appropriate safety measures.

MODULE SUMMARY

When it comes to electricity, a shock is a shock, whether from AC, or DC. The key is to know what conditions could lead to a possible shock in order to protect you from one. It's also important to remember that your firefighting PPE is not designed as electrical PPE. While they do present a high level of resistance when new and dry, yours may not offer as much protection in its current state. Besides, reliance on gear for protection is no substitute for knowledge and proper procedure.