

# Electrical Safety for Employees: Basic



This page intentionally blank

# OSHAcademy Course 115 Study Guide

## Electrical Safety Basic

Copyright © 2017 Geigle Safety Group, Inc.

No portion of this text may be reprinted for other than personal use. Any commercial use of this document is strictly forbidden.

Contact OSHAcademy to arrange for use as a training document.

This study guide is designed to be reviewed off-line as a tool for preparation to successfully complete OSHAcademy Course 115.

Read each module, answer the quiz questions, and submit the quiz questions online through the course webpage. You can print the post-quiz response screen which will contain the correct answers to the questions.

The final exam will consist of questions developed from the course content and module quizzes.

We hope you enjoy the course and if you have any questions, feel free to email or call:

OSHAcademy

15220 NW Greenbrier Parkway, Suite 230

Beaverton, Oregon 97006

[www.oshatrain.org](http://www.oshatrain.org)

[instructor@oshatrain.org](mailto:instructor@oshatrain.org)

+1 (888) 668-9079

### Disclaimer

This document does not constitute legal advice. Consult with your own company counsel for advice on compliance with all applicable state and federal regulations. Neither Geigle Safety Group, Inc., nor any of its employees, subcontractors, consultants, committees, or other assignees make any warranty or representation, either express or implied, with respect to the accuracy, completeness, or usefulness of the information contained herein, or assume any liability or responsibility for any use, or the results of such use, of any information or process disclosed in this publication. GEIGLE SAFETY GROUP, INC., DISCLAIMS ALL OTHER WARRANTIES EXPRESS OR IMPLIED INCLUDING, WITHOUT LIMITATION, ANY WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. Taking actions suggested in this document does not guarantee that an employer, employee, operator or contractor will be in compliance with applicable regulations. Ultimately every company is responsible for determining the applicability of the information in this document to its own operations. Each employer's safety management system will be different. Mapping safety and environmental management policies, procedures, or operations using this document does not guarantee compliance regulatory requirements.

This page intentionally blank

## Contents

Modules and Learning Objectives .....	1
Module 1: Electrical Hazards .....	2
Introduction .....	2
How Standards Minimize Hazards.....	3
The Value of an Electrical Safety Program .....	3
Recognizing Hazards .....	4
Terms You Need to Know .....	5
What Affects the Flow of Electricity? .....	6
How Does Water Affect the Flow of Electricity? .....	7
What Causes Shocks .....	7
Shocks Effect On The Body .....	7
Low Voltage Does Not Mean Low Hazard .....	8
Burns .....	9
High Voltage .....	10
Why People Freeze .....	10
Static Electricity .....	11
Overload Hazards .....	12
Module 2: Protective Measures .....	13
Protect Against Electrical Hazards.....	13
Insulation .....	13
Types of Insulation.....	13
Guarding .....	14

Grounding.....	14
Circuit Protection Devices .....	15
Safe Work Practices.....	16
Protection from Energized Parts .....	16
Protection Against Unexpected Startup.....	17
Protection from Overhead Power Lines .....	18
Electrical Protective Equipment .....	19
Tools.....	19
Training Requirements .....	20

## **Modules and Learning Objectives**

### **Module 1 - Electrical Hazards**

Learning objectives in this module include:

- Identify and describe the two primary OSHA electrical safety standards.
- Describe the benefits of an electrical safety program.
- Identify at least 10 electrical hazards commonly found in the workplace.
- Define "volt," "ampere," and "ohm."
- Discuss the difference between a series and parallel electrical circuit.
- Describe the factors that cause electrical shocks.
- Discuss the hazards associated with working around high voltage.
- Describe the hazards associated with static electricity.
- Discuss how overload conditions occur and electrical protective devices.

### **Module 2 - Protective Measures**

Learning objectives in this module include:

- List the three factors causing most electrical injuries.
- Describe the importance of and types of electrical insulation.
- Describe methods for effectively guarding electrical equipment.
- Define the term, "grounding," and give examples.
- List and give examples of circuit protection devices.
- Describe general safe work practices when working around electrical circuits.
- Discuss how to protect against energized parts and unexpected startup.
- Describe protection while working around overhead power lines.

## Module 1: Electrical Hazards

### Introduction

Electricity is essential to modern life, both at home and on the job. Some employees — engineers, electricians, electronic technicians, and power line workers, among them - work with electricity directly. Others, such as office workers and sales people, work with it indirectly. Perhaps because it has become such a familiar part of our daily life, many of us do not give any thought to how much our work depends on a reliable source of electricity. More importantly, we tend to overlook the hazards electricity poses and fail to treat it with the respect it deserves.

OSHA standards cover many electrical hazards in many different industries. OSHA's general industry electrical safety standards are published in:

- [1910.302 through 1910.308](#) — Design Safety Standards for Electrical Systems, and
- [1910.331 through 1910.335](#) — Electrical Safety-Related Work Practices Standards.

OSHA also has electrical safety standards for:

- Construction - in [29 CFR 1926, Subpart K](#).
- Marine terminals - in [29 CFR 1917](#), and longshoring, in [29 CFR 1918](#) reference the general industry electrical standards in [Subpart S of Part 1910](#).
- Shipyard standards - [29 CFR 1915](#), cover limited electrical safety work practices in [29 CFR 1915.181](#).

In the 24 states (in the United States) and 2 territories that operate their own OSHA-approved programs, the standards and other procedures governing electrical safety may not be identical to the federal requirements. They must, however, be at least as effective as the federal standards.



### **How Standards Minimize Hazards**

OSHA standards focus on the design and use of electrical equipment and systems. The standards cover only the exposed or operating elements of an electrical installation such as lighting, equipment, motors, machines, appliances, switches, controls, and enclosures, requiring that they be constructed and installed to minimize workplace electrical dangers. Also, the standards require that certain approved testing organizations test and certify electrical equipment before use in the workplace to ensure it is safe.

We highly recommend employees exposed to electricity in the workplace take this course as an annual refresher. This course is also equivalent to the one-hour requirement for OSHA Outreach 10-Hour Training for General Industry.

### **The Value of an Electrical Safety Program**

Every good safety and health program provides measures to control electrical hazards. The measures suggested in this course should be helpful in getting a better understanding of Introduction to Electrical Safety practices and will introduce you to the Electrical Safety Program. The responsibility for this program should be delegated to someone with a complete knowledge of electricity, electrical work practices, and the appropriate OSHA standards for installation and performance.

Everyone has the right to work in a safe environment. Safety and health add value to your business and your workplace. Through cooperative efforts, employers and employees can learn to identify and eliminate or control electrical hazards.

## Quiz Instructions

After each section, there is a quiz question. Make sure to read the material in each section to discover the correct answer to these questions. Circle the correct answer. When you are finished go online to take the final exam. This exam is open book, so you can use this study guide.

**1. OSHA standards require that exposed or operating elements of an electrical installation be constructed and installed to \_\_\_\_.**

- a. warn workers of electrical hazards
- b. NIOSH/CDC standards
- c. minimize workplace electrical dangers
- d. comply with the globally harmonized system

## Recognizing Hazards

Electricity has long been recognized as a serious workplace hazard, exposing employees to electric shock, electrocution, burns, fires, and explosions. Per the Bureau of Labor Statistics, in 2016, 134 workers died from electrocutions, which represents a decrease from 174 in 2011. What makes these statistics tragic is that most of these fatalities could have been easily avoided.

The first step toward protecting yourself is recognizing the many hazards you face on the job. To do this, you must know which situations can place you in danger. Knowing where to look helps you recognize hazards.

- Inadequate wiring is dangerous
- Exposed electrical parts are dangerous
- Overhead powerlines are dangerous
- Wires with bad insulation can shock you
- Electrical systems and tools that are not grounded or double-insulated are dangerous
- Overloaded circuits are dangerous
- Damaged power tools and equipment are electrical hazards
- Using the wrong PPE is dangerous

- Using the wrong tool is dangerous
- Some on-site chemicals are harmful
- Defective ladders and scaffolding are dangerous
- Ladders that conduct electricity are dangerous
- Electrical hazards can be made worse if the worker, location, or equipment is wet

**2. What is the first step toward protecting yourself from the many electrical hazards you may face on the job?**

- a. Recognizing hazards
- b. Complying with OSHA
- c. Knowing how to respond
- d. Reporting accidents

**Terms You Need to Know**

**What is a "volt?"** A volt is a measure of the electrical force that seems to push the current along. Think of voltage as a lot of water stored in a high-water tank. Because the water tank is high, the water will have more force behind it as it flows down the water pipe to your home. If the same tank was placed at ground level, your water pressure would not be as great. The symbols commonly used for voltage are "E" or "V".

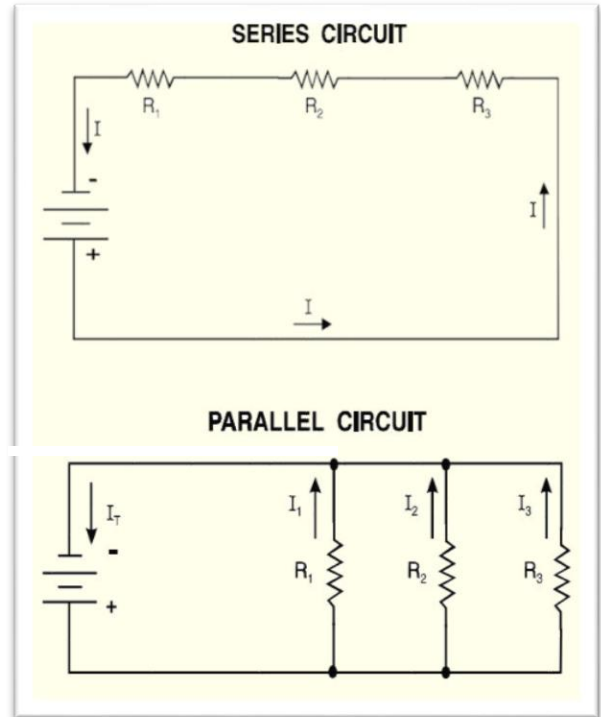
**What is an "ampere?"** An ampere is the unit used to measure the amount of electrical current. Amperage is often referred to as "current" by electrical workers and engineers. Let's go back to our water tank. If the diameter of your pipe coming from the water tank is large, a lot of water (amperage) will flow through the pipe. If the pipe's diameter is small, a smaller amount of water will flow through the pipe. If you need a lot of current (many amps) to operate your equipment, you will need large wires to run the current or they will burn up! The symbol for amperage is "I".

**What is an "ohm?"** Think of an ohm as "resistance". An ohm is the unit used to measure the opposition (also known as "resistance") to the flow of electrical current. Using our water analogy, a small water pipe is going to oppose a lot of water from flowing. Relatively little water will be able to flow through the pipe. So, the pipe offers a high resistance to the flow of water.

You can see that a large pipe would offer little resistance to the flow of water. Big pipe: a lot of water! It's that simple. In an electrical circuit, components are usually sources of resistance. Any component that heats up due to electrical current is a source of resistance. The symbol for resistance is "R."

**What is a "series" circuit?** The current in a series circuit takes only one path. For example, water from high in the mountains may flow down one stream (series) into a river that flows to the ocean.

**What is a "parallel" circuit?** The current in a parallel circuit takes many paths. For example, the water flowing from a water tank up a hill will flow through many different water pipes (parallel) before it reaches the ocean.



**3. Which of the following is the unit used to measure the resistance to the flow of electrical current?**

- a. Volt
- b. Ampere
- c. Ohm
- d. Newton

### What Affects the Flow of Electricity?

Electricity flows more easily through some materials than others. Some substances such as metals generally offer very little resistance to the flow of electric current and are called "conductors." A common but perhaps overlooked conductor is the surface or subsurface of the earth. Glass, plastic, porcelain, clay, pottery, dry wood, and similar substances generally slow or stop the flow of electricity. They are called "insulators." Even air, normally an insulator, can become a conductor, as occurs during an arc or lightning strike.

## How Does Water Affect the Flow of Electricity?

Pure water is a poor conductor. But small amounts of impurities in water like salt, acid, solvents, or other materials can turn water itself and substances that generally act as insulators into conductors or better conductors. Dry wood, for example, generally slows or stops the flow of electricity. But when saturated with water, wood turns into a conductor. The same is true of human skin. Dry skin has a high resistance to electric current. But when skin is moist or wet, it acts as a conductor. This means that anyone working with electricity in a damp or wet environment needs to exercise extra caution to prevent electrical hazards.

## What Causes Shocks

Electricity travels in closed circuits, normally through a conductor. But sometimes a person's body — an efficient conductor of electricity — mistakenly becomes part of the electric circuit. This can cause an electrical shock. Shocks occur when a person's body completes the current path with:

- both wires of an electric circuit;
- one wire of an energized circuit and the ground;
- a metal part that accidentally becomes energized due, for example, to a break in its insulation; or
- another "conductor" that is carrying a current.

## Shocks Effect On The Body

An electric shock can result in anything from a slight tingling sensation to immediate cardiac arrest. The severity depends on the following:

- the amount of current flowing through the body;
- the current's path through the body;
- the length of time the body remains in the circuit; and
- the current's frequency.

A severe shock can cause considerably more damage than meets the eye. A victim may suffer internal hemorrhages and destruction of tissues, nerves, and muscles that aren't readily visible. Renal damage also can occur. If you or a coworker receives a shock, seek emergency medical help immediately.

**4. All the following determine the severity of an electrical shock, EXCEPT \_\_\_\_\_.**

- a. the amount of current flow
- b. the path through the body
- c. the degree of electrical decay
- d. the current's frequency

**Low Voltage Does Not Mean Low Hazard**

This table shows the general relationship between the amount of current received and the reaction when current flows from the hand to the foot for just 1 second.

**Effects of Electrical Current\* on the Body**

Current	Reaction
1 milliamp	Just a faint tingle.
5 milliamps	Slight shock felt. Disturbing, but not painful. Most people can “let go.” However, strong involuntary movements can cause injuries.
6-25 milliamps (women) ** 9-30 milliamps (men)	Painful shock. Muscular control is lost. This is the range where “freezing currents” start. It may not be possible to “let go.”
50-150 milliamps	Extremely painful shock, respiratory arrest (breathing stops), sever muscle contractions. Flexor muscles may cause holding on; extensor muscles may cause intense pushing away. Heart fibrillation possible. Death is possible.
1,000-4,300 milliamps (1-4.3 amps)	Rhythmic pumping action of the heart ceases. Muscular contraction and nerve damage occur; death likely.

10,000 milliamps (10 amps)	Cardiac arrest and severe burns occur. Death is probable.
15,000 milliamps (15 amps)	Lowest overcurrent at which a typical fuse or circuit breaker opens a circuit.

*\*Effects are for voltages less than about 600 amps. Higher voltages also cause severe burns.*

*\*\*Differences in muscle and fat content affect the severity of shock.*

**5. Which of the following is the lowest level of electrical current that can cause heart fibrillation and death?**

- A 5-10 milliamps
- e. 50-150 milliamps
- f. 10 amps
- g. 15 amps

**Burns**

Burns are the most common shock-related injury. An electrical accident can result in an electrical burn, arc burn, thermal contact burn, or a combination of burns.

Electrical burns are among the most serious burns and require immediate medical attention. They occur when electric current flows through tissues or bone, generating heat that causes tissue damage.

Arc or flash burns result from high temperatures caused by an electric arc or explosion near the body. These burns should be treated promptly.

Thermal contact burns are caused when the skin touches hot surfaces of overheated electric conductors, conduits, or other energized equipment. Thermal burns can also be caused when clothing catches on fire, as may occur when an electric arc is produced.

In addition to shock and burn hazards, electricity poses other dangers. For example, arcs that result from short circuits can cause injury or start a fire. Extremely high-energy arcs can damage equipment, causing fragmented metal to fly in all directions. Even low-energy arcs can cause violent explosions in atmospheres that contain flammable gases, vapors, or combustible dusts.

**6. What are the most common injuries due to electrical hazards?**

- a. Falls
- b. Impact
- c. Shocks
- d. Burns

**High Voltage**

The U.S. Department of Energy (DOE) Electrical Safety Guidelines classify high voltage as over 600 volts. OSHA also classifies any use of electrical service over 600 volts as high voltage, and requires permanent warning signs that read, "DANGER-HIGH VOLTAGE - KEEP OUT," be posted.

Sometimes high voltages lead to additional injuries. High voltages can cause violent muscular contractions. You may lose your balance and fall, which can cause injury or even death if you fall into machinery that can crush you. High voltages can also cause severe burns.

At 600 volts, the current through the body may be as great as 4 amps, causing damage to internal organs such as the heart. High voltages also produce burns. In addition, internal blood vessels may clot. Nerves around the contact point may be damaged. Muscle contractions may cause bone fractures from either the contractions themselves or from falls.

**7. The U.S. Department of Energy and OSHA both classify high voltage as over \_\_\_\_\_ volts.**

- a. 50
- b. 120
- c. 240
- d. 600

**Why People Freeze**

When a person receives an electrical shock, sometimes the electrical stimulation causes the muscles to contract. This "freezing" effect makes the person unable to pull free of the circuit. It is extremely dangerous because it increases the length of exposure to electricity and because the current causes blisters, which reduce the body's resistance and increases the current.

The longer the exposure, the greater the risk of serious injury. Longer exposures at even relatively low voltages can be just as dangerous as short exposures at higher voltages. Low voltage does not imply low hazard.



In addition to muscle contractions that cause "freezing," electrical shocks can also cause involuntary muscle reactions. These reactions can result in a wide range of other injuries from collisions or falls, including bruises, bone fractures, and even death.

If a person is "frozen" to a live electrical contact, shut off the current immediately. If this is not possible, use boards, poles, or sticks made of wood or any other nonconducting materials and safely push or pull the person away from the contact. It is important to act quickly, but remember to protect yourself as well from electrocution or shock.

**8. What should you do if you find a person who is "frozen" to an energized electrical surface or wire?**

- a. Nothing, it's too late
- b. Pull the person off the point of contact
- c. Turn the power off immediately
- d. Try to yank the person away from the contact point

### Static Electricity

Static electricity also can cause a shock, though in a different way and generally not as potentially severe as a shock from DC or AC (dynamic electricity) sources.

Static electricity can build up on the surface of an object and, under the right conditions, can discharge to a person, causing a shock. The most familiar example of this is when a person reaches for a door knob or other metal object on a cold, relatively dry day and receives a shock.

However, static electricity also can cause shocks or can just discharge to an object with much more serious consequences, as when friction causes a high level of static electricity to build up at a specific spot on an object. This can happen simply through handling plastic pipes and materials or during normal operation of rubberized drive or machine belts found in many worksites.

In these cases, for example, static electricity can potentially discharge when sufficient amounts of flammable or combustible substances are located nearby and cause an explosion. Grounding or other measures may be necessary to prevent this static electricity build up and the results.

**9. Why is static electricity a serious potential hazard?**

- a. It can cause a fire or explosion
- b. It can surprise the worker causing an injury
- c. It can disrupt neurological pathways
- d. It can result in unintentional impact

**Overload Hazards**

Overloads in an electrical system are hazardous because they can produce heat or arcing. Wires and other components in an electrical system or circuit have a maximum amount of current they can carry safely. If too many devices are plugged into a circuit, the electrical current will heat the wires to a very high temperature. If a tool uses too much current, the wires will heat up.

The temperature of the wires can be high enough to cause a fire. If their insulation melts, arcing may occur. Arcing can cause a fire in the area where the overload exists, even inside a wall.

To prevent too much current in a circuit, a circuit breaker or fuse is placed in the circuit. If there is too much current in the circuit, the breaker "trips" and opens like a switch. If an overloaded circuit is equipped with a fuse, an internal part of the fuse melts, opening the circuit. Both breakers and fuses do the same thing: open the circuit to shut off the electrical current.

If the breakers or fuses are too big for the wires they are supposed to protect, an overload in the circuit will not be detected and the current will not be shut off. Overloading leads to overheating of circuit components (including wires) and may cause a fire.

You must recognize a circuit with improper overcurrent protection devices, or one with no overcurrent protection at all, is a hazard!

**10. Which of the following would be the most likely indication of an electrical circuit overload condition?**

- a. Notification by OSHA
- b. Excess heat or arcing
- c. Excess noise in the circuit
- d. Equipment fails to start

## Module 2: Protective Measures

### Protect Against Electrical Hazards

Most electrical accidents result from one of the following three factors:

1. Unsafe equipment or installation,
2. unsafe environment, or
3. unsafe work practices.

Some ways to prevent these accidents are with insulation, guarding, grounding, electrical protective devices, and safe work practices.

### Insulation

Insulators such as glass, mica, rubber, or plastic used to coat metals and other conductors help stop or reduce the flow of electrical current. This helps prevent shock, fires, and short circuits. To be effective, the insulation must be suitable for the voltage used and conditions such as temperature and other environmental factors like moisture, oil, gasoline, corrosive fumes, or other substances that could cause the insulator to fail.

### Types of Insulation

Insulation on conductors is often color coded. Insulated equipment grounding conductors usually are either solid green or green with yellow stripes. Insulation covering grounded conductors is generally white or gray. Ungrounded conductors, or "hot wires," often are black or red, although they may be any color other than green, white, or gray.

Before connecting electrical equipment to a power source, it is a good idea to check the insulation for any exposed wires for possible defects. Insulation covering flexible cords such as extension cords is particularly vulnerable to damage.

#### **1. To be effective as insulation, what criteria must be met?**

- a. Insulators must be tied in series
- b. It must be made from conductive material
- c. It must be suitable for the voltage used and conditions
- d. Insulation may not conduct in a vacuum

## Guarding

Guarding involves locating or enclosing electric equipment to make sure people do not accidentally contact live parts. Effective guarding requires equipment with exposed parts operating at 50 volts or more to be placed where it is accessible only to authorized people qualified to work with it. Recommended locations are:

- a room, vault, or similar enclosure;
- a balcony, gallery, or elevated platform; or
- a site elevated 8 feet or more above the floor.

Sturdy, permanent screens also can serve as effective guards

Conspicuous signs must be posted at the entrances to electrical rooms and similarly guarded locations to alert people to the electrical hazard and to forbid entry to unauthorized people. Signs may contain the word "Danger," "Warning," or "Caution," and beneath that, appropriate concise wording that alerts people to the hazard or gives an instruction, such as "Danger/High Voltage/Keep Out."

**2. Effective guarding requires equipment with exposed parts operating at \_\_\_\_\_ to be placed where it is accessible only to authorized people qualified to work with it.**

- a. up to 100 volts
- b. 50 volts or more
- c. 10 amps or greater
- d. 15 amps or 120 volts or more

## Grounding

"Grounding" a tool or electrical system means intentionally creating a low-resistance path that connects to the earth. This prevents the buildup of voltages that could cause an electrical accident.

Grounding is normally a secondary protective measure to protect against electric shock. It does not guarantee that you will not get a shock or be injured or killed by an electrical current. It will, however, substantially reduce the risk, especially when used in combination with other safety measures discussed in this course.

1910.304, Wiring Design and Protection, requires at times a service or system ground and an equipment ground in non-construction applications. A service or system ground is designed primarily to protect machines, tools, and insulation against damage. One wire, called the "neutral" or "grounded" conductor, is grounded. In an ordinary low-voltage circuit, the white or gray wire is grounded at the generator or transformer and at the building's service entrance.

An equipment ground helps protect the equipment operator. It furnishes a second path for the current to pass through from the tool or machine to the ground. This additional ground safeguards the operator if a malfunction causes the tool's metal frame to become energized. The resulting flow of current may activate the circuit protection devices.

**3. What is the intentional creation of a low-resistance path that connects to the earth?**

- a. Connecting
- b. Deenergizing
- c. Neutralizing
- d. Grounding

### Circuit Protection Devices

Circuit protection devices limit or stop the flow of current automatically in the event of a ground fault, overload, or short circuit in the wiring system. Well known examples of these devices are fuses, circuit breakers, ground-fault circuit interrupters (GFCI), and arc-fault circuit interrupters.

**Fuses** and **circuit breakers** open or break the circuit automatically when too much current flows through them. When that happens, fuses melt and circuit breakers trip the circuit open. Fuses and circuit breakers are designed to protect conductors and equipment. They prevent wires and other components from overheating and open the circuit when there is a risk of a ground fault.

**Ground-fault circuit interrupters**, or GFCIs, are used in wet locations, construction sites, and other high-risk areas. These devices interrupt the flow of electricity within as little as 1/40 of a second to prevent electrocution. GFCIs compare the amount of current going into electric equipment with the amount of current returning from it along the circuit conductors. If the difference exceeds 5 milliamperes, the device automatically shuts off the electric power.

Arc-fault devices provide protection from the effects of arc-faults by recognizing characteristics unique to arcing and by functioning to deenergize the circuit when an arc-fault is detected.

**4. Each of the following are well-known examples of circuit protection devices, EXCEPT**

\_\_\_\_\_.

- a. ground Fault Circuit Interrupters (GFCI)
- b. circuit breakers
- c. capacitors
- d. fuses

### Safe Work Practices

Electrical accidents are largely preventable through safe work practices. Examples of these practices include the following:

- De-energizing electric equipment before inspection or repair,
- keeping electric tools properly maintained,
- exercising caution when working near energized lines, and
- using appropriate protective equipment.

**5. Electrical safety-related work practices for general industry workplaces are detailed in 29 CFR \_\_\_\_\_ and for construction in 29 CFR \_\_\_\_\_.**

- a. 1910, 1926
- b. 1915, 1920
- c. 1918, 1904
- d. 1907, 1910

### Protection from Energized Parts

A break in an electric tool's or machine's insulation can cause its metal parts to become "hot" or energized, meaning that they conduct electricity. Touching these energized parts can result in an electrical shock, burn, or electrocution.

The best way to protect yourself when using electrical tools or machines is to establish a low-resistance path from the device's metallic case to the ground. This requires an equipment grounding conductor, a low-resistance wire that directs unwanted current directly to the ground.

A properly installed grounding conductor has a low resistance to ground and greatly reduces the amount of current that passes through your body. Cord and plug equipment with a three-prong plug is a common example of equipment incorporating this ground conductor. Never use a three-prong plug if the center ground prong is missing.

Another form of protection is to use listed or labeled portable tools and appliances protected by an approved system of double insulation or its equivalent. Where such a system is employed, it must be marked distinctively to indicate that the tool or appliance uses an approved double insulation system.

**6. What should be done if you see a power tool's plug with a missing center ground prong?**

- a. Use the tool because the plug is still safe
- b. Use the tool as it is normal
- c. Tag the tool before use
- d. Do not use it

### Protection Against Unexpected Startup

Proper lockout/tagout procedures protect you from the dangers of the accidental or unexpected startup of electrical equipment and are required for general industry by [OSHA Standard 1910.333, Selection and Use of Work Practices](#). Requirements for construction applications are in [29 CFR 1926.417, Lockout and Tagging of Circuits](#). These procedures ensure that electrical equipment is deenergized before it is repaired or inspected and protects you against electrocution or shock.

The first step before beginning any inspection or repair job is to turn the current off at the switch box and padlock the switch in the OFF position. (lockout/tagout) This applies even on so-called low-voltage circuits. Securely tagging the switch or controls of the machine or equipment being locked out of service clarifies to everyone in the area which equipment or circuits are being inspected or repaired.

Only qualified electricians who have been trained in safe lockout procedures should perform maintenance on electrical equipment. No two of the locks used should match, and each key should fit just one lock. In addition, one individual lock and key should be issued to each maintenance worker authorized to lock out and tag the equipment. All employees who repair a given piece of equipment should lock out its switch with an individual lock. Only authorized workers should be permitted to remove it.

**7. Which of the following procedures protects the electrician from accidental or unexpected equipment startup?**

- a. Electrical release procedures
- b. Lockout/tagout procedures
- c. Continual monitoring of equipment status
- d. Using a "buddy system" during maintenance

**Protection from Overhead Power Lines**

Before working under or near overhead power lines, ensure that you maintain a safe distance to the lines and, for very high-voltage lines, ground any equipment such as cranes that can become energized. If working on power lines, ensure that the lines have been deenergized and grounded by the owner or operator of the lines. Other protective measures like guarding or insulating the lines help prevent accidental contact.

Employees unqualified to work with electricity, as well as mechanical equipment, should remain at least 10 feet away from overhead power lines. If the voltage is more than 50,000 volts, the clearance increases by 4 inches for each additional 10,000 volts.

When mechanical equipment is operated near overhead lines, employees standing on the ground should avoid contact with the equipment unless it is located outside the danger zone. When factoring the safe standoff distance, be sure to consider the equipment's maximum reach.

Remember these important safe practices when working around downed power lines:

- Do NOT assume that a downed conductor is safe simply because it is on the ground or it is not sparking.
- Do NOT assume all coated, weatherproof or insulated wire is just telephone, television or fiber-optic cable.
- Low-hanging wires still have voltage potential even if they are not touching the ground. So, "don't touch them." Everything is energized until tested to be de-energized.
- Never go near a downed or fallen electric power line. Always assume it is energized. Touching it could be fatal.
- Electricity can spread outward through the ground in a circular shape from the point of contact. As you move away from the center, large differences in voltages can be created.



- Never drive over downed power lines. Assume that they are energized. And, even if they are not, downed lines can become entangled in your equipment or vehicle.
- If contact is made with an energized power line while you are in a vehicle, remain calm and do not get out unless the vehicle is on fire. If possible, call for help.
- If you must exit any equipment because of fire or other safety reasons, try to jump completely clear, making sure that you do not touch the equipment and the ground at the same time. Land with both feet together and shuffle away in small steps to minimize the path of electric current and avoid electrical shock. Be careful to maintain your balance.

**8. If contact is made with an energized power line while you are in a vehicle, be sure to do all the following, EXCEPT \_\_\_\_\_.**

- a. get out and slowly step away from the vehicle.
- b. stay in the car unless the vehicle is on fire.
- c. if you must, jump completely clear of equipment or vehicle.
- d. remain calm and, if possible, call for help.

### Electrical Protective Equipment

Employees who work directly with electricity should use the personal protective equipment required for the jobs they perform. This equipment may include rubber insulating gloves, hoods, sleeves, matting, blankets, line hose, and industrial protective helmets designed to reduce electric shock hazard. All this help reduce the risk of electrical accidents. General safe practices include:

- Electrical protective equipment must be periodically tested in accord with the test tables found in [OSHA 1910.137, Electrical Protective Equipment](#).
- Insulating equipment must be inspected for damage before each day's use. Equipment found defective must be taken out of service until repaired and retested.
- The arc-rated protective clothing and other protective equipment generally must cover the worker's entire body, except for hands, feet, head and face, which may be protected by other PPE.

### Tools

Appropriate and properly maintained tools help protect workers against electric hazards. It is important to maintain tools regularly because it prevents them from deteriorating and

becoming dangerous. Check each tool before using it. If you find a defect, immediately remove it from service and tag it so no one will use it until it has been repaired or replaced.

When using a tool to handle energized conductors, check to make sure it is designed and constructed to withstand the voltages and stresses to which it has been exposed.

**9. Insulating equipment, such as electrical protective gloves, found defective must be**

\_\_\_\_\_.

- a. thrown away and never used again
- b. taken out of service until repaired and retested
- c. checked and used carefully
- d. evaluated for changes in color or texture

### **Training Requirements**

All employees should be trained to be thoroughly familiar with the safety procedures for their jobs. Moreover, good judgment and common sense are integral to preventing electrical accidents. When working on electrical equipment, for example, some basic procedures to follow are to:

- Assume that all overhead wires are energized at lethal voltages. Never assume that a wire is safe to touch even if it is down or appears to be insulated.
- Never touch a fallen overhead power line. Call the electric utility company to report fallen electrical lines.
- Stay at least 10 feet away from overhead wires during cleanup and other activities. If working at heights or handling long objects, survey the area before starting work for the presence of overhead wires.
- If an overhead wire falls across your vehicle while you are driving, stay inside the vehicle and continue to drive away from the line. If the engine stalls, do not leave your vehicle. Warn people not to touch the vehicle or the wire. Call or ask someone to call the local electric utility company and emergency services.
- Never operate electrical equipment while you are standing in water.
- Never repair electrical cords or equipment unless qualified and authorized.
- Have a qualified electrician inspect electrical equipment that has gotten wet before energizing it.

- If working in damp locations, inspect electric cords and equipment to ensure that they are in good condition and free of defects, and use a ground-fault circuit interrupter (GFCI).
- Always use caution when working near electricity.

**10. How far should workers, or their equipment, stay away from overhead wires during cleanup and other activities?**

- a. No less than 3 feet
- b. Between 3 and 5 feet
- c. At least 10 feet
- d. Between 5 and 15 feet