ELECTRICAL SAFETY
Learning Objectives

By the end of this lesson, students will be able to:

- Describe/demonstrate how to inspect electrical equipment before using it
- Recognize damage to cords and plugs
- Explain what to do if you find damaged electrical equipment
- Explain the importance of using a Ground Fault Circuit Interrupter (GFCI) in wet or damp areas
- Explain the risks and proper procedures to follow when a coworker or other person appears to be shocked or in contact with live electricity
- Define lockout/tagout and explain how it protects workers

Time Needed: 60 Minutes

Materials Needed

- PowerPoint slides: *Electrical Hazards* (adapted from OSHA Office of Training and Education and Hispanic Work Safe, University of Massachusetts-Lowell)
- Handouts: *Electrical Safety and You* (A)
  *What All Students Need to Know about Electrical Safety* (B)
  *Electrical Safety Scenario* (C)
- Optional Props: Examples of damaged cords or wiring
  Ground fault circuit interrupter
  Lockout device

Preparing to Teach This Lesson

Before you present this lesson:

1. Make copies of handouts A) *Electrical Safety and You*, B) *What All Students Need to Know about Electrical Safety*, and C) *Electrical Safety Scenario*.

2. Familiarize yourself with the Electrical Hazards PowerPoint slides. There may be more slides than you have time for so decide ahead of time which ones you will show.

3. Collect examples of damaged equipment, GFCIs, and lockout devices for demonstration.
Detailed Instructors Notes

A. Introduction: Why is this subject important? (5 minutes)

1. Discuss why this topic is important.
   - Electricity can cause electrocution, burns, fire, electric shock.
   - Electrocuton is the third leading cause of work-related deaths among 16- and 17-year olds, after motor vehicle deaths and workplace homicide. Electrocuton causes 12% of all workplace deaths among young workers.
   - Many people come in contact with electricity in their jobs—either directly, like electricians or engineers, or indirectly.
   - Because electricity is so dangerous, it is important to know how to recognize hazards and work safely around electricity.

B. Powerpoint and discussion (20 minutes)

1. Give students Handout (A) Electrical Safety and You and Handout (B) What All Students Need to Know about Electrical Safety. Use the PowerPoint presentation, Electrical Hazards, to go over the main points of the handouts.

2. Use the following questions during or after the presentation to ensure students are getting some of the main points.

   How does an electrical shock affect your body?
   
   An electrical shock can affect your breathing, heart, brain, nerves and muscles. The body has its own electrical system for breathing, nerve transmission and heart rate. An electrical shock can shut off or “blow the fuses” in your body. When your body’s fuses are blown the heart can stop beating or you can stop breathing. A fatal shock is called electrocution. You can also receive electrical burns or fall due to a shock.

   What should you do if you find someone who has suffered electrical shock?
   
   The first two things are to call for help and shut off the source of electricity. It is critical to not touch the person until you are certain that they are not still part of the live circuit. Otherwise you could be the next victim. If it happens at school or work, call a teacher or supervisor and 911. If the situation is at home or along a road, call 911 and do not touch any wires or power lines.

   What possible hazards should you look for before using electrical equipment?
   
   If possible, have students look for any electrical hazards in the classroom (or bring in examples of equipment with damaged wire); ask them to demonstrate and explain what they’re looking for. Some examples:
   - Damaged wiring
   - Proper grounding
   - Working near heat sources, oil, or water
   - Warning signs: very hot cords or plugs, minor shocks.
What does grounding do?

Grounding provides a safe pathway for electricity to travel from the equipment or circuit to the ground, preventing shock. The third prong on a plug is the ground prong---don't remove it. Double-insulated tools, identified by the words “double insulated” or “double insulation” do not need to be grounded.

What are GFCI's and why are they important?

A GFCI (ground fault circuit interrupter) detects very small amounts of current leakage from a circuit to a ground and shuts the current off. It measures the difference between current flowing to an electrical device and current returning from the device. It trips in as little as 1/40th of a second when it senses a difference of 5mA. For example, if there is a short (current leakage) in a power tool, the metal casing can become “live.” A GFCI will cut off the power before the user gets a serious shock. Note that other “overcurrent” devices, like circuit breakers and fuses, are intended to protect equipment. GFCI's are used to protect people. Because water is a great conductor of electricity, some form of GFCI should be used whenever someone is working outdoors or in a wet area. GFCI's should also be used with extension cords and other temporary wiring.

When should you make repairs to electrical equipment?

You should never try to repair electrical equipment yourself. If tools or cords run very hot, or if you get a shock, or if the equipment is damaged, stop using the equipment and report the condition immediately. Never use a 3-prong grounded plug with the third prong broken off.

What is lockout/tagout?

Lockout/tagout (LOTO) stands for procedures, required by OSHA regulations, to prevent worker injury or death from the unexpected activation or startup of machinery or electric current, especially during service or maintenance activity. “Hazardous energy” that could harm a worker includes electricity and other forms of energy like mechanical, hydraulic, and pneumatic. If all possible sources of energy to machinery and electrical equipment are disabled, unsuspecting workers will not be caught in machinery or come in contact with live electricity while they are repairing or otherwise servicing equipment. Lockout/tagout procedures require two things:

1. An assigned person (the “authorized employee”) must turn off and disconnect (unplug) the machinery or equipment from its energy source(s) before performing service or maintenance.

2. The authorized employee must either lock or tag the energy-isolating device(s) to prevent the release of hazardous energy and take steps to verify that the energy can't reach the point where the work is taking place.
C. Electrical Safety Scenario (25 minutes)

1. Give students Handout (C) Electrical Safety Scenario. Read the scenario out loud.

2. Divide students into groups of 3 or 4. Ask each group to identify at least three things that could have been done to prevent this death.

3. Bring the class back together. Ask for one idea from each group. Write ideas on the board or on flipchart paper; add any that the students did not think of. Possible answers:

   - If the circuit had been equipped with a GFCI, the current would have been shut off before injury occurred. Equipment in wet or damp areas must be GFCI protected.
   - Do not work with electricity in wet or damp areas without proper insulating protective equipment. The recent mopping increased the risk of electrocution.
   - If the breakers had been labeled, which they are required to be, the manager would have known which breaker to shut off and would have been able to turn off the circuit more quickly.
   - Exposed receptacle boxes should be made of nonconductive material so that contact with the box will not constitute “a ground”.
   - All workers must be trained about electrical hazards on the job and how to work safely around these hazards, **before they start a job**. Workers need to know that if an electrical injury occurs they shouldn't touch the victim or the electrical equipment until the current has been shut off.

The following OSHA and State of Washington L&I-DOSH-WISHA codes correspond to information in this unit:

OSHA 29 CFR 1910.301 Electrical Safety
L&I DOSH WISHA WAC 296-800-280 Electrical, Basic Requirements (Core Rules)
Glossary of Electrical Terms
(from Electrical Safety Student Manual, NIOSH publication no. 2002-123)

ampacity - maximum amount of current a wire can carry safely without over-heating
amperage - strength of an electrical current, measured in amperes
ampere (amp) - unit used to measure current
arc-blast - explosive release of molten material from equipment caused by high-amperage arcs
arching - luminous electrical discharge (bright, electrical sparking) through the air that occurs when high voltages exist across a gap between conductors
AWG - American Wire Gauge - measure of wire size
bonding - joining electrical parts to assure a conductive path
bonding jumper - conductor used to connect parts to be bonded
circuit - complete path for the flow of current
circuit breaker - overcurrent protection device that automatically shuts off the current in a circuit if an overload occurs
conductor - material in which an electrical current moves easily
CPR - cardiopulmonary resuscitation - emergency procedure that involves giving artificial breathing and heart massage to someone who is not breathing or does not have a pulse (requires special training)
current - movement of electrical charge
de-energize - shutting off the energy sources to circuits and equipment and depleting any stored energy
double-insulated - equipment with two insulation barriers and no exposed metal parts
energized (live, “hot”) - similar terms meaning that a voltage is present that can cause a current, so there is a possibility of getting shocked
fault current - any current that is not in its intended path
fixed wiring - permanent wiring installed in homes and other buildings
flexible wiring - cables with insulated and stranded wire that bends easily
fuse - overcurrent protection device that has an internal part that melts and shuts off the current in a circuit if there is an overload
GFCI - ground fault circuit interrupter - a device that detects current leakage from a circuit to ground and shuts the current off
ground - physical electrical connection to the earth
ground fault - loss of current from a circuit to a ground connection
ground potential - voltage a grounded part should have; 0 volts relative to ground
guarding - covering or barrier that separates you from live electrical parts
insulation - material that does not conduct electricity easily
leakage current - current that does not return through the intended path, but instead “leaks” to ground
lock-out - applying a physical lock to the energy sources of circuits and equipment after they have been shut off and de-energized
milliampere (milliamp or mA) - 1/1,000 of an ampere

NEC - National Electrical Code - comprehensive listing of practices to protect workers and equipment from electrical hazards such as fire and electrocution

neutral - at ground potential (0 volts) because of a connection to ground

ohm - unit of measurement for electrical resistance

overcurrent protection device - device that prevents too much current in a circuit

overload - too much current in a circuit

power - amount of energy used each second, measured in watts

PPE - personal protective equipment (eye protection, hard hat, special clothing, etc.)

qualified person - someone who has received mandated training on the hazards and on the construction and operation of equipment involved in a task

resistance - material's ability to decrease or stop electrical current

risk - chance that injury or death will occur

shocking current - electrical current that passes through a part of the body

short - low-resistance path between a live wire and the ground, or between wires at different voltages (called a fault if the current is unintended)

tag-out - applying a tag that alerts workers that circuits and equipment have been locked out

trip - automatic opening (turning off) of a circuit by a GFCI or circuit breaker

voltage - measure of electrical force

wire gauge - wire size or diameter (technically, the cross-sectional area)
Electrical Safety and You

It is hard to think of any job today that does not involve the use of electricity. Some workers, such as engineers, electricians, and people who do wiring, work with electricity directly. Other workers, such as office workers and salespeople, use it indirectly. Working with electricity can be deadly if not done safely.

Electrical Shock

Electrical shock occurs when electricity enters your body. You become part of an electrical circuit. Electricity always seeks the shortest path to the ground. If you become part of that path, the electrical current flows through you to the ground. It is the flow, or amount, of electricity (amperes) and the length of time your body is in contact with the current that determine the amount of damage. The strength of the electricity (voltage) affects the amount of current, but electricity can cause serious injury or death at both low and high voltages.

How Electricity Works

Electricity is similar to water in a garden hose. Pressure is required to make the water flow out of the hose. If there is no pressure, no water will flow. At the end of the hose, a nozzle may be added that can turn the hose off. The pressure is still there but the flow is stopped. This is similar to the electrical switches in your school, house, or workplace. When you turn off the light, the flow of electricity stops but the electrical power is still there. The pressure of the electrical current is measured in volts.

It doesn't take much current to kill. Just 75/1000 of an ampere (the amount of flow necessary to light a Christmas tree light) can kill you if it passes through your chest.

An electrical shock can affect your breathing, heart, brain, nerves, and muscles. The body has its own electrical system for breathing, nerve transmission, and heart rate. An electrical shock can shut off or “blow the fuses” in your body. When your body’s fuses are blown the heart can stop beating or you can stop breathing. A fatal shock is called electrocution.

Electrocution is one of the leading causes of death of young workers.

Contact with overhead wires is a common cause of electrocution. This can happen when people are carrying ladders or poles or using equipment that is tall enough to touch electrical wires.
What Should You Do if Someone is Shocked by Electricity?

If you come upon someone who has been shocked by electrical current, do these things first:

- Disconnect the power source
- Call for emergency services or 911

Do not touch the person until you are certain the power is off and they are no longer part of the live current path. If you touch the person, you could well be the next victim. You must not administer CPR or first aid unless you know the power is disconnected and you are trained in these practices.

**Electrical Burns**

Burns can occur all along the path that current follows through the body, including where it enters and leaves.

**Other Electrical Hazards**

In addition to electrical shock, contact with electricity can cause other problems. It can throw you or make you fall. And, if you get an electrical shock while operating a power tool, you can lose control of the equipment, which can injure you or someone nearby.

**Electrical-related hazards that can cause electrical shocks, fires, or falls include:**

- Inadequate wiring
- Overloaded circuits
- Exposed electrical parts
- Wet conditions
- Overhead powerlines
- Damaged tools and equipment
- Defective insulation
- Improper personal protective equipment
- Improper grounding.
Grounding

Proper grounding of electrical equipment helps prevent electrical shock. An ungrounded power tool can lead to electrical shock, injury, or death if enough current passes through the body. Grounding provides a safe pathway for electricity to travel from the equipment or circuit to the ground, preventing shock. The third prong on a plug is the ground prong—don’t remove it. Double-insulated tools, identified by the words “double insulated” or “double insulation” do not need to be grounded.

A ground fault circuit interrupter, or GFCI, is an inexpensive lifesaver. A GFCI detects current leakage from a circuit to a ground and shuts the current off. For example, if there is a short (current leakage) in a power tool, the metal casing can become “live.” A GFCI will cut off the power before you get a serious shock. There are three types of GFCI:

- a GFCI receptacle
- a portable GFCI that plugs into a standard receptacle
- a GFCI circuit breaker

Because water is a great conductor of electricity, some form of GFCI should be used whenever someone is working outdoors or in a wet area.

Equipment needs to be grounded in any of these situations:

1. The equipment is within 8 feet vertically and 5 feet horizontally of the floor or walking surface.
2. The equipment is within 8 feet vertically and 5 feet horizontally of grounded metal objects you could touch.
3. The equipment is used outdoors.
4. The equipment is located in a wet or damp area and is not isolated.
5. The equipment is connected to a power supply by cord and plug and is not double insulated. (The third prong in portable tools and extension cords supplies grounding).

Adapted from Safety and the Young Worker - Student Manual, Workers’ Compensation Board, Northwest Territories, Canada and Electrical Safety: Safety and Health for Electrical Trades Student Manual, National Institute for Occupational Safety and Health (NIOSH)

What is Lockout/Tagout?

“Lockout/tagout” refers to specific practices and procedures to protect employees from machine Injuries or electric shock due to the unexpected energizing or startup of machinery and equipment during service or maintenance activities. “Hazardous energy” includes electricity as well as other forms of energy like mechanical, hydraulic, and pneumatic. OSHA developed the lockout/tagout regulation to prevent the deaths and serious injuries that result from unsuspecting workers being caught in machinery or contacting live electricity while they are doing repairs or otherwise servicing equipment.
Lockout/tagout procedures require that:

1. an assigned person (the “authorized employee”) turns off and disconnects (unplugs) the machinery or equipment from its energy source(s) before performing service or maintenance, and
2. the authorized employee either locks or tags the energy-isolating device(s) to prevent the release of hazardous energy and takes steps to verify that the energy has been isolated effectively.

**Lockout** involves the use of “locks to ensure that circuit breakers, switches, valves, etc. are held in the “off” position, or not operated until the person who has attached the lockout device, the “authorized employee,” removes it. These devices can only be removed with a key or other unlocking mechanism. Before the locks are removed and the equipment can be reenergized, everyone must be in a safe position and accounted for.

**Tagout** involves the use of “tags” to warn others that a circuit breaker, switch or valve, and the equipment that it is attached to, must not be used until the tag is removed. Because a tag only serves as a warning and does not physically prevent the equipment from being started, it is much less protective than an actual lockout device. Tags are supposed to be used only in conjunction with other procedures that provide protection equivalent to lockout devices.

Adapted from *Lockout/Tagout Factsheet*, at:
and:
*Serving Up Safety, A Guide to Occupational Safety and Health Standards for the Restaurant Industry* at
What All Students Need to Know about Electrical Safety

1. Keep tools and cords away from heat, oil, and sharp edges.
2. Do not use electrical equipment in damp or wet areas.
3. Do not use electrical equipment on or near metal ladders.
4. Be sure the control switch on equipment is in the “off” position before you plug it in or unplug it.
5. Disconnect tools and extension cords by holding the plug—not the cord.
6. Never use a 3-prong grounded plug with the 3rd prong broken off. Always plug a 3-prong plug into a properly installed 3-prong socket.
7. Use a Ground Fault Circuit Interrupter (GFCI) when using portable tools.
8. Avoid using extension cords. If you must use an extension cord, choose one with the same ampere rating as the tool. Make sure the insulation is intact and that all connections are tight. Make sure the cord does not create a tripping hazard.
9. Do not overload circuits.
10. If tools or cords run very hot or if you get a shock, report the condition to your supervisor immediately.
11. Report any damaged tool or equipment or one that gives off minor shocks to your supervisor immediately. Report exposed live parts to your supervisor immediately. Do not attempt to make repairs yourself.
Scenario: Electrical Safety

An 18 year-old worker with 15 months of experience at a fast food restaurant was plugging a toaster into a floor outlet when he received a shock. Since the restaurant was closed for the night, the floor had been mopped about 10 minutes before. The restaurant manager heard the worker scream and investigated. The worker was found with one hand on the plug and the other hand grasping the metal receptacle box. His face was pressed against the top of the outlet. The manager tried to take the worker’s pulse, but got a shock when he touched the worker. The manager could not locate the correct breaker for the circuit. He called the emergency squad, returned to the breaker box, and found the correct breaker. By the time the circuit was turned off, the worked had been exposed to the current for 3 to 8 minutes. His pulse was very rapid at this time.

By the time the rescue crew arrived, the worker had no pulse. Despite CPR, he was dead on arrival at the hospital.

What could have been done to prevent this death?
Introduction

- An average of one worker is electrocuted on the job every day
- There are four main types of electrical injuries:
  - Electrocution (death due to electrical shock)
  - Electrical shock
  - Burns
  - Falls
Electricity – How it Works

- Electricity travels in a closed circuit
- Electricity flows through conductors
  - water, metal, the human body

The human body is a conductor!

Electrical Shock

- Received when current passes through the body
- Severity of the shock depends on:
  - Path of current through the body
  - Amount of current flowing through the body
  - Length of time the body is in the circuit
- LOW VOLTAGE DOES NOT MEAN LOW HAZARD
Body as path to ground

Dangers of Electrical Shock

- Currents > 75 mA* can cause ventricular fibrillation (rapid, ineffective heartbeat)
- Will cause death in a few minutes unless a defibrillator is used

75 mA is not much current – a small power drill uses 30 times as much
Electrical shock

- Affects your breathing, heart, brain, nerves and muscles
- “Blows the fuses” in your body
- Electrocution (a fatal shock) is one of the leading causes of death of young workers
What to do if someone is shocked by electricity?

- Disconnect the power
- Call emergency medical services, or 911

Use appropriate first aid and CPR techniques only if you are trained to do so

What to do if someone is shocked by electricity?

Don’t

- Don’t touch the victim unless you are certain that the power has been shut off. If you do, you must be the next victim!
- Don’t touch bare wires, power lines, or power company equipment
- Don’t try to put out a fire started by electricity with water. The water can conduct electricity
Electrical Injuries: Burns

- Most common shock-related, nonfatal injury
- Occurs when you touch electrical wiring or equipment that is improperly used or maintained
- Usually occurs on the hands
- Very serious injury that needs immediate attention
Electrical injuries: Falls

- Electric shock can also cause indirect or secondary injuries
- Workers at heights who experience a shock can fall, resulting in serious injury or death

Inadequate Wiring Hazards

- Conductor is too small to safely carry the current
  - E.g., portable tool with extension cord too small for the tool
    - Cord can overheat and cause fire without tripping the circuit breaker
    - Breaker could be the right size for the circuit but not for the extension cord
Overload Hazards

- Too many devices plugged into a circuit
  - Overheated wires can cause a fire
  - If insulation melts, arcing could cause a fire, even inside a wall

Overhead Powerline Hazards

- Overhead powerlines are usually not insulated
- Powerline workers need special training and personal protective equipment (PPE) to work safely
- Do not use metal ladders – instead, use fiberglass ladders
- Beware of powerlines when you work with ladders and scaffolding
Overhead Line Incident

- Two workers were attempting to remove a metal pole.
- Pole made contact with 7200 volts.
- One worker died.

Defective Extension Cords

Plastic or rubber covering is missing

Damaged extension cords & tools
Damaged Cords

Cords can be damaged by:
- Aging
- Door or window edges
- Staples or fastenings
- Abrasion from adjacent materials
- Activity in the area

Improper use of cords can cause shocks, burns or fire

Taking care of electric cords & wires

✓ Check before use
✓ Use only cords that are 3-wire type
✓ Use only cords marked for hard or extra-hard usage
✓ Cords not marked for hard or extra-hard use, or which have been modified, must be taken out of service immediately
Extension Cord Use

- Do not pass through holes in walls, floors, or ceilings or through windows or doors
- Do not run behind building walls, ceilings, or floors
- Do not drive over them
- Do not attach to building surfaces (including hanging them from nails, staples or bare wire)
- Do not lay out in a manner that can cause tripping
- Do not use as a substitute for the fixed wiring of a structure

Be aware of the environment you will be working in. If the environment is wet or damp, use equipment and cords designed for that situation!
Hazard Control: Grounding

- Grounding provides a safe pathway for electricity to travel
- Proper grounding helps prevent electrical shock
- If you come into contact with an improperly grounded electrical device, YOU WILL BE SHOCKED
- Double insulated tools do not need to be grounded

Do Not Eliminate the Ground!

These are suicide plugs!

You’ll become the next-best path for current!

HispanicsWorkSafe.org
Safety Training and Educational Materials for Hispanic Workers
Electrical Protective Devices

- Shut off electricity flow in the event of an overload or ground-fault in the circuit
- Examples: Fuses, circuit breakers, and ground-fault circuit-interrupters (GFCI’s)
- Fuses and circuit breakers are overcurrent devices
  - When there is too much current:
    - Fuses melt
    - Circuit breakers trip open

Ground-Fault Circuit Interrupter

- Protects you from dangerous shock
- Detects current leakage from a circuit to a ground and shuts the current off.
- Can shut off electricity flow in as little as 1/40 of a second, protecting you from a dangerous shock
Remember...

- **Circuit Breakers and Fuses** *protect the building, equipment, and tools*
- **GFCI** is the only device which will *protect the worker* from shock and electrocution!

Fuses and circuit breakers protect equipment, not people, and don’t protect against shocks and electrocutions!

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**Equipment must be grounded if it’s...**

- Within 8’ vertically and 5’ horizontally of the floor or walking surface.
- Within 8’ vertically and 5’ horizontally of grounded metal objects you could touch.
- Used outdoors.
- Located in a wet or damp area and is not isolated.
- Connected to a power supply by cord and plug and is not double insulated. (The third prong in portable tools and extension cords supplies grounding.)

Young Worker Safety Resource Center, adapted from OSHA Office of Training and Education
What is Lockout/Tagout?

- De-energize (shut down) equipment before inspecting or making repairs
- Protect employees from the unexpected startup of machinery and equipment
- Lock or tag the energy-isolating device to prevent the release of hazardous energy

How do Lockout/Tagout Devices Work?

- Lockout devices can only be removed with a key or other unlocking mechanism.
- Tagout devices are warnings that the employee attaches to the power source to warn employees not to turn on equipment while that employee services or maintains it.
Electrical Safety: What to Look For

- Keep tools and cords away from heat, oil, and sharp edges.
- Do not use electrical equipment in damp or wet areas.
- Do not use electrical equipment on or near metal ladders.
- Be sure the control switch on equipment is in the “off” position before putting in or pulling out a plug.

Electrical Safety: What to Look For

- Disconnect tools and extension cords by holding the plug.
- Never break the 3rd prong off or use a plug with a broken 3rd prong.
- Use a Ground Fault Circuit Interrupter (GFCI) when using portable tools.
- Avoid using extension cords.
- Do not overload circuits.

Young Worker Safety Resource Center, adapted from OSHA Office of Training and Education
Report Damaged Equipment IMMEDIATELY

- If tools or cords run very hot.
- If tools or cords are giving off minor shocks.
- If you see live parts.

Do not attempt to make repairs yourself!

Young Worker Safety Resource Center, adapted from OSHA Office of Training and Education