FMCSA Technology Division

INSPECTING ELECTRIC DRIVE COMMERCIAL VEHICLES

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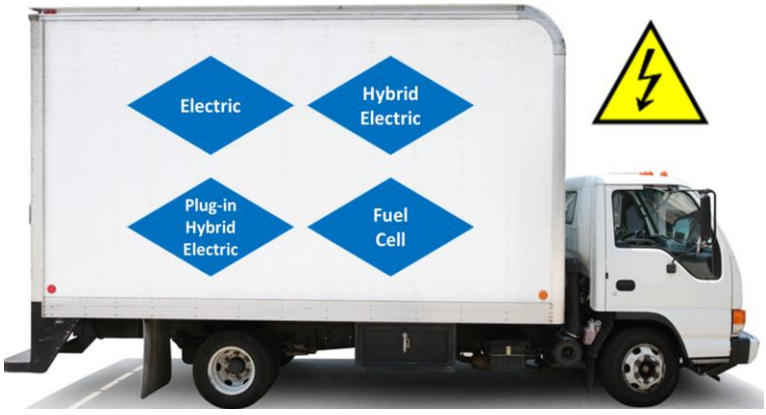

Figure 1. Picture of Electric Drive Commercial Motor Vehicle box truck with the following blue diamond labels: Electric, Hybrid Electric, Plug in Hybrid Electric, and Fuel Cell. Also a high voltage warning symbol, a black thunderbolt in a yellow triangle with a black border.

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Contents

Inspecting High Voltage Electric Drive Commercial Motor Vehicles

Introduction and Overview

Welcome to the Inspecting High Voltage Electric Drive Commercial Motor Vehicles Course.

Module 1: Introduction and Purpose of Training.

This module provides an introduction to the course. It provides a brief description of electric drive vehicles, such as hybrid electric vehicles, plug in hybrid electric vehicles, and battery electric vehicles, and potential hazards of high voltage electricity, such as a damaged battery pack and a hole in a high voltage barrier. It also includes the course objectives and a course menu.

Types of Electric Drive Commercial Motor Vehicles, CMV's

Electric drive vehicles, including hybrid electric vehicles, plug in hybrid electric vehicles, battery electric vehicles, and fuel cell electric vehicles have high voltage electrical systems not found on typical vehicles powered only by gasoline or diesel engines.

High Voltage Hazards

This course will familiarize commercial vehicle inspectors with high voltage electric drive vehicles, and teach them how to identify, during inspections, vehicles that may present a high voltage safety hazard, such as an exposed high voltage wire, a damaged battery pack, or a damaged high voltage disconnect. A serious hazard could lead to severe injury or death due to electric shock.

Course Objectives

After taking this course, you will be able to:

- Recognize commercial vehicles with high voltage electric drive systems
- Identify the major components of a high voltage electric drive system and how they are typically laid out on a commercial vehicle
- Identify the vehicle conditions that could create a serious hazard due to the potential for personal exposure to high voltage
- Identify what to do if a serious hazard related to the high voltage system on a commercial motor vehicle, or CMV, exists, and
- Identify hazards associated with high voltage electricity.

Electric Drive Vehicle Safety

Electric drive vehicles are safe if properly designed and maintained, and will rarely have a serious hazard. However, certain system or component conditions can create a serious hazard to vehicle operators, mechanics, and the general public by increasing the potential for someone to contact high voltage.

North American Standard, N A S

North American Standard, or N A S, inspection procedures include a check of 14 safety critical items.

However, the high voltage system on an electric drive commercial vehicle is not included as a safety critical item, current N A S inspection procedures do not include checks of any high voltage components.

This training is intended to raise awareness that electric drive vehicles potentially pose high voltage risks, and to provide information that will allow commercial vehicle inspectors to conduct supplemental inspection of high voltage components on these vehicles, beyond current N A S inspection procedures.

High Voltage

For automotive applications, any voltage greater than 30 volts alternating current, or AC, or 60 volts direct current, or DC, is considered to be a high or hazardous voltage due to the potential to produce serious injury or death due to electric shock.

Electric drive systems on commercial vehicles can operate at voltages as high as 800 volts, both AC and DC, and can produce peak currents as high as 100 amps, which make contact with high voltage components even more dangerous.

More information about the Dangers of High Voltage. will be covered in Module 6.

Course Menu

This course is comprised of six instructional modules with photos, graphic displays, and a video animation of an electric drive vehicle. There is an end of course examination after the training.

Module 1.	Introduction, which we just completed.
Module 2.	Identifying CMV's with High Voltage Systems
Module 3.	Types of Electric Drive CMV's
Module 4.	High Voltage Hazards
Module 5.	Low & High Voltage Systems
Module 6.	Dangers of High Voltage
Examination	

This concludes module 1, Introduction. To continue, proceed to Module 2.

Module 2: Identifying CMV's with High Voltage Systems

Objectives:

Upon completion of this module you will be able to recognize commercial vehicles with high voltage electric drive systems, and identify some of the major indicators that a vehicle is a high voltage electric drive vehicle.

Module 2: Identifying CMV's with High voltage Systems

There are currently no mandatory labeling requirements for electric drive commercial vehicles, and no standard label format used by all manufacturers.

Electric Drive Vehicle Labels

Despite this, virtually all commercial vehicles with high voltage electric drives will likely have signage and one or more badges or labels that identify them as being a particular type of vehicle, such as:

Hybrid, hybrid electric

Plug in, plug in vehicle, or plug in hybrid electric

Electric, electric vehicle, electric drive, electric powered or

Fuel cell, hydrogen fuel cell, or hydrogen powered.

Electric Drive Vehicle Labels

Some vehicles may also have badging, labeling, branding, or signage added by the owner to identify them as a low emission vehicle, Exhaust Free, Zero emission vehicle, environmentally friendly, or a Green Vehicle.

The location of vehicle labels may be on the vehicle cab, but may also be on the vocational body, as we see on these vehicles.

Diamond Shaped Labels

It's also possible that electric drive vehicles will have traditional diamond shaped labels, which are frequently used for alternative fuel vehicles.

High Voltage Warnings

All high voltage components, or compartments that house high voltage components, are identified with a hazardous voltage label that generally incorporates a yellow triangle with a black thunderbolt, and warning text.

If one or more such labels is present on a vehicle it has a high voltage electric drive system.

The Rechargeable Energy Storage System, R E S S

Virtually all electric drive vehicles will have a high voltage rechargeable energy storage system, or R E S S, which stores energy for use by the drive system. Usually the R E S S contains chemical batteries, but may also include high voltage capacitors. The R E S S is often large and noticeable, and can be another way to identify vehicles with high voltage electric drives. A commercial motor vehicle may have more than one R E S S.

The Rechargeable Energy Storage System, R E S S

On the vehicles you see here, the R E S S's are located on the outside of the frame rail behind the cab. R E S S's may also be located on the frame rail behind the vehicle cab or between the frame rails, under, or behind, the cab. The R E S S on a hybrid electric vehicle is typically smaller than on a similar battery electric vehicle.

R E S S Warning Labels

The R E S S's should have high voltage warning labels.

High Voltage Cables

Visible orange cables are another indication that a vehicle has a high voltage system. That is because there is a voluntary Society of Automotive Engineers, or SAE, Recommended Practice that specifies that all high voltage cables have an orange outer covering. While voluntary, this practice has been adopted by virtually all manufacturers. Orange high voltage cables will connect the R E S S to other high voltage components, and these cables are visible on some vehicles.

High Voltage Cables Hidden

On other vehicles, the high voltage cables can be hidden by body panels and are not visible.

High Voltage Equipment

Most high voltage equipment and cabling on commercial electric drive vehicles will be located in, under, or near the vehicle cab, in the same locations where you find the engine, transmission and fuel tanks on diesel and gasoline vehicles.

High Voltage System Equipment

As will be discussed more fully in Module 3, the high voltage equipment installed on virtually all electric drive vehicles will include an R E S S, an electric drive motor/generator, and an inverter/rectifier. Some vehicles may also have a DC/DC converter and a charge port.

Location of High Voltage Equipment

The high voltage equipment may be:

Under the hood, in the engine compartment,

Between the frame rails, under, or behind the vehicle cab,

Or on the outside of the frame rails, at the back of, or behind the vehicle cab.

Hidden High Voltage Equipment

On some vehicles, all or most high voltage equipment and cables will be obscured by panels or other body parts, so just because you don't see them does not mean they are not there. They are hidden.

High Voltage Equipment in Hybrid Motorcoaches

Electric drive coach buses may have high voltage equipment installed inside the luggage bays below the passenger compartment.

High Voltage Equipment in Transit Buses

Electric drive transit buses will likely have the R E S S installed on the roof, under a cowl, and will have other high voltage equipment installed in the rear engine compartment at the back of the bus behind the passenger compartment.

High Voltage Equipment Layouts

Hybrid Electric Vehicles, Battery Electric Vehicles, and Fuel Cell Electric Vehicles have some different components, and may have different layouts of high voltage electrical equipment. You can review Module 3 for more information on the different Types of Vehicles and their High voltage Systems.

Safe Electric Drive Vehicles

In almost every case, high voltage electrical components will be operating safely and securely. However, in rare cases serious problems can exist that lead to safety hazards. You can learn how to identify high voltage hazards and what to do about them in Module 4.

Knowledge Check. Practice What You Have Learned.

Question: A transit bus has the following large lettering on the side: Hydrogen Fuel Cell, Hybrid Electric Drive, Zero Emission.

Does this vehicle have high voltage?

Yes

No

Some clues of high voltage, but nothing definite

There's nothing definite, but it's still possible

Answer:

Yes. Correct.

No. Incorrect.

Some clues of high voltage, but nothing definite. Incorrect.

There's nothing definite, but it's still possible. Incorrect.

Question: The back of a lift truck has the following lettering on the side: Plug in Hybrid Power. Also, a large electric plug graphic is located by the Altec Logo on the lift bucket. Does this vehicle have high voltage?

Yes

No

Some clues of high voltage, but nothing definite

There's nothing definite, but it's still possible

Answer:

Yes. Correct.

No. Incorrect.

Some clues of high voltage, but nothing definite. Incorrect.

There's nothing definite, but it's still possible. Incorrect.

This is the end of Module 2: Identifying CMV's with High Voltage Systems. Continue to proceed to Module 3.

Module 3: Vehicles with High Voltage Systems

Objectives:

Upon completion of this module you will be able to describe the types of vehicles that include high voltage electric drive systems and how they differ from each other, including the major high voltage components included on each.

Module 3: Vehicles with High voltage Systems

There are four types of commercial vehicles that include high voltage electric drive systems:

Hybrid Electric Vehicles or H E V's

Plug in Hybrid Electric Vehicles or P H E V's

Battery Electric Vehicles or B E V's, and

Hydrogen Powered Fuel Cell Electric Vehicles or F C E V's

Hybrid Electric Vehicles

A Hybrid Electric Vehicle:

Includes both an internal combustion or IC engine, such as a diesel or gasoline engine, and an electric drive system.

The electric drive system includes one or more motors/generators, an R E S S, and a power control module that includes an inverter/rectifier. All of these components operate at high voltage.

It may also contain a converter that converts high voltage DC current from the R E S S to lower voltages to power vehicle accessory loads such as lights.

The R E S S is typically smaller than on a similar battery electric vehicle.

Different configurations are possible, but in general the internal combustion engine directly powers the vehicle most of the time, but when vehicle power needs are high, in other words, during acceleration and hill climbing, the internal combustion engine is supplemented by energy stored in the R E S S, working through the motor/generator.

Plug in Hybrid Electric Vehicles

A Plug in Hybrid Vehicle is very similar to a hybrid electric vehicle, but typically has a larger R E S S, and a charge port to connect to the electrical grid.

This vehicle has a hybrid electric lift, while the truck itself is powered by bio diesel fuel.

Over a day of operation, part of the net energy required to power the lift is supplied by the fuel used by the diesel engine, and part is supplied by the electrical grid, via energy stored in the R E S S.

Battery Electric Vehicles

Battery Electric Vehicles do not include an internal combustion engine.

Like hybrid vehicles, battery electric vehicles include an R E S S, an electric drive motor/generator, and a power control module that includes an inverter/rectifier, all of which operate at high voltage. It is very likely that a battery vehicle will also include a converter to convert high voltage current from the R E S S to lower voltages, to power vehicle accessory loads, such as lights.

The R E S S is recharged by plugging into the electric grid through the charge port, and the stored energy is used to provide both propulsion power, via the electric drive motor, and to power vehicle auxiliary loads such as lights, heating, and air conditioning.

The drive motor may also be used as a generator during vehicle braking, with the electrical energy that is generated put back into the R E S S for later use.

All net energy required to power the vehicle is supplied by the electrical grid.

Battery Electric R E S S

The R E S S is typically much larger than those found on similar hybrid electric vehicles, and there may be more than one R E S S, as you see on this vehicle. The Battery Electric vehicle will also have a charge port so that the vehicle can be plugged into the electrical grid.

Fuel Cell Electric Vehicles

A Fuel Cell Vehicle includes a hydrogen fuel cell engine.

The fuel cell engine directly produces high voltage electricity through low temperature chemical oxidation of hydrogen in galvanic cells.

This electricity is used to provide propulsion power, via a high voltage electric drive motor, and to power vehicle auxiliary loads such as lights, heating, and air conditioning, after being converted to lower voltages via a converter.

Fuel cell vehicles usually also include an R E S S to supplement the fuel cell engine when propulsion power needs are high, and to store energy generated by the drive motor during braking.

A fuel cell vehicle is an electric vehicle, but it does not plug into the electrical grid. All net energy required to power the vehicle is provided by the hydrogen fuel used by the fuel cell engine.

Knowledge Check. Practice What You Have Learned.

Question: A commercial motor vehicle has components including an internal combustion engine, an electric motor generator, an R E S S, a DC/DC converter, a power inverter/rectifier and a plug in electrical socket.

What type of electric drive vehicle is this?

Battery Electric

Fuel Cell Electric

Plug in Hybrid Electric

Hybrid Electric

Answer:

Battery Electric. Incorrect.

Fuel Cell Electric. Incorrect.

Plug in Hybrid Electric. Correct.

Hybrid Electric. Incorrect.

Question: A commercial motor vehicle has components including an internal combustion engine, an electric motor generator, an R E S S, a DC/DC converter, and a power inverter/rectifier.

What type of electric drive vehicle is this?

Battery Electric

Fuel Cell Electric

Plug in Hybrid Electric

Hybrid Electric

Answer:

Battery Electric. Incorrect.

Fuel Cell Electric. Incorrect.

Plug in Hybrid Electric. Incorrect.

Hybrid Electric. Correct.

Question: Components on a commercial motor vehicle include an electric motor/generator, an R E S S, a DC/DC converter, a power inverter, and a plug in electrical socket.

What type of electric drive vehicle is this?

Battery Electric

Fuel Cell Electric

Plug in Hybrid Electric

Hybrid Electric

Answer:

Battery Electric. Correct.

Fuel Cell Electric. Incorrect.

Plug in Hybrid Electric. Incorrect.

Hybrid Electric. Incorrect.

Question: Components on a commercial motor vehicle include a fuel cell engine, a hydrogen fuel tank, an electric motor/generator, an R E S S, a DC/DC converter, and a power inverter/rectifier.
What type of electric drive vehicle is this?

Battery Electric
Fuel Cell Electric
Plug in Hybrid Electric
Hybrid Electric

Answer:
Battery Electric. Incorrect.
Fuel Cell Electric. Correct.
Plug in Hybrid Electric. Incorrect.
Hybrid Electric. Incorrect.

This is the end of module 3: Vehicles with High Voltage Systems. Continue to proceed to Module 4.

Module 4: High Voltage Hazards

Objectives:

Upon completion of this module you will be able to recognize the vehicle conditions that could create a serious hazard due to the potential for personnel exposure to high voltage, and describe what to do if a serious hazard related to the high voltage system on a CMV exists.

Module 4: High Voltage Hazards

Any condition on an electric drive vehicle that creates the possibility of the driver, a mechanic, a vehicle inspector, or the general public to directly contact an energized high voltage component is A SERIOUS HAZARD due to the potential for severe injury or death due to electric shock.

High Voltage Hazards
For example, two of these conditions are:
High voltage components not securely attached to the vehicle and
A high voltage disconnect switch that is damaged or inoperable.

High Voltage Hazards

Two more conditions are:

Exposed high voltage equipment due to missing or damaged barriers or enclosures, and

Broken or cracked high voltage barriers that could allow finger access to interior high voltage components.

Damaged High Voltage Wiring

Another hazardous condition is wiring that is chafed or damaged such that current carrying conductors are exposed.

NOTE that most high voltage wiring will include a layer of fine metal mesh between the outer protective sheath and the conductors. This is part of the electromagnetic shielding; this metal mesh layer does not carry high voltage current. Exposure of this mesh layer does not create a serious hazard.

Loss of High Voltage Isolation

Loss of high voltage isolation can also create a serious hazard, by creating a path for current to leak from the high voltage system to the vehicle chassis under certain conditions.

Determining whether or not appropriate high voltage isolation is maintained requires special equipment and knowledge, vehicle inspectors cannot conduct these tests.

Most electric drive vehicles will be equipped with a fault detection system. If there is a loss of high voltage isolation, the fault detection system should light a red warning light in the vehicle cab and the high voltage system should be disabled. In other words, contactors in the R E S S will open to deenergize most high voltage components, isolating high voltage to the R E S S. Note that high voltage warning lights are usually telltale lights that are not visible on the dash unless lit, similar to an engine warning light.

Most vehicles will also have multiple ways to deactivate the high voltage system.

For example, in the panel on the right it is possible to deactivate the high voltage system using the red button.

An active high voltage fault is a serious safety hazard.

Damaged R E S S

Fluid does not usually leak from a damaged R E S S.

Most high voltage batteries used in the R E S S will have solid or gel electrolytes which will stay in the battery even if the case is damaged.

However, some high voltage batteries do use liquid electrolyte, which can be corrosive or toxic.

Water on R E S S

CAUTION: Make certain that the leaking fluid is not just water or condensation that has accumulated on the R E S S compartment due to exposure to rain or moisture. Accumulated water on the R E S S, or dripping off of the compartment, would not create a hazard.

Damaged High Voltage Disconnect

A high voltage disconnect, damaged in a way that exposes current carrying conductors, is also a serious hazard.

Damaged High Voltage Vehicles

High voltage components, in particular the R E S S, can suffer interior damage in a severe vehicle crash, or when fully submersed in water or impacted by fire.

While not visible from the outside such interior damage could increase the risk of loss of high voltage electrical isolation, which would create a shock hazard and could result in a vehicle fire, even several days after the incident.

Vehicles with high voltage electrical systems known to have been involved in a crash or fire, or to have been submersed in water, should be considered potentially hazardous until the high voltage electrical system can be inspected by a qualified technician.

Inspection Safety Precautions

When inspecting a commercial vehicle with a high voltage electrical system:

DO NOT touch any exposed metal, usually copper, inside a high voltage cabinet, enclosure, conduit, or component.

DO NOT touch any fluid observed leaking from a high voltage R E S S.

DO NOT pierce, pry, dismantle, or otherwise force open any enclosure, barrier, shield, cabinet, or conduit labeled High Voltage.

DO NOT insert any tools or body parts into cracks, holes, crevices, or openings in cabinets, enclosures, barriers, shields, or conduit labeled High Voltage, and

DO NOT cut any orange colored cables, conduits, or wires.

Towing and Storage of a High Voltage CMV

When a high voltage hazard exists, or a vehicle with a high voltage electrical system is known or suspected to have been submersed in water or damaged in an accident or fire, and the vehicle must be towed, it should be towed by personnel trained in high voltage safety, following any towing instructions specified by the manufacturer.

If the vehicle must be stored, it should be isolated at least 50 feet away from other vehicles and structures.

Knowledge check. Practice What You Have Learned.

Question: Orange cables are connected to a panel with the sign: Danger, High Voltage, Do Not Powerwash. A few inches of bare wires are exposed in one of the cables.

Is there a safety hazard?

Yes, it is a serious safety hazard.

No, there is no safety hazard.

Yes, but it's not a serious safety hazard.

Answer:

Yes, it is a serious safety hazard. Correct.

No, there is no safety hazard. Incorrect.

Yes, but it's not a serious safety hazard. Incorrect.

Question: A large gray R E S S has broken support straps and a gap between the R E S S case and the lid.

Is there a safety hazard?

Yes, it is a serious safety hazard.

No, there is no safety hazard.

Yes, but it's not a serious safety hazard.

Answer:

Yes, it is a serious safety hazard. Correct.

No, there is no safety hazard. Incorrect.

Yes, but it's not a serious safety hazard. Incorrect.

Question: A damaged high voltage disconnect plug has bare copper wires exposed.

Is there a safety hazard?

Yes, it is a serious safety hazard.

No, there is no safety hazard.

Yes, but it's not a serious safety hazard.

Answer:

Yes, it is a serious safety hazard. Correct.

No, there is no safety hazard. Incorrect.

Yes, but it's not a serious safety hazard. Incorrect.

This is the end of Module 4. High Voltage Hazards. Continue to proceed to Module 5.

Module 5: Low and High Voltage Systems

Objectives:

Upon completion of this module you will be able to describe how a high voltage electric drive system differs from the low voltage systems installed on all commercial vehicles, and how these systems are related and interconnected.

Module 5: Low and High Voltage Systems

High voltage electric drive vehicles have high voltage electrical systems which are used primarily for vehicle propulsion, and low voltage electrical systems, which are used to power typical vehicle controls and auxiliary loads.

Low Voltage System

All commercial vehicles will have a low voltage electrical system to power vehicle controls and other auxiliary loads such as

- Lighting
- Alarms
- Cab climate control
- Audio equipment, and
- Vehicle starting

High Voltage System

In addition to the low voltage system, electric drive vehicles will have a high voltage electrical system that is solely or primarily used to provide vehicle propulsion. This module discusses the differences between these systems, as well as how these systems relate to each other.

Low Voltage System

The low voltage system will operate at either 12 volts or 24 volts direct current.

Major components of the system include:

- A lead acid battery or batteries, usually in a battery box mounted to the vehicle frame,
- Fuses or circuit breakers and solenoids,
- An engine mounted alternator,
- An engine mounted starter,
- A Low voltage wiring harness or harnesses, and
- Individual electrical loads in the cab and other areas of the vehicle such as head lights, tail lights, and marker lights.

The negative side of the vehicle battery and all loads are grounded to the metal vehicle chassis. In other words, the system is referenced to chassis ground.

The voltage and current in a low voltage electrical system is low enough that the potential for damaging or lethal electrical shocks is very low.

High Voltage System

Major components of the high voltage system include:

- An R E S S, which usually consists of one or more battery packs that contain 50 or more Nickel metal hydride or Lithium ion battery modules wired in series; the R E S S may also include high voltage capacitors instead of, or in combination with, high voltage batteries
- One or more large electric motor/generators,
- An inverter/rectifier to convert between AC power, in and out of the motor/generator, and DC power, in and out of the R E S S,
- Fuses or circuit breakers and high voltage contactors and disconnects,
- A fault detection circuit, and
- High voltage cables.

Depending on the type of vehicle, the high voltage system might also include a charge port to connect to the electrical grid, especially for battery electric vehicles, and plug in hybrid electric vehicles.

The high voltage system is not referenced to chassis ground. All high voltage components are connected by positive and negative cables, and metal components of the vehicle chassis are electrically isolated from the high voltage system.

The high voltage system can operate at voltages of up to 800 volts, with peak currents of more than 100 amps.

The voltage and current produced by the high voltage system are high enough to produce damaging or lethal electrical shocks.

DC/DC Converter

Battery electric vehicles, some fuel cell electric vehicles, and some hybrid electric vehicles and plug in hybrid electric vehicles, will have a DC/DC converter which links the low and high voltage systems so that low voltage vehicle loads can be powered by the high voltage R E S S and/or high voltage fuel cell engine.

Interconnection of Low and High Voltage Systems

The low voltage electrical system is also used to control high voltage contactors in the R E S S.

When low voltage power is applied, the contactors close, energizing the high voltage system.

When low voltage power to the contactors is disrupted, the contactors open, deenergizing the high voltage system and isolating high voltage to the R E S S.

When low voltage is lost, the battery management system becomes inoperable. When that occurs, it is impossible to get any information on the status of the high voltage system, including the state of charge, and electrical isolation. This is not a problem during normal vehicle operation, but can be an impediment to determining the condition and health of the high voltage system in the aftermath of a crash or vehicle that has been submersed in water.

Fault Detection System

As we mentioned earlier, most vehicles should include a fault detection system to detect loss of high voltage electrical isolation, which should set off warning lights in the vehicle cab and/or open contactors in the R E S S that will deenergize the high voltage system.

High voltage vehicles may also have switches in the cab to manually turn off the high voltage system.

Deenergizing High Voltage Systems

There are generally at least two, and up to four additional ways that you can disable or deenergize the high voltage system on electric drive vehicles. You can:

Remove the positive battery cable of the low voltage system, this applies to all vehicles, or

Turn off the vehicle ignition switch, this applies to most vehicles, or

Disconnect the low voltage 12 or 24 volt system using a disconnect switch, if one is installed, or

Operate the manual high voltage disconnect switch at the R E S S, this applies to some vehicles.

All of these methods will cause contactors in the R E S S to open, deenergizing high voltage components on the vehicle and isolating high voltage to the R E S S.

Deenergizing High Voltage Systems

NOTE: Some high voltage components may continue to be energized for up to 10 minutes after high voltage contactors in the R E S S are opened. Always use caution and treat high voltage components as if they are live.

CAUTION: There will always be live high voltage in the R E S S whether or not high voltage contactors are open. Never remove or open R E S S panels, shields, or enclosures.

Knowledge Check. Practice What You Have Learned.

Question: What are possible ways to deenergize a high voltage system? Select all that apply.

Remove the positive battery cable of the low voltage system.

Turn off the vehicle ignition switch.

Disconnect the low voltage 12 or 24 volt system using a disconnect switch, if one is installed.

Operate the manual high voltage disconnect switch at the R E S S, if one is installed.

Answer:

Remove the positive battery cable of the low voltage system. Correct.

Turn off the vehicle ignition switch. Correct.

Disconnect the low voltage 12 or 24 volt system using a disconnect switch, if one is installed. Correct.

Operate the manual high voltage disconnect switch at the R E S S, if one is installed. Correct.

Question: What functions can high voltage systems provide on a hybrid CMV? Select all that apply.

Provide vehicle propulsion when propulsion power needs are high

Store energy generated by the drive motor during braking

Provide power to accessories after being converted to low voltage

Provide power to the electrical grid

Answer:

Provide vehicle propulsion when propulsion power needs are high. Correct.

Store energy generated by the drive motor during braking. Correct.

Provide power to accessories after being converted to low voltage. Correct.

Provide power to the electrical grid. Incorrect.

Question: Which statements are true about deenergizing a CMV's high voltage system? Select all that apply.

There will always be live high voltage in the R E S S whether or not high voltage contactors are open.

Some high voltage components may continue to be energized for up to 10 minutes after high voltage contactors in the R E S S are opened.

Except for the R E S S, all high voltage components will always be deenergized immediately after high voltage contactors in the R E S S are opened.

Once a high voltage system is deenergized, it is safe to remove R E S S panels or shields, and open high voltage enclosures.

Answer:

There will always be live high voltage in the R E S S whether or not high voltage contactors are open. Correct.

Some high voltage components may continue to be energized for up to 10 minutes after high voltage contactors in the R E S S are opened. Correct.

Except for the R E S S, all high voltage components will always be deenergized immediately after high voltage contactors in the R E S S are opened. Incorrect.

Once a high voltage system is deenergized, it is safe to remove R E S S panels or shields, and open high voltage enclosures. Incorrect.

This is the end of Module 5, Low and High Voltage Systems. Continue to proceed to Module 6.

Module 6: Dangers of High Voltage

Objective:

Upon completion of this module you will be able to describe the hazards associated with high voltage electricity.

Module 6: Dangers of High Voltage

As we mentioned earlier, for automotive applications, any voltage greater than 30 volts alternating current or 60 volts direct current is considered to be a high or hazardous voltage due to the potential to produce serious injury or death due to electric shock.

Electric drive systems on commercial vehicles can operate at voltages as high as 800 volts, both AC and DC, and can produce peak currents of 100 amps or more, dramatically increasing the danger of high voltage contact.

Dangers of High Voltage

Direct exposure to high voltage can cause electrical current to flow through the body which can result in:

Severe burns at the entry and exit points of the electrical current,

Muscle tissue and nerve damage along the current path through the body,

Kidney or other organ failure,

Heart fibrillation and cardiac arrest, or

Damage leading to limb amputations or other physical disability, permanent cognitive impairment, or death.

In terms of shock hazard both the voltage and current levels are important.

Higher currents create more damage.

Higher voltages overcome the resistance of human skin, allowing current to flow through the body.

Broken or wet skin has significantly lower resistance, allowing current to flow at lower voltage.

Every effort should be made to prevent high voltage electrical injury!

By following the guidelines outlined in this course, you should be able to detect high voltage electrical hazards.

Knowledge Check. Practice What You Have Learned.

Question: Which consequences can result from exposure to high voltage? Select all that apply.

Heart fibrillation and cardiac arrest
Severe burns at the entry and exit points of the electrical current
Permanent cognitive impairment

Death

Answer:
Heart fibrillation and cardiac arrest. Correct.
Severe burns at the entry and exit points of the electrical current. Correct.
Permanent cognitive impairment. Correct.
Death. Correct.

This concludes module 6 and the course. Continue to take the examination. Answers will be provided after each test item.

Inspecting High Voltage Electric–Drive

Commercial Motor Vehicles Examination

1. A transit bus has a Metro hybrid label on the side.

   Does this vehicle have high voltage?

   Yes.
   No.
   Some clues of high voltage, but nothing definite.
   There's nothing definite, but it's still possible.

   Answer:
   Yes. Correct.
   No. Incorrect.
   Some clues of high voltage, but nothing definite. Incorrect.
   There's nothing definite, but it's still possible. Incorrect.

2. A UPS truck has lettering saying Electric Vehicle.

   Does this vehicle have high voltage?

   Yes.
   No.
   Some clues of high voltage, but nothing definite.
   There's nothing definite, but it's still possible.

   Answer:

Yes. Correct.
No. Incorrect.
Some clues of high voltage, but nothing definite. Incorrect.
There's nothing definite, but it's still possible. Incorrect.

3. A commercial truck cab has two large R E S S's on the outside of the frame rails.

   Does this vehicle have high voltage?

   Yes.
   No.
   Some clues of high voltage, but nothing definite.
   There's nothing definite, but it's still possible.

   Answer:
   Yes. Correct.
   No. Incorrect.
   Some clues of high voltage, but nothing definite. Incorrect.
   There's nothing definite, but it's still possible. Incorrect.

4. A transit bus has the following large signage on the side: Hydrogen Fuel Cell, Hybrid Electric Drive, Zero Emission.

   Does this vehicle have high voltage?

   Yes.
   No.
   Some clues of high voltage, but nothing definite.
   There's nothing definite, but it's still possible.

   Answer:
   Yes. Correct.
   No. Incorrect.
   Some clues of high voltage, but nothing definite. Incorrect.
   There's nothing definite, but it's still possible. Incorrect.

5. Which of the following are considered high voltages? Select all that apply.

   25 volts direct current.
   25 volts alternating current.
   50 volts alternating current.
   50 volts direct current.
   75 volts direct current.
   400 volts alternating current.

600 volts direct current.

Answer:
25 volts direct current. Incorrect.
25 volts alternating current. Incorrect.
50 volts alternating current. Correct.
50 volts direct current. Incorrect.
75 volts direct current. Correct.
400 volts alternating current. Correct.
600 volts direct current. Correct.

6. What color of wire or cable insulation indicates high voltage?

Red
Green
White
Yellow
Orange
Black
Blue

Answer:
Red. Incorrect.
Green. Incorrect.
White. Incorrect.
Yellow. Incorrect.
Orange. Correct.
Black. Incorrect.
Blue. Incorrect.

7. An electric vehicle known to have been submerged in water or damaged in an accident or fire should be stored a minimum of _____ from vehicles and structures.

10 feet
20 feet
50 feet
100 feet

Answer:

10 feet. Incorrect.
20 feet. Incorrect.
50 feet. Correct.
100 feet. Incorrect.

8. Electric drive high voltage systems on commercial vehicles _____. Select all that apply.

   Can always be plugged into the grid.
   Are NOT referenced to chassis ground.
   Are primarily used to provide vehicle propulsion.
   Can provide power to low voltage components through a DC/DC converter.

   Answer:
   Can always be plugged into the grid. Incorrect.
   Are NOT referenced to chassis ground. Correct.
   Are primarily used to provide vehicle propulsion. Correct.
   Can provide power to low voltage components through a DC/DC converter. Correct.

9. How can a CMV's high voltage system generally be deenergized? Select all that apply.

   Turning off the ignition key.
   Removing the positive cable on the 12 or 24 volt battery.
   Using a low voltage disconnect switch, if installed.
   Using a high voltage disconnect switch near the R E S S, if installed.

   Answer:
   Turning off the ignition key. Correct.
   Removing the positive cable on the 12 or 24 volt battery. Correct.
   Using a low voltage disconnect switch, if installed. Correct.
   Using a high voltage disconnect switch near the R E S S, if installed. Correct.

10. Which statements are true about deenergizing a CMV's high voltage system? Select all that apply.

    There will always be live high voltage in the R E S S whether or not high voltage contactors are open.

Some high voltage components may continue to be energized for up to 10 minutes after high voltage contactors in the R E S S are opened.
Except for the R E S S, all high voltage components will always be deenergized immediately after high voltage contactors in the R E S S are opened.
Once a high voltage system is deenergized, it is safe to remove R E S S panels or shields, and open high voltage enclosures.

Answer:
There will always be live high voltage in the R E S S whether or not high voltage contactors are open. Correct.
Some high voltage components may continue to be energized for up to 10 minutes after high voltage contactors in the R E S S are opened. Correct.
Except for the R E S S, all high voltage components will always be deenergized immediately after high voltage contactors in the R E S S are opened. Incorrect.
Once a high voltage system is deenergized, it is safe to remove R E S S panels or shields, and open high voltage enclosures. Incorrect.

11. When inspecting an electric drive CMV, which actions should you NOT take? Select all that apply.

Cut orange colored cables, conduits, or wires.
Touch any fluid observed leaking from a high voltage R E S S.
Touch any exposed metal, usually copper, inside a high voltage cabinet, enclosure, conduit, or component.
Pierce, pry, dismantle, or otherwise force open any enclosure, barrier, shield, cabinet, or conduit labeled High Voltage.
Insert any tools or body parts into cracks, holes, crevices, or openings in cabinets, enclosures, barriers, shields, or conduit labeled High Voltage.
Inspect to see if there is any damage, or if there are issues with the high voltage electrical system or its enclosures.

Answer:
Cut orange colored cables, conduits, or wires. Correct.
Touch any fluid observed leaking from a high voltage R E S S. Correct.
Touch any exposed metal, usually copper, inside a high voltage cabinet, enclosure, conduit, or component. Correct.
Pierce, pry, dismantle, or otherwise force open any enclosure, barrier, shield, cabinet, or conduit labeled High Voltage. Correct.

Insert any tools or body parts into cracks, holes, crevices, or openings in cabinets, enclosures, barriers, shields, or conduit labeled High Voltage. Correct.
Inspect to see if there is any damage, or if there are issues with the high voltage electrical system or its enclosures. Incorrect.

12. A barrier with the sign Danger High Voltage Do Not Powerwash, has a one inch hole punctured in it.
Is there a safety hazard?

Yes, it is a serious safety hazard.
No, there is no safety hazard.
Yes, but it's not a serious safety hazard.

Answer:
Yes, it is a serious safety hazard. Correct.
No, there is no safety hazard. Incorrect.
Yes, but it's not a serious safety hazard. Incorrect.

13. One of two orange cables behind a commercial vehicle cab shows a few inches of exposed copper wire.
Is there a safety hazard?

Yes, it is a serious safety hazard.
No, there is no safety hazard.
Yes, but it's not a serious safety hazard.

Answer:
Yes, it is a serious safety hazard. Correct.
No, there is no safety hazard. Incorrect.
Yes, but it's not a serious safety hazard. Incorrect.

14. A medium large silver and gray R E S S has a large broken area in the cover, exposing the inside.
Is there a safety hazard?

Yes, it is a serious safety hazard.
No, there is no safety hazard.

Yes, but it's not a serious safety hazard.

Answer:
Yes, it is a serious safety hazard. Correct.
No, there is no safety hazard. Incorrect.
Yes, but it's not a serious safety hazard. Incorrect.

15. A Hybrid Emergency High Voltage Stop Button has more than half of the button missing.
Is there a safety hazard?

Yes, it is a serious safety hazard.
No, there is no safety hazard.
Yes, but it's not a serious safety hazard.

Answer:
Yes, it is a serious safety hazard. Correct.
No, there is no safety hazard. Incorrect.
Yes, but it's not a serious safety hazard. Incorrect.

16. You inspect an electric drive CMV with a lighted red warning light in the vehicle cab because of a loss of high voltage isolation. Is there a safety hazard?

Yes, it is a serious safety hazard.
No, there is no safety hazard.
Yes, but it's not a serious safety hazard.

Answer:
Yes, it is a serious safety hazard. Correct.
No, there is no safety hazard. Incorrect.
Yes, but it's not a serious safety hazard. Incorrect.

17. You inspect an electrical drive CMV with fluid on top of and dripping from a high voltage R E S S. Is it a safety hazard?

Yes, it is a serious safety hazard.
It may be a safety hazard if the liquid is electrolyte.
No, it is not a safety hazard.

Answer:

Yes, it is a serious safety hazard. Incorrect.
It may be a safety hazard if the liquid is electrolyte. Correct.
No, it is not a safety hazard. Incorrect.

18. How must a damaged electrical drive CMV be towed? Select all that apply.

By any tow truck.
By personnel trained in high voltage safety.
By any tow truck specializing in trucks and buses.
Following any towing instructions specified by the manufacturer.

Answer:
By any tow truck. Incorrect.
By personnel trained in high voltage safety. Correct.
By any tow truck specializing in trucks and buses. Incorrect.
Following any towing instructions specified by the manufacturer. Correct.

19. What is the standard symbol for high voltage danger?

A circle with an electric plug inside.
A red triangle outline with white or yellow inside.
A black thunderbolt on a white or yellow background.
A black thunderbolt on a yellow background within a black triangle.

Answer:
A circle with an electric plug inside. Incorrect.
A red triangle outline with white or yellow inside. Incorrect.
A black thunderbolt on a white or yellow background. Incorrect.
A black thunderbolt on a yellow background within a black triangle. Correct.

20. What consequences can result from exposure to high voltage? Select all that apply.

Kidney or other organ failure.
Heart fibrillation and cardiac arrest.
Severe burns at the entry and exit points of the electrical current.
Damage of muscle tissue and nerves along the electrical current path through the body.
Severe limb damage leading to amputation.

Physical disability.
Permanent cognitive impairment.
Death.

Answer:
Kidney or other organ failure. Correct.
Heart fibrillation and cardiac arrest. Correct.
Severe burns at the entry and exit points of the electrical current. Correct.
Damage of muscle tissue and nerves along the electrical current path through the body. Correct.
Severe limb damage leading to amputation. Correct.
Physical disability. Correct.
Permanent cognitive impairment. Correct.
Death. Correct.

This concludes the examination.