Train-the-Trainer: Basic Electricity Safety

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Objectives:

- To acquire basic knowledge about electricity, hazards associated with electric shock and means of prevention.
- To understand how severe electric shock is in the human body.
- To develop good habits when working around electricity.
- To recognize the hazards associated with the different types of power tools and the safety precautions necessary to prevent those hazards.

Activity 1: The Electric Shock (Ice Breaker)

1. Ask participants to form a circle and then ask a volunteer to leave the room.

2. Once the volunteer has left the room, explain to the participants that one of them will carry "electric current" but that no one should say anything. There will be paper pieces in a hat and the first person that picks a red colored piece of paper will carry the electric current.

They should all remain silent, except when the volunteer guesses who carries the electric current. Once the volunteer has touched the shoulder of the person with the electric current, all of the participants should scream and make noise.

3. Call the volunteer to come in and let him/her know that one of the participants from the circle has electric current and that he needs to guess who it is by going around the circle and tapping them on the shoulder.

4. There will be a list of questions that participants must answer. If the volunteer guesses who the person with the electric current is within the first three tries, then the person with the current must answer the question. If the volunteer does not guess whom the person with the electric current is, then he/she must answer the question.

5. The person that carried the electric current will be the next one to go outside to guess who the next person with the current is. This will go on until we have asked 8 questions about electricity and the use of power tools.

Note: This activity will serve as an icebreaker and a pre-test.

Activity 2: Introduction to Electricity

Start by asking participants to raise their hand if they ever come in contact with electricity at their jobs.

Electricity has become essential to modern life because of how practical and useful it is. Much of our daily work relies on electricity, whether at an office, retail, restaurant, construction site or any other industry and perhaps because it is so familiar to us, that oftentimes we tend to overlook the hazards associated with this source of energy. A lot of workers are killed or injured by electricity every year. It may be because of a lack of understanding of how electricity works or not being careful when working with electricity. Understanding the dangers of electricity, how to respond in an emergency and proper safety procedures will go a long way in preventing injury or death caused by this powerful force.

This workshop will describe how electricity works, identifying the hazards and injuries associated with electricity, general precautions and tips to be safe, controlling hazards, and first aid advice. We will also cover how to use different power tools in a safely manner.

Here are some definitions you should know:

- *Current* is the flow of electricity.
- *Voltage* is the measurement of electric potential.
- A *Circuit* is a network consisting of a closed loop, giving a return path for the current.
- *Alternating Current* is the form in which electric power is delivered to businesses and residences.(such as the power from your wall outlet).
- *Direct Current* the flow of electric charge is only in one direction (such as from a battery).
- *Conductor* is an object or type of material that allows the flow of electricity.
- *Resistance* is the capacity of a material to lower or stop electric current.

Activity 3: Let's generate some energy!

Note to facilitators: You can use a potato clock kit or you can make your own. What you will need:

- A knife
- A potato
- 2 pennies
- 2 zinc-galvanized nails
- Copper wire
- A small light bulb or a small clock

Information to protect workers

Share the following information with participants. Using pictures of PPE and circuit protection devices, show participants what the proper equipment is to protect themselves when working with or near electric power.

What are circuit protection devices and how do they work? 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, 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 milliamps, 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 de-energize the circuit when an arc-fault is detected.

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.

Here are other ways to protect yourself:

- Use Ground Fault Circuit Interrupters (GFCIs) to help protect people from electrical shock in homes, offices, hospitals, schools, worksites, and outdoors. GFCIs meet the latest NEC® and UL requirements.
- Wear voltage rated rubber gloves
- Use rubber boots for damp locations.
- Wear a hat or cap. Wear an approved safety helmet (hard hat) if the job requires.

- Confine long hair or keep hair trimmed and avoid placing the head in close proximity to rotating machinery. Do not wear jewelry. Gold and silver are excellent conductors of electricity.
- Make sure the space is cool enough to avoid excessive sweating.

What you need to do:

1. Cut the potato in half with the knife to expose the interior. Use the knife to cut a penny-sized slit in the middle of the potato half.
2. Wrap a piece of copper wire around each penny. Press the wire-wrapped pennies into the slits created in each of the potato halves. Leave some of the wire hanging out of the potato.
3. Slide one nail into the end of each potato half. Wind copper wire around each nail.
4. Attach the loose copper wire from a penny to the copper wire on the nail attached to the opposite potato. Do not connect the nail and penny wires in the same potato.
5. Connect the two loose wires from the remaining penny and nail, to the light bulb. When the wires touch the bulb, it lights up.

Here are some things that might be helpful when conducting this test:

- If the nail and a penny touch, the experiment will not work.
- Peeling the potato or soaking it in Gatorade sometimes helps conduct the electricity.
- Use caution with the wires once it becomes an electric conduit.

Once the closed circuit is created, ask a volunteer to open the circuit through one of the cables and one of the metal parts. Then ask the participant to hold the cable with one of his/her hands and hold the metal piece with the other hand. The clock should turn on again, making the participant part of the closed circuit. Then explain to participants that they became part of the closed circuit and that if the voltage was any higher, they could potentially get hurt or shocked. After the experiment with the potato, ask participants to describe in their own words how electricity works. Make sure to emphasize the importance of understanding that when a closed circuit is interrupted, electricity will look for the closest path or conductor to the ground. What does this exercise teach us about electricity?

NOTE: *Because the voltage that the potatoes generate is very low (less than 1 milliamp), the participants DO NOT run the risk of getting hurt or shocked.*

How Does Electricity Work?

Ask participants: Can anyone tell me why birds that sit on electrical post wires do not get electrocuted? Give room for possible answers.

Basically, a circuit consists of three essential elements: 1) the source of energy, which supplies the driving force or voltage to make the current flow; 2) the user of electricity, for example a light bulb or a clock; and 3) transmission lines or wires to conduct the electricity. For current to flow there must be a complete or closed circuit. If a wire is cut or disconnected somewhere forming an open circuit, charges will accumulate and stop the flow of current. Electricity wants nothing more than to go to ground and will always do so by the easiest most direct route. A bird on a wire doesn't give electricity anywhere to go but back to the wire – easier for the current to stay right where it is in the wire and continue on its way.

Note: It is important to understand that short of killing you, electric shock can cause burns as the current dissipates across your body's natural resistance (that is, your skin).

To understand how electricity works, let's take a look at static electricity. By a show of hands, who here has felt a shock when turning on a light switch or grabbing a doorknob? Do you know why you felt that shock?

Static Electricity is a very common form of electricity. Think about when you walk in a carpeted room and then touch a doorknob. Static electricity originates when two different materials are brought together, such as the soles of the shoes and the carpet. When they are separated, then two different types of electricity are produced (one on the carpet, one on the shoe soles) because they have different voltage or electric intensity. Both types of electricity attract each other and are trying to get back together to recombine. If they are not able to recombine where they originated and then you touch a doorknob or a light switch, then the electricity travels through your body to connect with the source you just touched. That's when you feel a shock, as the electricity leaves your body. The electricity is then gone from your body and you should not get another shock unless you generate more electricity. Can you give me another example of two things that can generate electricity? Give the example of the balloon.

Basically our bodies become conductors and electricity seeks the easiest and shortest path to the ground, which oftentimes that shortest path is a person. "Conductors" conduct electricity freely and in large amounts – all metals, water, humans and even non-metallic materials (trees, ropes etc.) can conduct electricity depending on moisture content and surface contamination; that is why it is important to be extra careful when working with electricity.

Activity 4: Developing Safe Practices Around Electricity

How Dangerous Is Electricity?

Even if you are not an electrician, it is very likely that you will have to work with or around electricity, and therefore you can be exposed to electrical hazards. In each workplace, there are a lot of different tools and materials, as well as a lot of activities happening at the same time. The dangers are also increased by the use of power tools.

Effects Of Electric Shock

As we have learned earlier, a closed circuit is essential for the safety of anyone that comes in contact with electricity. Contact with electric voltage can cause the current to flow through the body, which can then result in electric shock, burns and even death. This can happen in different scenarios or situations. If two cables have different voltage, the current can flow through them if they are connected. If you touch both cables at the same time, then your body becomes a conductor and the current of electricity will pass through your body. Also, if you touch a cable that has current flow and also touch an electric connection that is grounded, then you become the easiest path for electricity to go to the ground.

The severity of the injuries caused by an electric shock varies depending on the voltage and the time that the current takes to pass through your body. The amount of current a person can tolerate and still be able to control his or her hand and arm muscles is less than 10 mA. However, it is important to mention that currents as low as 10 milliamps can cause muscle contractions.

Like mentioned before, the damage that the current of electricity can do depends on different factors: the intensity of the voltage, the length of the exposure, the muscle structure of the individual, and other different conditions. People with less muscular tissue are usually affected at lower levels of electric current.

Electric shocks, depending on certain conditions, can be fatal, even at relatively low voltages. The amount of time that an electrical current lasts has a great influence in the severity of the injuries. If the electric current has a short duration, then it may just cause pain. If the electric shock is longer, then it can be fatal, even if the voltage is not very high.

Take a look at the following chart:

EFFECTS OF ELECTRICAL CURRENT IN THE HUMAN BODY	
Current	Reaction
Below 1 Milliamp	Generally not perceptible
1 Milliamp	Faint Tingle
5 Milliamps	Slight shock felt. Not painful but disturbing. Average individual can let go. Strong involuntary reactions can lead to other injuries.
6 to 25 Milliamps (women)	Painful shocks. Loss of muscle control.
9 to 30 Milliamps (men)	The freezing current or “let go” range. If extensor muscles are excited by shock, the person may be thrown away from the power source. Individuals cannot let go. Strong involuntary reactions can lead to other injuries.
50 to 150 Milliamps	Extreme pain, respiratory arrest, severe muscle reactions. Death is possible.
1.0 to 4.3 Amps	Rhythmic pumping action of the heart ceases.

	Muscular contraction and nerve damage occur; death is likely.
10 Amps	Cardiac arrest, severe burns, death is probable.

Can you think of any situations in which you could face those amounts of electrical current?

Another factor that influences how dangerous electric shock can be is resistance. Resistance blocks the current. Working conditions in environments that are wet will reduce the resistance dramatically. We know that the human body is an excellent conductor for electricity and that electricity is always looking for a quick and simple path to the ground. Because about 70 percent of a human body is made up of water, it's extremely easy for electricity to course through you in a matter of seconds.

The journey the electric current takes through the body also influences the severity of the shock. The currents that pass through the heart or nervous system are the most dangerous. If your head makes contact with a live wire, it is very likely that your nervous system will be affected. If a hand comes in contact with an electrical component with current (and at the same time the other side of your body makes a path to the ground), this will make the current pass through your chest and possibly produce injuries to the heart and lungs.

At a minimum, electric shock can cause:

- Headache
- Muscle fatigue or spasms
- Temporary unconsciousness
- Temporary breathing difficulty

Some of the more serious and possibly fatal side effects of electrical shock are:

- Severe burns at point of contact and along the electricity's course through the body
- Vision loss
- Hearing loss
- Brain damage
- Respiratory arrest or failure
- Cardiac arrest (heart attack)
- Death

So what does that mean?

Respiratory Paralysis- If the current is greater than 10mA, it can paralyze or freeze the muscles and you will not being able to let go. In fact, you might even hold whatever is causing the electric shock even tighter and exposing yourself longer to electricity. If you cannot let go at all, then the current continues flowing through your body and it can cause respiratory paralysis, which means you will stop breathing.

Ventricular Fibrillation- Currents that are greater than 75 mA can cause your heart to shift its regular beating pattern*.* If this happens, your heart muscles go out of whack in a way that causes blood to stop pumping. In this situation, even if you cut the current, your heart might not be able to find its proper rhythm, and you could die. The only way a person can survive is if treated with a defibrillator.

It is also important to note that high voltage can cause additional injuries. For example, if you are working at an elevated surface and get shocked, the shock can cause violent muscle cramps, which might make you lose your balance and thus fall. Severe burns are also an aftermath of electrical current flowing through the body.

An intense shock can cause more serious damage than it is possible to see. A person may suffer internal bleeding and destruction of tissues, nerves and muscles. Sometimes, death may occur subsequently due to the hidden wounds caused by electric shocks.

How Much Is Too Much?

Most resistance in your body is in your skin. If your skin is wet or damp, that resistance is lowered. If you handle an electrical device with damp hands, even low voltages might be sufficient to do you serious damage. The current coming out of your electrical outlet is more than enough to kill you.

As stated before, there are many factors that can affect the way electric current can hurt you. There is no rule as to what level of voltage will kill or seriously injure a person because of all the variables, so it is always important to be careful when working with electricity.

Regardless of how much voltage you work with, develop safe work habits now.

How Can I Protect Myself From Getting Shocked?

It’s common sense that you should not stick your finger into an electrical outlet, but there are other good practices that can protect you from turning your body into a current conductor.

Take off all jewelry!

Metal is an excellent conductor. It is not a very smart idea to wear rings or other metal jewelry around electricity. This is because body's resistance can be very low when your skin is surrounded by metal. Another good reason to avoid jewelry is that it can get stuck on things like machinery or a breadboard filled with wires and tiny components.

Stay dry!

Don't work in a wet environment (like outdoors if it's raining, wet lawns, damp garages, etc.). Also, make sure your body is completely dry before working with electricity, this includes sweat. This might seem like common sense, but oftentimes we do not consider things like having drinks around our workspace, which can spill and cause accidents. You need to become super careful about anything wet or moist in or near your work area.

Look Up!

Always be aware of overhead wires. Take extra care when working near overhead power lines; make sure you maintain a safe distance from overhead power lines.

Ladders- Remember that electricity wants a conductor. Metal is an excellent conductor, so make sure not to use metal ladders around overhead power lines (beware that even wood ladders might contain metal parts). Be safe, electricity can jump and often does when a potential conductor like a metal ladder comes within certain proximity. Keep away from overhead power lines (at least 10 feet).

Trimming trees- A rule should be to always plant trees away from power lines. However, if you have a tree that has grown into power lines DO NOT attempt to trim it yourself. Remember, electricity does not need metal to flow, water will be just fine. The moisture in the tree and in you will be a great conductor. Call the Department of Power for assistance.

Note: Never climb Electrical Utility poles or towers.

Look Down!

There may be power wires underground. If you plan to excavate, call 811 first to make sure there are no power lines or other utilities that can get damaged.

Stay away from pad mount transformers (green metal boxes that contain the above ground portion of an underground electrical installation). These transform high voltage electricity to low voltage electricity, which is then carried in insulated underground power lines to your home. Always stay away from these boxes.

Never touch a downed wire. Keep at least 10 meters away from fallen wires and call the Department of Power to notify them of any downed lines.

Check your tools!

Appropriate and properly maintained tools help protect workers against electric hazards. It's 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.

Always respect electricity!

The main rule when working with or around electricity is NEVER touch a component in a circuit that has power. Turn off all power sources or remove the source from the circuit entirely before touching it. Note that even if the source of current is eliminated, some electricity might remain. For that reason, it is always important to test the circuit before touching it to make sure no energy remains. Also, never take someone's word that the power is off, you should always check it yourself.

If you are not a trained/certified electrician, you should never do electric work.

Play the first 2 minutes of the video "Look Up and Live". Stop the video and ask participants to explain what went wrong and how could they have protected themselves. The video can be found at:

https://www.youtube.com/watch?v=DvUxBKDomcU

Once participants have shared some prevention methods, point out that the workers were not electricians and the work that they were hired to do had nothing to do with electrical work. Just like in this case, because we often have to work with or around electrical power, it is important to follow all the precautions that were discussed throughout the training. Play the rest of the video to see the prevention steps the workers should have taken.

What Is Lockout/Tagout?

Electrical power must be removed when electrical equipment is inspected, serviced, or repaired. To ensure the safety of personnel working with the equipment, power is removed and the equipment must be locked out and tagged out. Per OSHA standards, equipment is locked out and tagged out before any preventive maintenance or servicing is performed. Lockout is the process of removing the source of electrical power and installing a lock, which prevents the power from being turned ON. Tagout is the process of placing a danger tag on the source of electrical power, which indicates that the equipment may not be operated until the danger tag is removed.

Lockouts and tagouts do not by themselves remove power from a circuit. An approved procedure is followed when applying a lockout/tagout. Lockouts and tagouts are attached only after the equipment is turned OFF and tested to ensure that power is OFF.

Here are some samples of tags used:

First Aid

If someone nearby has contact with a live electric current and receives an electrical shock, DO NOT touch the person. If you touch him or her, the electricity can move from that person's body into yours, shocking you both in the process.
Electrical shocks always need emergency medical attention, even if the person seems to be fine afterward. Here are some steps you can take to help a victim:

1. Separate the Person From Current's Source

To turn off power:

- Unplug an appliance if plug is undamaged or shut off power via circuit breaker, fuse box, or outside switch.

If you can't turn off power:

- Stand on something dry and non-conductive, such as dry newspapers, telephone book, or wooden board.
- Try to separate the person from current using non-conductive object such as wooden or plastic broom handle, chair, or rubber doormat.

If high voltage lines are involved:

- The local power company must shut them off.
- Do not try to separate the person from current if you feel a tingling sensation in your legs and lower body. Hop on one foot to a safe place where you can wait for lines to be disconnected.
- If a power line falls on a car, instruct the passengers to stay inside unless explosion or fire threatens.

2. Do CPR, if Necessary
When you can safely touch the person, do CPR if the person is not breathing or does not have a pulse. Only a person that knows CPR should do it. Additionally, OSHA regulation requires employees should be certified annually to perform CPR.

3. Check for Other Injuries

- If the person is bleeding, apply pressure and elevate the wound if it's in an arm or leg.
- There may be a fracture if the shock caused the person to fall.

4. Wait for 911 to Arrive

What OSHA standards address electrical safety in the construction industry?
29 CFR Part 1926 Safety and Health Regulations for Construction

(b) Branch circuits-(1) Ground-fault protection-(I) General.
The employer shall use either ground-fault circuit interrupters as specified in paragraph (b)(1)(ii) of this section or an assured equipment grounding conductor program as specified in paragraph (b)(1)(iii) of this section to protect employees on construction sites. These requirements are in addition to any other requirements for equipment grounding conductors.

(ii) Ground-fault circuit interrupters. All l20-volt, single-phase, 15- and 20-ampere receptacle outlets on construction sites, which are not a part of the permanent wiring of the building or structure and which are in use by employees, shall have approved ground-fault circuit interrupters for personnel protection. Receptacles on a two wire, single-phase portable or vehicle-mounted generator rated not more than 5kW, where the circuit conductors of the generator are insulated from the generator frame and all other grounded surfaces, need not be protected with ground-fault circuit interrupters.

(iii) Assured equipment grounding conductor program. The employer shall establish and implement an assured equipment grounding conductor program on construction sites covering all cord sets, receptacles which are not a part of the building or structure, and equipment connected by cord and plug which are available for use or used by employees. This program shall comply with the following minimum requirements:

(A) A written description of the program, including the specific procedures adopted by the employer, shall be available at the jobsite for inspection and copying by the Assistant Secretary and any affected employee.

(B) The employer shall designate one or more competent persons (as defined in § 1926.32(f)) to implement the program.

(C) Each cord set, attachment cap, plug and receptacle of cord sets, and any equipment connected by cord and plug, except cord sets and receptacles which are fixed and not exposed to damage, shall be visually inspected before each day's use for external defects, such as deformed or missing pins or insulation damage, and for indications of possible internal damage. Equipment found damaged or defective shall not be used until repaired.

(D) The following tests shall be performed on all cord sets, receptacles which are not a part of the permanent wiring of the building or structure, and cord-and plug-connected equipment required to be grounded:

(1) All equipment grounding conductors shall be tested for continuity and shall be electrically continuous.

(2) Each receptacle and attachment cap or plug shall be tested for correct attachment of the equipment grounding conductor. The equipment grounding conductor shall be connected to its proper terminal.

(E) All required tests shall be performed:

(1) Before first use;

(2) Before equipment is returned to service following any repairs;

(3) Before equipment is used after any incident which can be reasonably suspected to have caused damage (for example, when a cord set is run over); and

(4) At intervals not to exceed 3 months, except that cord sets and receptacles which are fixed and not exposed to damage shall be tested at intervals not exceeding 6 months.

(F) The employer shall not make available or permit the use by employees of any equipment which has not met the requirements of paragraph (b)(1)(iii) of this section.

(G) Tests performed as required in this paragraph shall be recorded. This test record shall identify each receptacle, cord set, and cord- and plug-connected equipment that passed the test and shall indicate the last date it was tested or the interval for which it was tested. This record shall be kept by means of logs, color coding, or other effective means and shall be maintained until replaced by a more current record. The record shall be made available on the jobsite for inspection by the Assistant Secretary and any affected employee.

Activity 5: Post Test

Using the same paper colors used in the icebreakers activity, randomly ask participants to pick a piece of paper. After that, the facilitator should randomly pick a few papers and ask the folks that picked whatever color was selected to answer the post-test questions.

Contacting OSHA

If you identify a hazard at your job, please report it!

To report an emergency, file a complaint or seek OSHA advice, assistance or products, call (800) 321-OSHA or contact your nearest OSHA regional or area office.

This material was adapted from material produced by the NIOSH, OSHA, The Power Tool Institute and other sources.

Pre/Post Test: Basic Electricity Safety

Questions:

1. What is voltage?

2. Can you explain how a closed circuit works?

3. What is a "conductor" of electricity?

4. What effects can electric shock have on the human body?

5. Can electric shock be fatal even if the voltage is not very high?

6. True or False: If a person nearby has contact with a live electric current and receives an electrical shock you should grab them and pull them off the current of electricity.

Answers:

1. Voltage is the measurement of electric potential.

2. A closed circuit provides an uninterrupted path for current to flow, and can be defined as a complete electrical circuit around which current flows.

3. A conductor is an object or type of material that allows the flow of electricity.

4. Headaches, muscle fatigue or spasms, temporary unconsciousness, temporary breathing difficulty, severe burns, vision loss, hearing loss, brain damage, respiratory arrest or failure, cardiac arrest (heart attack), death.

5. Yes, an electric shock can be fatal even if the voltage is not very high.

6. FALSE

Basic Electricity Safety and Power Tools Level 1 Evaluation Form

Name of Facilitator: ________________________________
Date: __________________________
Location: ___________________________________

From 1 through 8, rate whether you agree or disagree with the following statements:

1. I found the training was useful for me:

Strongly Disagree						Strongly Agree	
1	2	3	4	5	6	7	8

2. My personal knowledge on the topic increased with this training:

Strongly Disagree						Strongly Agree	
1	2	3	4	5	6	7	8

3. The facilitator was prepared and knowledgeable on the subject:

Strongly Disagree						Strongly Agree	
1	2	3	4	5	6	7	8

4. There was enough room for participation and my input was appreciated:

Strongly Disagree						Strongly Agree	
1	2	3	4	5	6	7	8

5. I feel more confident about my safety at the workplace after this training:

Strongly Disagree						Strongly Agree	
1	2	3	4	5	6	7	8

6. Overall, the workshop has met my expectations:

Strongly Disagree						Strongly Agree	
1	2	3	4	5	6	7	8

Additional comments:

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