OSHA Training Institute

Construction
Focus Four: Electrocution Hazards

INSTRUCTOR GUIDE

OSHA Directorate of Training and Education
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Construction Focus Four: Electrocution Hazards

Table of Contents

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TRAINER PREPARATION GUIDANCE

The "Construction Focus Four: Electrocution Hazards" lesson is part of the 4-hour block consisting of segments on each of the Focus Four Hazards: Falls, Caught-In or -Between, Struck-By and Electrocution. Because most construction fatalities are caused by fall hazards, falls must be covered for at least one hour, and we recommend at least one hour and 15 minutes. The other focus four hazards lessons, such as this one, must be covered for a minimum of one-half hour each. This training is developed to be used in both the 10- and 30-hour OSHA Outreach Training programs and if applicable, for other safety and health training purposes.

Using the Instructor Guide (IG): The IG consists of instructions for trainer preparation, resources, a lesson plan, references, and Appendices. The IG contains content, activities and notes for the instructor. **It is not intended to be a script that is read verbatim to the students. Rather, instructors should review the entire guide (including referenced materials and internet links) prior to conducting training, and use it as a resource in their planning and presentation.**

The learning objectives and testing: The "Construction Focus Four: Electrocution Hazards" lesson segment was developed based on the terminal (TO) and enabling objectives (EO) below. These objectives are the expected student outcomes; therefore, 1) the instructor may not vary from these objectives when planning the training session; and 2) the objectives must be measured by testing the student's achievement. A test is provided in Appendix A; however, the trainer may develop a modified set of test questions to meet the needs of the audience as well as to measure the student's achievement of the stated objectives.

TO: Given current OSHA and industry information regarding construction worksite illnesses, injuries and/or fatalities, the student will be able to recognize electrocution hazards in construction.

Specifically, the student will be able to:

EO 1: Identify major electrocution hazards
EO 2: Describe types of electrocution hazards
EO 3: Protect him/herself from electrocution hazards
EO 4: Recognize employer requirements to protect workers from electrocution hazards

Using the Slide Presentation: The Microsoft PowerPoint® 2003 presentation file consists of electrocution hazard recognition photos which the trainer may use as an activity during the session. The presentation format is one slide asking if students recognize any hazards followed by a slide displaying the same photo containing the answer. The instructor may add additional slides to the presentation based on the lesson content or use their own slides, if appropriate to the lesson content.

Appendices: Provided in the Appendices are the instructor and student copies of the lesson test, lesson activity documents along with student handouts. Refer to the Table of Contents for details.

Media and/or Teaching Methods: This lesson is one of four segments covering the construction focus four hazards. It has been set up as a facilitated, interactive training session. Students are given small "chunks" of information, and then are able to practice their understanding of the subject matter via activities and workshops. There is a lesson test provided for each focus four segment.

Ideal Setting or Conditions for the Training Session: The ideal setting is a classroom or other area where students have space to break into groups.

Disclaimer: This Compliance Assistance product is **not** a standard or regulation, and it creates no new legal obligations. The Compliance Assistance product is advisory in nature, informational in content, and is intended to assist employers in providing a safe and healthful workplace. Pursuant to the Occupational Safety and Health Act, employers must comply with safety and health standards promulgated by OSHA or by a State with an OSHA-approved State Plan. In addition, pursuant to Section 5(a)(1), the General Duty Clause of the Act, employers must provide their employees with a workplace free from recognized hazards likely to cause death or serious physical harm. Employers can be cited for violating the General Duty Clause if there is a recognized hazard and they do not take reasonable steps to prevent or to abate the hazard. However, failure to implement these recommendations is not, in itself, a violation of the General Duty Clause. Citations can only be based on standards, regulations, and the General Duty Clause.

Online Resources

California Department of Public Health:
http://www.cdph.ca.gov/programs/ohb-face/Pages/Publications.aspx

Construction Chart Book, Fourth Edition:
http://www.cpwr.com/rp-chartbook.html
http://www.elcosh.org/en/document/54/d000038/the-construction-chart-book-4th-edition.html

Construction Safety:
http://www.cdc.gov/niosh/topics/constructionsafety/

Controlling Electrical Hazards: **http://www.osha.gov/Publications/osha3075.pdf**

Electrical Safety: **http://www.cdc.gov/niosh/topics/electrical/**

Electrical Safety eTool:
http://www.osha.gov/SLTC/etools/construction/electrical_incidents/mainpage.html

Electrical Safety and Health Topics: **http://www.osha.gov/SLTC/electrical/index.html**

Electrical Safety Tips OSHA quick Card:
http://www.osha.gov/OshDoc/data_Hurricane_Facts/electrical_safety.pdf

Electrical Safety: Safety and Health for Electrical Trades Student Manual:
http://www.cdc.gov/niosh/docs/2009-113/default.html

Electrocutions During Work with Scaffolds Near Overhead Power Lines:
http://www.cdc.gov/niosh/91-110.html

Fatality Assessment and Control Evaluation (FACE) Program:
http://www.cdc.gov/niosh/face/

NFPA 70E: Standard for Electrical Safety in the Workplace®
http://www.nfpa.org/aboutthecodes/AboutTheCodes.asp?DocNum=70E

NIOSH Electrical Safety Manual: **http://www.cdc.gov/niosh/docs/2009-113/**

NIOSH Face Reports: **http://www.cdc.gov/niosh/face/stateface.html**

Portable Generator Safety Tips OSHA Quick Card:
http://www.osha.gov/OshDoc/data_Hurricane_Facts/portable_generators.pdf

Preventing Fatalities of Workers Who Contact Electrical Energy: **http://www.cdc.gov/niosh/87-103.html**

Preventing Electrocutions Due to Damaged Receptacles and Connectors: **http://www.cdc.gov/niosh/87-100.html**

Using Portable Generators Safely. OSHA Fact Sheet:
http://www.osha.gov/OshDoc/data_Hurricane_Facts/portable_generator_safety.pdf

Working Safely with Electricity. OSHA Fact Sheet:
http://www.osha.gov/OshDoc/data_Hurricane_Facts/elect_safety.pdf

Construction Focus Four: Electrocution Hazards

Overview

The purpose of this lesson is to provide workers with information that will enable them to recognize major electrocution hazards at construction worksites. This Instructor Guide (IG) is intended to be used when presenting the OSHA Training Institute Construction Outreach 10- and/or 30- hour course. The lesson is comprised of the following four topics:

1. What is an electrocution hazard?
2. What are the major types of electrocution hazards in construction?
3. How can I protect myself from electrocution hazards?
4. What is my employer required to do to protect workers from electrocution?

Materials Needed:

- Flip chart and markers
- Presentation slides
- Student handouts
- Student copies of planned activities
- Copy of the OSHA Construction Standards
- Questions for Review & Answers
- If activity files are used for hazard recognition, copy PPTinstrHazRecAlt_Electr_April2011.pdf and PPTstudentHazRecAlt_Electr_April2011.pdf

Training Preparation:

- Helpful References/Online Resources listed in this document
- OSHA Construction Standards
- **Appendix A:** Test Questions [instructor and student copies]
- **Appendix B:** Activity Options A and B [instructor and student copies]
- **Appendix C:** Fatal Facts Worksheets [instructor and student copies]
- **Appendix D:** Student Handouts

Student Handouts:

- "Construction Focus Four: Electrocution, Safety Tips for Workers" tri-fold brochure format
- Focus Four Toolbox Talks 1, 2, and 3 produced by IUOE National Training Fund under OSHA grant number SH-16591-07-06-F-11
- OSHA Quick Card™ "Electrical Safety"

Instruction for this session:

1. Ask the class if they can give an example of an electrical hazard on a construction site that could cause a worker to be electrocuted. Discuss the examples with the class. Be sure that examples of the most common electrical hazards are covered such as, contact with power lines, faulty extension cords, improper grounding of equipment, etc.
2. Discuss the content.
3. Show photos of electrocution hazards and have the class identify the hazards shown.
4. If time permits, conduct one of the following small group activities:
   - Option A: Wet Conditions / Ground Fault Circuit Interrupters
   - Option B: Extension Cords, Copper and Current
5. Conduct the lesson test and discuss answers with the students

NOTES:

Refer to "Condensed Electrical Glossary" section of the Construction Focus Four: Electrocution tri-fold handout [Appendix D]

Preview photos in "Hazard Recognition" PowerPoint presentation. As an alternative, trainers can use their own photos in the hazard recognition presentation. If the presentation is used as provided, the trainer can use the activity files provided to add interactivity by having the students involved in note taking. To conduct the activity, locate and print the PDF files titled: PPTinstrHazRecAlt_Electr_April2011.pdf and PPTstudentHazRecAlt_Electr_April2011.pdf

Option A and Option B scenarios and student worksheets are found in Appendix B

Locate instructor and student copies of test in Appendix A.

Topic 1: What is an electrocution hazard?

A. Definition
B. Examples
C. Statistics

Content for Topic 1:

A. Definition

Electrocution results when a person is exposed to a lethal amount of electrical energy.

Preview photos in "Hazard Recognition" PowerPoint presentation.

An electrical hazard can be defined as a serious workplace hazard that exposes workers to the following:

- **B**urns
- **E**lectrocution
- **S**hock
- **A**rc Flash/Arc Blast
- **F**ire
- **E**xplosions

Therefore, **BE SAFE** by recognizing, avoiding and protecting against all of these electrical hazards. These BE SAFE terms are defined as:

B = Burns:
A burn is the most common shock-related injury. Burns from electricity are one of three types: Electrical, Arc/Flash or Thermal Contact.

E = Electrocution:
Electrocution is fatal; it means to kill with electricity. Electrocution results when a human is exposed to a lethal amount of electrical energy.

S = Shock:
Shock results when the body becomes part of the electrical circuit; current enters the body at one point and leaves at another. Electrical shock is defined as a reflex response to the passage of electric current through the body.

A = Arc Flash/Blast:
An arc flash is the sudden release of electrical energy through the air when a high-voltage gap exists and there is a breakdown between conductors. An arc flash gives off thermal radiation (heat) and bright, intense light that can cause burns. Temperatures have been recorded as high as 35,000 °F. High-voltage arcs can also produce considerable pressure waves by rapidly heating the air and creating a blast.

F = Fire:
Most electrical distribution fires result from problems with "fixed wiring" such as faulty electrical outlets and old wiring. Problems with cords (such as extension and appliance cords), plugs, receptacles, and switches also cause electrical fires.

NOTES:

The types of burns from electricity are further defined as:

- Electrical burns result from heat generated by the flow of electric current through the body
- Arc/Flash burns are high temperature burns caused by an electric arc or explosion
- Thermal contact burns occur when skin comes in contact with overheated electric equipment

An arc flash can be spontaneous or result from inadvertently bridging electrical contacts with a conducting object. Other causes may include dropped tools or the buildup of conductive dust or corrosion.

For more information on arc flash/blast, including best practices in electrical safety, refer to NFPA 70E: Standard for Electrical Safety in the Workplace® online at: htpp://www.nfpa.org

E = Explosions:
An explosion can occur when electricity ignites an explosive mixture of material in the air.

Note that although a) electricity is the source of these hazards, and b) all of these hazards are of equal importance, for this focus four module, this lesson focuses on electrocution hazards.

NOTES:

B. Examples
The following are examples of electrocutions that have occurred in the construction industry:

- Two workers were moving an aluminum ladder. One of them was electrocuted when the ladder came in contact with overhead power lines.
- A worker was raising a mast on a water well drilling truck when the mast came in contact with high voltage overhead lines, electrocuting the worker.
- Worker [victim] was electrocuted when the boom of a rotary drilling truck contacted an overhead power line. The victim and another worker had just finished drilling a water well at a residential property. The victim moved the truck away from the well. The victim was standing at the controls, lowering the boom and was thrown several feet away from the truck.
- Worker was fatally injured when he was electrocuted and fell to the concrete floor while working from an 8' fiberglass step ladder. Worker was changing an energized ballast on a two bulb florescent light fixture, located approximately 11' 6" off the ground.
- The worker was electrocuted while connecting a replacement electrical service box to the electrical service drop to the building.

Provide examples of accidents related to the type of work your audience does. Locate accident summaries on OSHA's website. Go to: **http://www.osha.gov/pls/imis/accidentsearch.html**

Within the keyword field, enter a keyword to be searched against. For example, to obtain accident investigations involving electrocutions, enter the key word electrocuted. To view a list of key words, use the keyword list at the bottom of the Accident Investigation Search page.

C. Statistics

Data from the U.S. Bureau of Labor Statistics (BLS) show that electrocution was the fourth leading cause of death in construction in 2005, after falls to a lower level, transportation injuries, and being struck by objects and equipment.

Electrocutions caused 9% of 1,243 construction worker deaths, but accounted for less than 1% of reported recordable nonfatal injuries in 2005.

For 2003-2005, the death rate from electrocutions for the construction industry was 1.1 per 100,000 full-time workers, for was an average of 121 electrocutions per year. The highest rates of death from electrocution were among electrical power installers and repairers and earth drillers.

The construction occupations with the highest average number of deaths per year due to electrocution were electricians (29), construction laborers (19), supervisors/managers (13), electrical power installers and repairers (10).

NOTES:

For the most current statistical data, or for more detail, see: **http://www.bls.gov/iif/**

Topic 2. What are the major types of electrocution hazards in construction?

A. Contact with overhead power lines
B. Contact with energized sources (e.g., live parts, damaged or bare wires, defective equipment or tools)
C. Improper use of extension and flexible cords

Content for Topic 2

A. Contact with power lines

Major Hazards

Overhead and buried power lines are especially hazardous because they carry extremely high voltage. Fatalities are possible as electrocution is the main risk; however, burns and falls from elevations are also hazards that workers are exposed to while working in the vicinity of high voltage power lines. Workers may not realize that cranes are not the only equipment that reaches overhead power lines. Working on a ladder or in a man-basket suspended under or near power lines also poses a risk of electrocution.

Important to note: The covering on an overhead power line is primarily for weather protection; therefore, workers need to know that if they touch a power line, covered or bare, death is probable.

NOTES:

Refer to Toolbox Talks #1 "What increases your risk of electrocution?" handout [Appendix D]

Voltages of overhead lines range from 120 to 750,000 volts. The most reliable way to know the voltage is to ask the utility company that owns the line.

Classroom Exercise
Fatal Facts Accident Summaries

NOTES:

Discuss how these accidents could have been prevented.

- Two workers were installing aluminum siding on a farmhouse when it became necessary to remove a 36-foot high metal pole CB antenna. One worker stood on a metal pick board between two ladders and unfastened the antenna at the top of the house. The other worker, who was standing on the ground, took the antenna to lay it down in the yard. The antenna made electrical contact with a 7200-volt power transmission line 30 feet 10 inches from the house and 23 feet 9 inches above the ground. The worker handling the antenna received a fatal shock and the other worker a minor shock.

Distribute student worksheet, Fatal Facts Accident Summary No. 11 [Appendix C]

- A lineman was electrocuted while working on grounded de-energized lines. He was working from a defective basket on an articulated boom aerial lift when the basket contacted energized lines which ran beneath the de-energized lines. The defective basket permitted current to pass through a drain hole cut into the body of the basket, then through the worker, and to ground via the de-energized line.

Distribute student worksheet, Fatal Facts Accident Summary No. 28 [Appendix C]

- Two workers were spreading concrete as it was being delivered by a concrete pumper truck boom. The truck was parked across the street from the worksite. Overhead power lines ran perpendicular to the boom on the pumper truck. One worker was moving the hose (elephant trunk) to pour the concrete when the boom of the pumper truck came in contact with the overhead rover line carrying 7,620 volts. One worker received a fatal electric shock and fell on the other worker who was assisting him. The second worker received massive electrical shock and burns.

Distribute student worksheet, Fatal Facts Accident Summary No. 49 [Appendix C]

B. Contact with energized sources
Major hazards:

The major hazards regarding contact with energized sources are electrical shock and burns. Electrical shock occurs when the body becomes part of the electric circuit, either when an individual comes in contact with both wires of an electrical circuit, one wire of an energized circuit and the ground, or a metallic part that has become energized by contact with an electrical conductor.

The severity and effects of an electrical shock depend on a number of factors, such as the pathway through the body, the amount of current, the length of time of the exposure, and whether the skin is wet or dry. Water is a great conductor of electricity, allowing current to flow more easily in wet conditions and through wet skin.

(1,000 milliamperes = 1 amp; therefore, 15,000 milliamperes = 15 amp circuit)

Current	Reaction
Below 1 milliampere	Generally not perceptible
1 milliampere	Faint tingle
5 milliampere	Slight shock felt; not painful but disturbing. Average individual can let go. Strong involuntary reactions can lead to other injuries.
6-25 milliamperes (women)	Painful shock, loss of muscular control
9-30 milliamperes (men)	The freezing current or "let-go" range. Individual cannot let go, but can be thrown away from the circuit if extensor muscles are stimulated.
50 150 mlliamperes	Extreme pain, respiratory arrest, severe muscular contractions. Death is possible.
1,000 - 4,300 milliamperes	Rhythmic pumping action of the heart ceases. Muscular contraction and nerve damage occur; death likely.
10,000 milliamperes	Cardiac arrest, severe burns; death probable

NOTES:

Refer to “Effects of Electric Current in the Human Body” section of the Construction Focus Four: Electrocution, Safety Tips for Workers tri-fold handout [Appendix D]

Electrical burns can be arc burns, thermal contact burns, or a combination of burns. Electrical burns are among the most serious burns and require immediate medical attention. They occur when an electric current flows through tissue or bone, generating heat that causes tissue damage. The body cannot dissipate the heat generated by current flowing through the resistance of the tissue therefore, burns occur.

To further illustrate how easily a person can receive a fatal shock, consider a voltage that is common to every location in the United States, 120-volts. Under average working conditions where the person is perspiring and has a resistance of only 1000-ohms from hand-to-hand, using the simple Ohm's Law formula (current equals the voltage divided by the resistance) the current flow will be 0.12 amperes or 120 mA.

If the power supply to electrical equipment is not grounded or the path has been broken, or if there are live parts or bare wires, a fault current may travel through a worker's body, causing electrical burns or death. Even when the power system is properly grounded, electrical equipment can instantly change from safe to hazardous because of extreme conditions and rough treatment.

NOTES:

Classroom Exercise
Working with Overhead Lamps

Discuss the following accident and how it could have been prevented.

The employee was attempting to correct an electrical problem involving two non-operational lamps. He proceeded to the area where he thought the problem was. He had not shut off the power at the circuit breaker panel nor had he tested the wires to see if they were live. He was electrocuted when he grabbed the two live wires with his left hand and then fell from the ladder.

NOTES:

Distribute student worksheets, Fatal Facts Accident Summary No. 60 [Appendix C]

C. Improper use of extension and flexible cords
Major hazards:

The normal wear and tear on extension and flexible cords can loosen or expose wires, creating a hazardous condition. Cords that are not 3-wire type, not designed for hard-usage, or that have been modified, increase the risk of contacting electrical current. With the wide use of power tools on construction sites, flexible extension cords are often necessary.

Refer to “General Rules for Electrical Work” section of the Construction Focus Four: Electrocution, Safety Tips for Workers tri-fold handout [Appendix D]

Because they are exposed, flexible, and unsecured, they are more susceptible to damage than fixed wiring. Hazards are created when cords, cord connectors, receptacles, and cord- and plug-connected equipment are improperly used and maintained.

To reduce hazards, flexible cords must connect to devices and to fittings in ways that prevent tension at joints and terminal screws. A flexible cord may be damaged by door or window edges, staples and fastenings, abrasion from adjacent materials, or simply by aging. If the electrical conductors become exposed, there is a danger of shocks, burns, or fire.

When a cord connector is wet, electric current can leak to the equipment grounding conductor, and to anyone who picks up that connector if they provide a path to ground. Such leakage can occur not just on the face of the connector, but at any wetted portion.

Classroom Exercise

1) Ground Pin Missing on Cord's Plug *or*
2) Electrical Equipment In Poor Condition

Discuss one of the following accidents and how it could have been prevented.

OPTION 1) Ground Pin Missing on Cord's Plug
A fan connected to a 120-volt electrical system via an extension cord provided ventilation for a worker performing a chipping operation from an aluminum stepladder. The insulation on the extension cord was worn through and exposed the bare, energized conductor made contact with the ladder. The ground wire was not attached on the male end of the cord's plug. When the energized conductor made contact with the ladder, the path to ground included the worker's body, resulting in death.

NOTES:

Source:
https://www.osha.gov/SLTC/etools/construction/electrical_incidents/fatexground.html

OPTION 2) Electrical Equipment In Poor Condition

An 18-year-old worker at a construction site was electrocuted when he touched a light fixture while descending from a scaffold for his afternoon break. The source of the electricity was apparently a short in a receptacle, but examination revealed that the electrical equipment used by the contractor was in such poor condition that it was impossible to make a certain determination of the source of the short. Extension cords had poor splices, no grounds, and reversed polarity. One hand drill was not grounded, and the other had no safety plate. Out of several possible scenarios, the most likely was contact between the exposed wires of an extension cord and a screw that protruded from the receptacle, which had its face plate removed. The light fixture, which served as a ground, was known to be faulty for at least 5 months before the incident.

NOTES:

Topic 3. How can I protect myself from electrocution hazards?

A. Maintain a safe distance from overhead power lines
B. Use ground-fault circuit interrupters (GFCI)
C. Inspect portable tools and extension cords
D. Use power tools and equipment as designed
E. Follow lockout/tagout procedures

CONTENT for Topic 3:

A. Maintain safe distance from overhead power lines

Staying away from power lines is the best option. The following table shows the safe power line clearance distance for various line voltages.

Power Line Clearance Distances

Table A – Minimum Clearance Distances	
Voltage (nominal, kV, alternating current)	Minimum clearance distance (feet)
Up to 50	10
Over 50 to 200	15
Over 200 to 350	20
Over 350 to 500	25
Over 500 to 750	35
Over 750 to 1000	45
Over 1000	(As established by the power line owner/operator or registered professional engineer who is a qualified person with respect to electrical power transmission and distribution)

Source: 29 CFR 1926.1408(h) Table A

Following are preventive measures for workers to consider:

NOTES:

General

Before work begins, be sure that the:

- Equipment/activity is located within a safe working distance from power lines
- Utility company has de-energized and visibly grounded the power lines or installed insulated sleeves on power lines
- Flagged warning lines have been installed to mark horizontal and vertical power line clearance distances
- Tools and materials used are nonconductive

Cranes and other high reaching equipment

Be sure the utility company has confirmed the voltage and therefore the safe working distance from the power lines. Also, if applicable and feasible, use a/an: observer; insulated link; boom cage guard; proximity device.

Mobile heavy equipment

If provided, use installed rider posts under power lines to avoid working too close to the power lines.

Ladders

Use nonconductive ladders and be sure to retract them before moving.

Material storage

- Ensure that no materials are stored under power lines
- Use caution tape and signs to cordon off area under power lines

Excavations

- Locate and know what the markings from the local underground line locator service has marked before digging
- Hand dig within three feet of cable location. Be aware that more than one underground cable may be buried in area of locator markings

NOTES:

Refer to the "General Rules for Electrical Work" and "General Rules for Construction Electrical Safety" sections in the Construction Focus Four: Electrocution, Safety Tips for Workers tri-fold handout

Classroom Exercise

Boom crane truck close to a power line
Discuss the following accident and how it could have been prevented.

Workers were moving a steel canopy structure using a "boom crane" truck. The boom cable made contact with a 7200 volt electrical power distribution line electrocuting the operator of the crane; he was the foreman at the site.

B. Use ground-fault circuit interrupters (GFCI)
A "GFCI" is a ground fault circuit interrupter that is designed to protect people from severe and sometimes fatal electrical shock. A GFCI detects ground faults and interrupts the flow of electric current, and is designed to protect the worker by limiting the duration of an electrical shock.

A Classic Example of the GFCI at Work: An old drill that has a loose bare wire inside it touching the outer metal housing is being used. With the drill plugged in, the housing is charged with electricity. If it used outside in the rain and the worker is standing on the ground, there is a path from the hot wire inside the drill through the worker to ground. If electricity flows from hot to ground through the worker, it could be fatal. The GFCI can sense the current flowing through you because not all of the current is flowing from hot to neutral as it expects -- some of it is flowing through the worker to the ground. As soon as the GFCI senses that, it trips the circuit and cuts off the electricity.

There are three types of GFCI:

1. **Receptacle GFCI:** Often found on construction work sites, outdoor areas and other locations where damp conditions do or could exist. The receptacle GFCI fits into the standard outlet box and protects users against ground faults when an electrical product is connected to the GFCI protected outlet.

NOTES:

Distribute student worksheet, Fatal Facts Accident Summary No. 17 [Appendix C]

These should be tested after installation and once a month by:

- Plug in a test light or power tool and turn "On"
- Push the "Test" button on the receptacle; the "Test" button should pop up and the power to the light or tool should be "Off"
- Push "Reset" to restore power to the outlet
- If the above steps worked, the GFCI passed the test and is functioning properly; If the GFCI failed the test, remove it from service

NOTES:
If the light or tool [other product] remains "ON" when the "Test" button is pushed, the GFCI is not working properly or has been incorrectly installed (miswired). If this is the case, a qualified electrician (equivalent to qualified electrician is a 'licensed', 'certified', and/or 'registered' electrician) needs to be contacted to properly wire or replace the GFCI device.

2. **Temporary/portable GFCI:** AP portable GFCI is an extension cord combined with a GFCI. It adds flexibility in using receptacles that are not protected by GFCIs. Extension cords with GFCI protection incorporated should be used when permanent protection is unavailable.

   These should be tested prior to each and every use by:

   - Visually inspect device for obvious defects and/or broken parts
   - Plug in a test light/tool to the extension cord
   - Push "Reset" button on the GFCI device
   - Push "Test" button to verify no voltage at outlet (e.g., the light or tool shuts off)
   - Push "Reset" button to verify power is restored

3. **Circuit Breaker GFCI:** The GFCI circuit breaker controls an entire circuit, and is installed as a replacement for a circuit breaker on the main circuit board. Rather than install multiple GFCI outlets, one GFCI circuit breaker can protect the entire circuit. At sites equipped with circuit breakers, this type of GFCI might be installed in a panel box to give protection to selected circuits.

Circuit breaker GFCIs should be tested monthly. Keep in mind that the test will disconnect power to everything on the circuit.

Classroom Exercise

No GFCI in use

Discuss the following accident and how it could have been prevented.

NOTES:

A worker was climbing a metal ladder to hand an electric drill to the journeyman installer on a scaffold about five feet above him. When the victim reached the third rung from the bottom of the ladder he received an electric shock that killed him.

Distribute student worksheets, Fatal Facts Accident Summary No. 57 [Appendix C]

The investigation revealed that the extension cord had a missing grounding prong and that a conductor on the green grounding wire was making intermittent contact with the energizing black wire thereby energizing the entire length of the grounding wire and the drill's frame. Also, the drill was not double insulated.

C. Inspect portable tools and extension cords

Refer to Toolbox Talks handouts [Appendix D]:

- #2 “What protective devices and procedures can you use to prevent electrocution?” and
- #3 “How can we prevent electrocutions while using power tools?”

Workers need to inspect extension cords prior to their use for any cuts or abrasion. Extension cords may have damaged insulation. Sometimes the insulation inside an electrical tool or appliance is damaged. When the insulation is damaged, exposed metal parts may become energized if a live wire inside touches them. Electric hand tools that are old, damaged, or misused may have damaged insulation inside.

Flexible cords used with temporary and portable lights shall be designed for hard or extra-hard usage. They shall be marked with usage type designation size and number of conductors. The cord could be marked with a 14/3 meaning the conductor size (AWG) is 14 and the number of conductors is 3.

For more information on AWG, refer to Factsheet B1 – Wire Size and Ampacity [Appendix B].

D. Use power tools and equipment as designed

Workers using power tools and equipment should follow tool safety tips to avoid misusing equipment.

Tool safety tips

- Never carry a tool by the cord
- Never yank the cord to disconnect it
- Keep cords away from heat, oil, and sharp edges
- Disconnect when not in use and when changing accessories such as blades and bits
- Avoid accidental starting. Do not hold fingers on the switch button while carrying a plugged-in tool
- Use gloves and appropriate footwear
- Store in dry a place when not using
- Don't use in wet/damp environments
- Keep working areas well lit
- Ensure that cords do not cause a tripping hazard
- Remove damaged tools from use
- Use double-insulated tools

Common examples of misused equipment

- Using multi-receptacle boxes designed to be mounted by fitting them with a power cord and placing them on the floor.
- Fabricating extension cords with ROMEX wire.
- Using equipment outdoors that is labeled for use only in dry, indoor locations.
- Attaching ungrounded, two-prong adapter plugs to three-prong cords and tools.
- Using circuit breakers or fuses with the wrong rating for over-current protection, e.g., using a 30-amp breaker in a system with 15 or 20 amp receptacles. Protection is lost because it will not trip when the system's load has been exceeded.
- Using modified cords or tools, i.e., ground prongs removed, face plates, insulation, etc.
- Using cords or tools with worn insulation or exposed wires.

Workers need to know that even when the power system is properly grounded, electrical equipment can instantly change from safe to hazardous because of extreme conditions and rough treatment.

NOTES:

OSHA standards:

- Use only equipment that is approved [29 CFR 1926.403(a)]
- Use all equipment according to the manufacturer's instructions [29 CFR 1926.403(b)(2)]

E. Follow lockout/tagout procedures

Lockout/tagout is an essential safety procedure that protects workers from injury while working on or near electrical circuits and equipment. In addition, lockout/tagout prevents contact with operating equipment parts such as, blades, gears, shafts, etc. Also, lockout/tagout prevents the unexpected release of hazardous gases, fluids, or solid matter in areas where workers are present.

To protect against being electrocuted, workers need to follow lockout/tagout procedures. When performing lockout/tagout on circuits and equipment, the following checklist can be used:

- Identify all sources of electrical energy for the equipment or circuits in question
- Disable backup energy sources such as generators and batteries
- Identify all shut-offs for each energy source
- Notify all personnel that equipment and circuitry must be shut off, locked out, and tagged out (Simply turning a switch off is not enough)
- Shut off energy sources and lock switch gear in the OFF position. Each worker should apply his/her individual lock and keys kept with the worker
- Test equipment and circuitry to ensure they are de-energized. This must be done by a qualified person
- Deplete stored energy (for example, in capacitors) by bleeding, blocking, grounding, etc.
- Apply a lock or tag to alert other workers that an energy source or piece of equipment has been locked or tagged out
- Make sure all workers are safe and accounted for before equipment and circuits are unlocked and turned back on. Only a qualified person may determine when it is safe to re-energize circuits.

NOTES:

Source: NIOSH Electrical Safety Manual [2009-113]: http://www.cdc.gov/niosh/docs/2009-113

OSHA 29 CFR 1926.449 defines “qualified person” as: One familiar with the construction and operation of the equipment and the hazards involved.

Only qualified persons may work on electric circuit parts or equipment that has not been deenergized. Such persons must be capable of working safely on energized circuits and must be familiar with the proper use of special precautionary techniques, PPE, insulating and shielding materials, and insulated tools.

NOTES:

Classroom Exercise

Locking and tagging of circuits

Distribute student worksheet, Fatal Facts Accident Summary No. 30 [Appendix C]

Discuss the following accident and how it could have been prevented.

An electrician was removing a metal fish tape from a hole at the base of a metal light pole. (A fish tape is used to pull wire through a conduit run.) The fish tape became energized, electrocuting him.

Protecting workers from electrical hazards tips:

Refer to the "Electrical Safety Overview" section in the Construction Focus Four: Electrocution, Safety Tips for Workers tri-fold handout

Recognize Hazards:

- ✧Inadequate wiring
- ✧Exposed electrical parts
- ✧Wires with bad insulation
- ✧Ungrounded electrical systems and tools
- ✧Overloaded circuits
- ✧Damaged power tools and equipment
- ✧Using the wrong PPE and tools
- ✧Overhead power lines
- ✧All hazards are made worse in wet/damp conditions

Follow Protective Measures:

- ✧Ensure proper grounding of equipment
- ✧Use GFCI's
- ✧Check fuses and circuit breakers
- ✧Guard live parts
- ✧Use flexible cords safely and properly
- ✧Participate in training
- ✧Inspect portable electrical tools and extension cords before use

Topic 4. What is my employer required to do to protect workers from electrocutions?

A. Ensure overhead power line safety
B. Isolate electrical parts
C. Supply ground-fault circuit Interrupters (GFCI)
D. Ensure proper grounding
E. Ensure power tools are maintained in a safe condition
F. Ensure proper guarding
G. Provide training
H. Enforce **a** LOTO safety-related work practices
I. Ensure Proper Use of Flexible Cords

CONTENT for Topic 4:

A. Ensure overhead power line safety

Overhead power lines must be deenergized and grounded by the owner or operator of the lines, or other protective measures must be provided before work is started such as PPE (rubber insulating gloves, hoods, sleeves, matting, blankets, line hose, and industrial protective helmets.) Protective measures (such as guarding or insulating the lines) must be designed to prevent contact with the lines.

There are three major ways employers should control power line hazards:

1. Maintaining a safe distance from lines;
2. Having the power company de-energize and ground the power line(s). Have a power company representative at the site; and
3. Having the power company install insulated sleeves (also known as “eels”) over power lines.

Employers should train workers regarding power line hazards and about the available protective measures. Workers need to be fully informed about what jobs may have electrical hazards, and the measure(s) they will take to control the hazards. Also, workers should be reminded that they should always ask questions if they have any doubts about maintaining safe working conditions.

NOTES:

OSHA standards for contact with power lines: 29 CFR 1926 Subpart K, Electrical. 1926.416, General requirements 1926.416(a), Protection of employees

For power line safety regarding the operation of cranes and derricks refer to OSHA 29 CFR 1926 Subpart CC

B. Isolate electrical parts

- Electrical parts, conductors entering boxes, cabinets, or fittings shall be protected from abrasion, and openings through which conductors enter and shall be effectively closed. Unused openings in cabinets, boxes, and fittings shall also be effectively closed.
- All pull boxes, junction boxes, and fittings shall be provided with covers. Metal covers shall be grounded. In energized installations each outlet box shall have a cover, faceplate, or fixture canopy. Covers of outlet boxes having holes through which flexible cord pendants pass shall be provided with bushings designed for the purpose or shall have smooth, well-rounded surfaces on which the cords may bear.

C. Supply GFCI

OSHA ground-fault protection rules and regulations have been determined necessary and appropriate for worker safety and health. Therefore, it is the employer's responsibility to provide either:

(a) ground-fault circuit interrupters on construction sites for receptacle outlets in use and not part of the permanent wiring of the building or structure; or
(b) a scheduled and recorded assured equipment grounding conductor program on construction sites, covering all cord sets, receptacles which are not part of the permanent wiring of the building or structure, and equipment connected by cord and plug which are available for use or used by workers.

Receptacles on the ends of extension cords must be protected by GFCIs. Also there are GFCI circuit breakers. These protected circuit breakers are installed in the main circuit board. It protects an entire circuit.

NOTES:

For more information refer to OSHA 29 CFR 1926.405

The requirements which employers must meet, if they choose the GFCI option, are stated in 29 CFR 1926.404(b)(1)(ii).

OSHA standards for lack of ground-fault protection: 29 CFR 1926 Subpart K, Electrical. OSHA Standard. 1926.404, Wiring and design protection 1926.404(b)(1)(i)

The employer is required to provide approved ground-fault circuit interrupters for all 120-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 workers.

GFCIs monitor the current-to-the-load for leakage to ground. When this leakage exceeds 5 mA ± 1 mA, the GFCI interrupts the current. They are rated to trip quickly enough to prevent electrocution.

D. Establish and implement an assured equipment grounding conductor program (AEGCP)

The assured equipment grounding conductor program covers all cord sets, receptacles which are not a part of the permanent wiring of the building or structure, and equipment connected by cord and plug which are available for use or used by employees. OSHA requires that a written description of the employer's assured equipment grounding conductor program, including the specific procedures adopted, be kept at the jobsite. This program should outline the employer's specific procedures for the required equipment inspections, tests, and test schedule.

The required tests must be recorded, and the record maintained until replaced by a more current record. The written program description and the recorded tests must be made available, at the jobsite, to OSHA and to any affected employee upon request. The employer is required to designate one or more competent persons to implement the program.

Electrical equipment noted in the assured equipment grounding conductor program must be visually inspected for damage or defects before each day's use. Any damaged or defective equipment must not be used by the employee until repaired.

Two tests are required by OSHA. One is a continuity test to ensure that the equipment grounding conductor is electrically continuous. It must be performed on all cord sets, receptacles which are not part of the permanent wiring of the building or structure, and on cord- and plug-connected equipment which is required to be grounded. This test may be performed using a simple continuity tester, such as a lamp and battery, a bell and battery, an ohmmeter, or a receptacle tester.

NOTES:

OSHA standards for path to ground missing or discontinuous: 29 CFR 1926 Subpart K, Electrical. OSHA Standard. 1926.404, Wiring design and protection 1926.404(b)(1)(i), General

The requirements which the program must meet are stated in 29 CFR 1926.404(b)(1)(iii), but employers may provide additional tests or procedures or provide GFCIs as noted previously.

29 CFR 1926.404(b)(1)(iii)(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.

E. Ensure power tools are maintained in safe condition

The employer needs to ensure that all power tools and equipment are maintained in a safe condition to:

- Ground power supply systems, electrical circuits, and electrical equipment
- Frequently inspect electrical systems to insure path to ground is continuous
- Ensure workers understand to inspect electrical equipment prior to use
- Ensure ground prongs are not removed from tools or extension cords
- Ground exposed metal parts of equipment

NOTES:
OSHA standards for equipment not used in manner prescribed: 29 CFR 1926 Subpart K, Electrical. OSHA Standard. 1926.403, General requirements 1926.403(b)(2), Installation and use 1926.951 and Subpart I

F. Ensure proper guarding

- Guarding involves locating or enclosing electrical equipment to ensure workers do not accidentally come into contact with its live parts
- Effective guarding requires equipment with exposed parts operating at 50 volts or more to be placed where they are accessible only to authorized people qualified to work with/on the equipment
- 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 can also serve as effective guards

See OSHA standards 29 CFR 1926.403 (i), .403(j), and .405

G. Provide training

Workers need be trained in and familiar with the safety-related work practices that pertain to their respective job assignments. Train workers working with electric equipment in safe work practices to:

- Deenergize electric equipment before inspecting or repairing
- Use cords, cables, and electric tools that are in good repair
- Lockout / Tagout recognition and procedures
- Use appropriate protective equipment

H. Enforce LOTO safety-related work practices

- Controls that are to be deactivated during the course of work on energized or de-energized equipment or circuits shall be locked out, tagged or both
- Equipment or circuits that are deenergized shall be rendered inoperative and post tags attached at all points where such equipment or circuits can be energized
- Tags shall be placed to plainly identify the equipment or circuits being worked on
- While any worker is exposed to contact with parts of fixed electric equipment or circuits which have been de-energized, the circuits energizing the parts shall be locked out, tagged out or both

NOTES:
See OSHA standards 29 CFR 1926.416 and .417

I. Ensure proper use of flexible cords

See OSHA standards 29 CFR 1926.405(g) and 1926.951

The OSHA construction standard requires flexible cords to be rated for hard or extra-hard usage. These ratings are derived from the National Electrical Code, and are required to be indelibly marked approximately every foot along the length of the cord.

Examples of these codes are: S, ST, SO, and STO for hard service, and SJ, SJO, SJT, and SJTO for junior hard service.

Extension cords must be 3-wire type so they may be grounded, and to permit grounding of any tools or equipment connected to them.

Limit exposure of connectors and tools to excessive moisture by using watertight or sealable connectors.

Classroom Exercise

Power Line Kills Worker

Discuss the following accident and how it could have been prevented.

Five employees were constructing a chain link fence in front of a house and directly below a 7200-volt energized power line. They were installing 21-foot sections of metal top rail on the fence. One employee picked up a 21-foot section of top rail and held it up vertically. The top rail contacted the 7200-volt line, and the employee was electrocuted.

Summary

During this lesson, you have been given an overview of major electrocution hazards, ways to protect yourself, and what employers must do to protect workers from electrocution hazards.

Conduct lesson test

Distribute student copies and allow time for students to complete the test. When they have finished, provide and discuss the correct answers with the class.

Thank participants for their time, attention, and involvement in the session.

NOTES:

Distribute student worksheet, Fatal Facts Accident Summary No. 40 [Appendix C]

Refer to "Electrical Safety Overview" section of the Construction Focus Four: Electrocution tri-fold handout [Appendix D]

Instructor answer key and student copies of the lesson test are provided in Appendix A.

References/Sources

OSHA Website

BLS Website

CDC/NIOSH Website

The Construction Chart Book (CPWR, 2007)

Central New York COSH, 2007, *Construction Safety & Health Electrocution hazards* Grantee module, Grant Number SH-16586-07-06-F-36 from OSHA

CDC/NIOSH in partnership with CPWR-The Center for Construction Research and Training, Hollywood, Health and Society, and the Spanish-language network Telemundo, http://www.cdc.gov/Features/ConstructionElectrocution/

Laborers' Health & Safety Fund of North America, *Preventing Electrocution in Construction*, an OSHA Alliance product

Appendix A: Electrocution Hazards Lesson Test

Instructor Copy - *answers provided separately*
See file: Electr_TestwAns_April2011.pdf

Student copy to distribute follows

“

APPENDIX A

Construction Focus Four: Electrocution Hazards Lesson Test

NAME: _____ DATE: ___/___/___

1. "BE SAFE" reminds workers that burns, electrocution, shock, arc flash/arc blast, fire and explosions are all:
   a. Electrical hazards workers are exposed to when working around cranes and power lines.
   b. Serious workplace hazards that workers are exposed to when working in and/or around electrical power sources.
   c. Electrical hazards workers are exposed to when working with flammables.

2. A ground fault circuit interrupter (GFCI):
   a. Detects ground faults and interrupts the flow of electric current, and is designed to protect the worker by limiting the duration of an electrical shock.
   b. Detects ground faults and interrupts the electric source thus, it disables the equipment that is attached; however, the worker is still exposed to electrocution.
   c. A tool used to determine if a power system is properly grounded.

3. To protect yourself from being electrocuted by contact with overhead power lines, you should always assume overhead lines are energized and keep yourself and equipment at least ____ away from power lines up to 50kV.
   a. 5 feet
   b. 8 feet
   c. 10 feet

4. Which of the following is a safe work practice to protect you from electrocution hazards?
   a. Use GFCI only when using double insulated power tools
   b. Do not operate electrical equipment when working in wet conditions
   c. Attach ungrounded, two-prong adapter plugs to three-prong cords and tools

5. Some requirements employers must do to protect workers from electrocution hazards are: ensure overhead power lines safety; supply GFCIs; isolate electrical parts; ensure proper grounding, and:
   1. Provide training
   2. Ensure power tools are maintained in a safe condition
   3. Ensure proper use of flexible cords
   4. Report worker jobsite complaints to OSHA

   a. 1, 2, and 3
   b. 2, 3, and 4
   c. 1, 3 and 4

6. When a power system is properly grounded workers need to be aware that:
   a. It is a safe system and can not change from safe to hazardous; therefore working with electrical equipment is always safe.
   b. Electrical equipment can instantly change from safe to hazardous because of extreme conditions and rough treatment.
   c. The system will remain safe and will not be impacted by changing worksite conditions or electrical equipment.

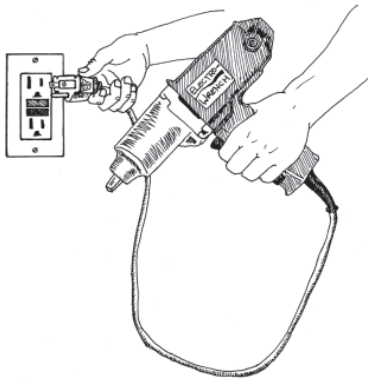
Appendix B: Activity Options A and B

ACTIVITY OPTION A **Instructor Copy**
Wet Conditions / Ground Fault Circuit Interrupters

Source: Central New York (COSH) Susan Harwood Training Grant #SH-16586-07-06-F-36

In your small group, read fact sheets A1 and A2, and the following scenario. Then answer the questions that follow.

- You're an experienced worker in building maintenance, helping a new worker to learn the job. The task involves cleaning up a flooded basement. The new worker has started setting up electrical cords and tools for the job. You tell her, "Hold on a minute, let's check out the wiring first." Then you say, "No, we can't do this without GFCI protection. I'll tell you why."



Safe Work: UL approved, 3-condcutor grounded extension cord, #12 wires.

1. What would you tell your new co-worker?
"You need to take extra precautions any time you're using electrical equipment around water. If your skin is wet for ANY reason (flooding, raining, or sweating), your electrical resistance in ohms goes down. As your **resistance goes down,** any **current *(amps)*** that may flow through your body **will go up.** *A milliamp (mA)* = 1/1,000 of 1 Amp."

"It doesn't take a lot of current to kill you, especially if it flows through your heart. Currents above *75 milliamps (mA)* – quite common in wet conditions – can cause *ventricular fibrillation***,** which can be fatal." "GFCIs, which compare currents on the *hot* and *neutral* sides of a circuit, will trip and shut off electricity, within 1/40 of a second, if there is a difference between the two currents *(current leakage)* of about *5 mA* (such as current flowing in your body)."

2. What can you do to correct this problem for now?
Check to see if there are any permanently wired *GFCI receptacles,* or if there are *GFCI-protected receptacles*. If not, you should use a *plug-in GFCI* or a *GFCI extension cord***.**

If you are working on a site with *temporary wiring*, and if the employer has not provided GFCI or GFCI-protected receptacles, you should bring your own plug-in GFCI outlet or GFCI extension cord. **Test your GFCI every time you use it. It must TRIP when you press "Test" and it must ENERGIZE when you press "Reset."**

3. What is the best way to deal with this in the future?
Get the employer or building owner to install GFCI outlets or GFCI-protected outlets in all wet or damp areas: bathrooms, kitchens, basements, outdoor circuits.

4. What work practices help protect you against electrical hazards?
Electrical accidents are largely preventable through safe work practices. Examples of these practices include the following: deenergizing electric equipment before inspection or repair, keeping electric tools properly maintained, exercising caution when working near energized lines, and using appropriate protective equipment. For construction applications, electrical safety-related work practice requirements are detailed in Subpart K of 29 CFR Part 1926.416 to 1926.417.

Examples of accidents related to wet conditions/ground fault circuit interrupters

A journeyman HVAC worker was installing metal duct work using a double-insulated drill connected to a drop light cord. Power was supplied through two extension cords from a nearby residence. The individual's perspiration-soaked clothing/body contacted bare exposed conductors on one of the cords, causing an electrocution. No GFCI's were used. Additionally, the ground prongs were missing from the two cords.

Factsheet A1 – Using Electrical Equipment in Wet Locations

Using electrical tools or equipment in wet areas can be a hazard. If your skin is dry, it has quite a lot of *resistance* (measured in *ohms* or Ω). However, if your skin is wet for any reason (rain, sweat, standing in a puddle of water), the skin's electrical resistance drops dramatically. The amount of electrical **current**, in *amps,* that flows through your body **goes up when resistance** in *ohms* **goes down. Amps = Volts/Ohms.**

The Current in **Amps** = Voltage in **Volts** DIVIDED BY Resistance in **Ohms**.
HIGHER VOLTAGE = more current (if resistance remains the same).
LOWER RESISTANCE = more current (if voltage remains the same).
HOW MUCH CURRENT DOES IT TAKE TO KILL ME?

It doesn't take much, especially if it passes through your heart. Currents above about *75 milliamps(mA)* can cause a condition called *ventricular fibrillation***.** (A milliamp is 1/1,000 of 1 amp.) If your heart goes into fibrillation, it beats very rapidly – but it doesn't pump any blood – because it's not beating in its normal rhythm. If your blood can't carry oxygen to your brain, you'll experience brain death in 3 to 4 minutes. The way to get you back involves another electric shock, from a *defibrillator.*

If your skin is wet and you get your body across 120 volts of electricity, it's very likely that you'll have a current of 100 mA or more flowing through your heart. ***Currents ABOVE* 10 *mA*** can cause *muscle paralysis.* You may not be able to let go of energized tools or equipment. ***Shocks that are longer in duration are more severe.***

Electrical systems must be wired with either *fuse*s or *circuit breakers.* These devices are known as *overcurrent protection* and they are rated in amps. Most common household circuits are wired for 15 amps or 20 amps. **Overcurrent protection devices protect wiring and equipment from overheating and fires.** They may – or may not – protect you

from electrical shock. If the current isn't high enough, the fuse won't blow or the circuit breaker won't trip. You could be shocked or killed without ever blowing a fuse or tripping a circuit breaker.

Factsheet A2 – GFCIs to the Rescue

A great breakthrough in electrical safety came with the invention of the *ground fault circuit interrupter (GFCI).* A *ground fault* occurs when electrical current flows on a path where it's not supposed to be. Under normal conditions, current flows in a circuit, traveling from the source, through the device it operates, called the *load,* and then back to the source. [See Activity 2 for more about wiring of electrical circuits.]

Current (amps) flows out to the load from the "hot" side (which is generally at 120 volts AC) and returns on the "neutral" side (which is at zero volts). Under normal conditions, these two currents (hot and neutral) are equal. If they are not equal, because of *current leakage* (current returning on a different path than the neutral conductor), we get a ground fault. This can occur if current flows through your body and returns to the source through a path to ground. **Electricity will take ANY available path to return to its source.** We want it to return only on the neutral.

The ground fault circuit interrupter (GFCI) works by using the above principles. It measures total current on the hot side and total current on the neutral side of the circuit. They are supposed to be equal. If these two currents differ from each other by *more than 5 milliamps* (plus or minus 1 mA), the GFCI acts as a fast-acting circuit breaker and shuts off the electricity within 1/40 of 1 second. You can still feel this small amount of current, but it will quickly shut off.

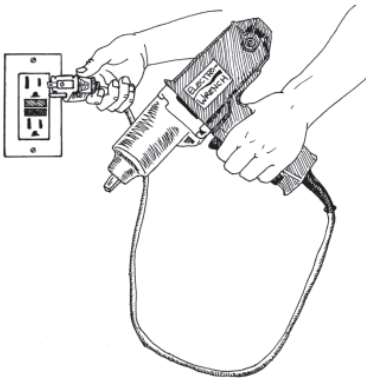
GFCIs are manufactured in many forms. The most common one is the GFCI outlet. However, there are also GFCI circuit breakers, plug-in GFCI outlets and GFCI extension cords, as well as GFCIs hard-wired into devices such as hair dryers. All types have **"Test"** and **"Reset"** functions. **The GFCI must trip when you press the "Test" button. It must also energize the circuit when you press "Reset." If either test fails, you must replace the GFCI in order to be protected!**

ACTIVITY OPTION A **Student Copy**
Wet Conditions / Ground Fault Circuit Interrupters

Source: Central New York (COSH) Susan Harwood Training Grant #SH-16586-07-06-F-36

In your small group, read fact sheets A1 and A2, and the following scenario. Then answer the questions that follow.

- You're an experienced worker in building maintenance, helping a new worker to learn the job. The task involves cleaning up a flooded basement. The new worker has started setting up electrical cords and tools for the job. You tell her, "Hold on a minute, let's check out the wiring first." Then you say, "No, we can't do this without GFCI protection. I'll tell you why."



1. What would you tell your new co-worker?

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2. What can you do to correct this problem for now?

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3. What is the best way to deal with this in the future?

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4. What work practices help protect you against electrical hazards?

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Examples of accidents related to wet conditions/ground fault circuit interrupters

A journeyman HVAC worker was installing metal duct work using a double-insulated drill connected to a drop light cord. Power was supplied through two extension cords from a nearby residence. The individual's perspiration-soaked clothing/body contacted bare exposed conductors on one of the cords, causing an electrocution. No GFCI's were used. Additionally, the ground prongs were missing from the two cords.

Factsheet A1 – Using Electrical Equipment in Wet Locations

Using electrical tools or equipment in wet areas can be a hazard. If your skin is dry, it has quite a lot of *resistance* (measured in *ohms* or Ω). However, if your skin is wet for any reason (rain, sweat, standing in a puddle of water), the skin's electrical resistance drops dramatically. The amount of electrical **current**, in *amps,* that flows through your body **goes up when resistance** in *ohms* **goes down. Amps = Volts/Ohms.**

The Current in **Amps** = Voltage in **Volts** DIVIDED BY Resistance in **Ohms**.
HIGHER VOLTAGE = more current (if resistance remains the same).
LOWER RESISTANCE = more current (if voltage remains the same).
HOW MUCH CURRENT DOES IT TAKE TO KILL ME?

It doesn't take much, especially if it passes through your heart. Currents above about *75 milliamps(mA)* can cause a condition called *ventricular fibrillation***.** (A milliamp is 1/1,000 of 1 amp.) If your heart goes into fibrillation, it beats very rapidly – but it doesn't pump any blood – because it's not beating in its normal rhythm. If your blood can't carry oxygen to your brain, you'll experience brain death in 3 to 4 minutes. The way to get you back involves another electric shock, from a *defibrillator.*

If your skin is wet and you get your body across 120 volts of electricity, it's very likely that you'll have a current of 100 mA or more flowing through your heart. ***Currents ABOVE* 10 *mA*** can cause *muscle paralysis.* You may not be able to let go of energized tools or equipment. ***Shocks that are longer in duration are more severe.***

Electrical systems must be wired with either *fuses* or *circuit breakers.* These devices are known as *overcurrent protection* and they are rated in amps. Most common household circuits are wired for 15 amps or 20 amps. **Overcurrent protection devices protect wiring and equipment from overheating and fires.** They may – or may not – protect you from electrical shock. If the current isn't high enough, the fuse won't blow or the circuit breaker won't trip. You could be shocked or killed without ever blowing a fuse or tripping a circuit breaker.

Factsheet A2 – GFCIs to the Rescue

A great breakthrough in electrical safety came with the invention of the *ground fault circuit interrupter (GFCI).* A *ground fault* occurs when electrical current flows on a path where it's not supposed to be. Under normal conditions, current flows in a circuit, traveling from the source, through the device it operates, called the *load,* and then back to the source. [See Activity 2 for more about wiring of electrical circuits.]

Current (amps) flows out to the load from the "hot" side (which is generally at 120 volts AC) and returns on the "neutral" side (which is at zero volts). Under normal conditions, these two currents (hot and neutral) are equal. If they are not equal, because of *current leakage* (current returning on a different path than the neutral conductor), we get a ground fault. This can occur if current flows through your body and returns to the source through a path to ground. **Electricity will take ANY available path to return to its source.** We want it to return only on the neutral.

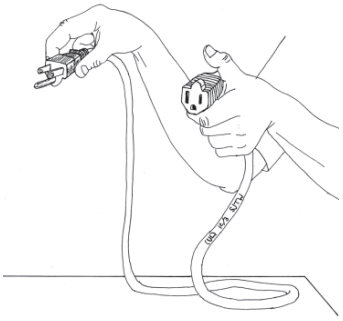
The ground fault circuit interrupter (GFCI) works by using the above principles. It measures total current on the hot side and total current on the neutral side of the circuit. They are supposed to be equal. If these two currents differ from each other by *more than 5 milliamps* (plus or minus 1 mA), the GFCI acts as a fast-acting circuit breaker and shuts off the electricity within 1/40 of 1 second. You can still feel this small amount of current, but it will quickly shut off.

GFCIs are manufactured in many forms. The most common one is the GFCI outlet. However, there are also GFCI circuit breakers, plug-in GFCI outlets and GFCI extension cords, as well as GFCIs hard-wired into devices such as hair dryers. All types have **"Test"** and **"Reset"** functions. **The GFCI must trip when you press the "Test" button. It must also energize the circuit when you press "Reset." If either test fails, you must replace the GFCI in order to be protected!**

Activity Option B **Instructor Copy**
Extension Cords, Copper and Current

In your small group, read fact sheets B1 and B2, and the following scenario. Then answer the questions that follow.

SCENARIO:
You're at work one day and a co-worker starts screaming: It looks like his saw is smoking, it smells like it's burning and his extension cord is getting hot enough to burn his hand. You walk over, take one look at the scene and start shaking your head. "Well, I know what your problem is, and I'll explain if you stop shouting," you tell him.



Safe Work: UL approved, 3-conductor grounded extension cord, #12 wires.

1. What is your explanation to the worker?
"The wires in your extension cord aren't heavy enough for the *electrical load* (in *amps*) from your saw. If there is too much current flowing through a wire that's not heavy enough, the wire will heat up and it could cause a fire."

"If the extension cord wire is too small, and ESPECIALLY if it's a long extension cord, you may also get a *voltage drop* across the extension cord. In such a case, the cord could act as a *series resistor*, resulting in lower voltage for your tools. This lower voltage could damage your equipment." "You need to match the *rating* of the extension cord (either in *amps* or in watts), with the current which the tool uses. **(Watts** DIVIDED BY **volts = amps.)**"

2. What are some steps to deal with this issue?
All workers should get some basic training on electrical safety. They need to know about the problems and hazards which could result from *overloaded conductors*. Overloaded extension cords will heat up and *may cause a fire*, even if total circuit current isn't high enough to blow a fuse or trip a circuit breaker. Workers should read the operator's manuals for electric tools. They often have tables showing the wire size needed for extension cords of various lengths.

3. What is the best way to correct the problem?
Ideally, the employer should supply all necessary electrical devices, including UL approved, properly rated, *grounded* extension cords.

APPENDIX B

Factsheet B1 – Wire Size and Ampacity

In terms of conducting electrical current, size matters: the size of the electrical conductor. Take a look at the following table regarding *ampacity,* the current carrying capacity of a conductor in amps. You'll notice two things: the **amount of current** a wire can safely carry **increases** as the **diameter** (and area) of the wire increases and as the number of the **wire size decreases**. Welcome to the American Wire Gauge (AWG).

AWG Copper Wire Table

Copper Wire Size (AWG)	Diameter (mils)	Area (Circular mils)	Ampacity in free air	Ampacity as part of 3-conductor cable
14 AWG	64.1	4109	20 Amps	15 Amps
12 AWG	80.8	6529	25 Amps	20 Amps
10 AWG	101.9	10,384	40 Amps	30 Amps
8 AWG	128.5	16,512	70 Amps	50 Amps

BUT I DON'T WANT TO BE AN ENGINEER...

Hey, neither do I, but this stuff is important. Notice that a #8 wire is ***twice the diameter,*** but ***four times the area*** of a #14 wire. There are a couple of practical applications here. For one thing, the gauge of the wire determines the rating of a fuse or circuit breaker in amps. A circuit wired with #14 copper will get a 15 amp circuit breaker. A circuit with #12 copper can get a 20 amp breaker; #10 copper can be 30 amps, and so on.

The second thing to consider is that it's possible to create a fire hazard by *overloading an extension cord.* This occurs when too much current is flowing in a conductor that's not heavy enough for the electrical load in amps. The circuit can be properly wired and its circuit breaker correctly rated, but if too much current flows through an extension cord whose wires are too small, the cord will heat up. Sometimes there is also a *voltage drop* over a longer extension cord, which could damage your tools.

Factsheet B2 – Extension Cord Facts

With the wide use of power tools on construction sites, flexible extension cords often are necessary. Because they are exposed, flexible, and unsecured, they are more susceptible to damage than is fixed wiring. Hazards are created when cords, cord connectors, receptacles, and cord- and plug connected equipment are improperly used and maintained. **Here are some factors on extension cord safety noted by OSHA.**

Strain Relief

- To reduce hazards, flexible cords must connect to devices and to fittings in ways that prevent tension at joints and terminal screws. Flexible cords are finely stranded for flexibility, so straining a cord can cause the strands of one conductor to loosen from under terminal screws and touch another conductor.

Cord Damage

- A flexible cord may be damaged by door or window edges, by staples and fastenings, by abrasion from adjacent materials, or simply by aging. If the electrical conductors become exposed, there is a danger of shocks, burns, or fire. Replace frayed or damaged cords. Avoid running cords over sharp corners and edges.

Durability

- The OSHA construction standard requires flexible cords to be rated for hard or extra-hard usage. These ratings are derived from the National Electrical Code, and are required to be indelibly marked approximately every foot along the length of the cord. Examples of these codes are: S, ST, SO, and STO for hard service, and SJ, SJO, SJT, and SJTO for junior hard service.

Grounding

- Extension cords must be 3-wire type so they may be grounded, and to permit grounding of any tools or equipment connected to them.

Wet Conditions

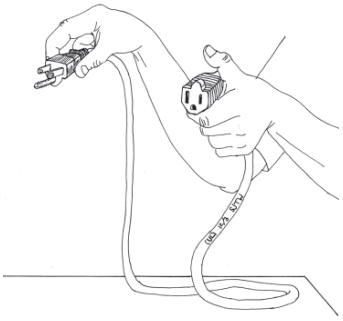
- When a cord connector is wet, electric current can leak to the equipment grounding conductor, and to anyone who picks up that connectors if they provide a path to ground. Such leakage can occur not just on the face of the conductor, but at any wetter portion. Limit exposure of connectors and tools to excessive moisture by using watertight or sealable connectors.

APPENDIX B

Activity Option B **Student Copy**
Extension Cords, Copper and Current

In your small group, read fact sheets B1 and B2, and the following scenario. Then answer the questions that follow.

SCENARIO:
You're at work one day and a co-worker starts screaming: It looks like his saw is smoking, it smells like it's burning and his extension cord is getting hot enough to burn his hand. You walk over, take one look at the scene and start shaking your head. "Well, I know what your problem is, and I'll explain if you stop shouting," you tell him.



1. What is your explanation to the worker?

2. What are some steps to deal with this issue?

3. What is the best way to correct the problem?

Factsheet B1 – Wire Size and Ampacity

In terms of conducting electrical current, size matters: the size of the electrical conductor. Take a look at the following table regarding *ampacity,* the current carrying capacity of a conductor in amps. You'll notice two things: the **amount of current** a wire can safely carry **increases** as the **diameter** (and area) of the wire increases and as the number of the **wire size decreases**. Welcome to the American Wire Gauge (AWG).

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Strain Relief

- To reduce hazards, flexible cords must connect to devices and to fittings in ways that prevent tension at joints and terminal screws. Flexible cords are finely stranded for flexibility, so straining a cord can cause the strands of one conductor to loosen from under terminal screws and touch another conductor.

Cord Damage

- A flexible cord may be damaged by door or window edges, by staples and fastenings, by abrasion from adjacent materials, or simply by aging. If the electrical conductors become exposed, there is a danger of shocks, burns, or fire. Replace frayed or damaged cords. Avoid running cords over sharp corners and edges.

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- The OSHA construction standard requires flexible cords to be rated for hard or extra-hard usage. These ratings are derived from the National Electrical Code, and are required to be indelibly marked approximately every foot along the length of the cord. Examples of these codes are: S, ST, SO, and STO for hard service, and SJ, SJO, SJT, and SJTO for junior hard service.

Grounding

- Extension cords must be 3-wire type so they may be grounded, and to permit grounding of any tools or equipment connected to them.

Wet Conditions

When a cord connector is wet, electric current can leak to the equipment grounding conductor, and to anyone who picks up that connectors if they provide a path to ground. Such leakage can occur not just on the face of the conductor, but at any wetter portion. Limit exposure of connectors and tools to excessive moisture by using watertight or sealable connectors.

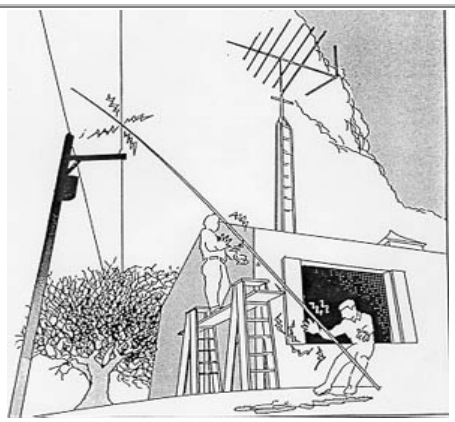
Appendix C: Fatal Facts

Contents:

ACCIDENT REPORT FATAL FACTS

ACCIDENT SUMMARY No. 11

Accident Type:	Electrocution
Weather Conditions:	Wet Ground
Type of Operation:	Remodeling
Size of Work Crew:	2
Collective Bargaining	No
Competent Safety Monitor on Site:	Yes
Safety and Health Program in Effect:	No
Was the Worksite Inspected Regularly:	Yes
Training and Education Provided:	No
Employee Job Title:	Carpenter
Age & Sex:	33-Male
Experience at this Type of Work:	30 Days
Time on Project:	3 Days



BRIEF DESCRIPTION OF ACCIDENT

Two employees were installing aluminum siding on a farmhouse when it became necessary to remove a 36-foot high metal pole CB antenna. One employee stood on a metal pick board between two ladders and unfastened the antenna at the top of the house. The other employee, who was standing on the ground, took the antenna to lay it down in the yard. The antenna made electrical contact with a 7200-volt power transmission tine 30 feet 10 inches from the house and 23 feet 9 inches above the ground. The employee handling the antenna received a fatal shock and the other employee a minor shock.

INSPECTION RESULTS

Following its investigation, OSHA issued one citation for two alleged serious violations of its construction standards. Had these standards been adhered to, the fatality might have been prevented.

ACCIDENT PREVENTION RECOMMENDATIONS

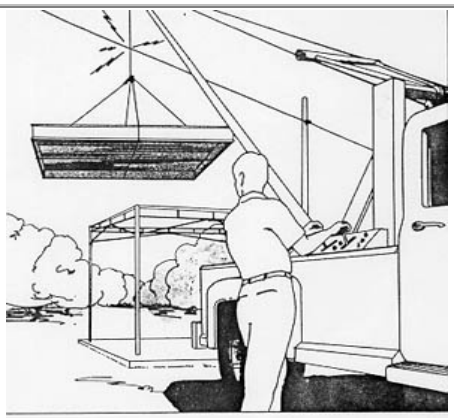
1. Note the presence of power lines and be extremely cautious when working near them. Train employees to recognize and avoid electrical hazards (29CFR 1926.21(b)(2)).
2. Do not permit employees to work near any part of an electrical power circuit which might be contacted in the course of the work. Guard all electrical power circuits against accidental contact by insulating the circuit or deenergizing it or by other effective means that would protect the employee (29CFR 1926.400(C)(1)).

NOTE: *The Fatal Facts were selected as being representative of fatalities caused by improper work practices. No special emphasis or priority is implied nor is the case necessarily a recent occurrence. The legal aspects of the incident have been resolved, and the case is now closed. Current as of: 11/01/2001.*

ACCIDENT REPORT FATAL FACTS

ACCIDENT SUMMARY No. 17

Accident Type:	Electrocution
Weather Conditions:	Sunny, Clear
Type of Operation:	Steel Erection
Size of Work Crew:	3
Collective Bargaining	No
Competent Safety Monitor on Site:	Yes - Victim
Safety and Health Program in Effect:	No
Was the Worksite Inspected Regularly:	Yes
Training and Education Provided:	No
Employee Job Title:	Steel Erector Foreman
Age & Sex:	43-Male
Experience at this Type of Work:	4 months
Time on Project:	4 Hours



BRIEF DESCRIPTION OF ACCIDENT

Employees were moving a steel canopy structure using a "boom crane" truck. The boom cable made contact with a 7200 volt electrical power distribution line electrocuting the operator of the crane; he was the foreman at the site.

INSPECTION RESULTS

As a result of its investigation. OSHA issued citations for four serious violations of its construction standards dealing with training, protective equipment, and working too close to power lines. OSHA's construction safety standards include several requirements which, If they had been followed here. might have prevented this fatality.

ACCIDENT PREVENTION RECOMMENDATIONS

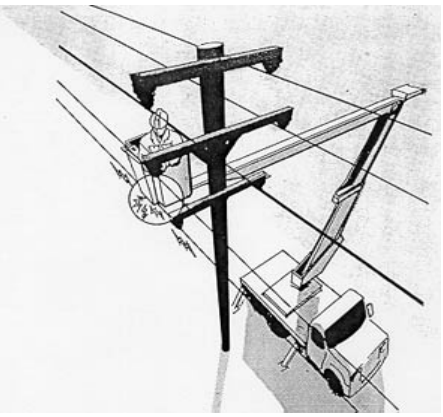
1. Develop and maintain a safety and health program to provide guidance for safe operations (29 CFR 1926.20(b)(1)).
2. Instruct each employee on how to recognize and avoid unsafe conditions which apply to the work and work areas (29 CFR 1926.21(b)(2))
3. If high voltage lines are not de-energized, visibly grounded, or protected by insulating barriers, equipment operators must maintain a minimum distance of 10 feet between their equipment and the electrical distribution or transmission lines (29 CFR 1926.550(a)(15)(i)).

NOTE: *The Fatal Facts were selected as being representative of fatalities caused by improper work practices. No special emphasis or priority is implied nor is the case necessarily a recent occurrence. The legal aspects of the incident have been resolved, and the case is now closed. Current as of: 11/01/2001.*

ACCIDENT REPORT FATAL FACTS

ACCIDENT SUMMARY No. 28

Accident Type:	Electrocution
Weather Conditions:	Clear
Type of Operation:	Power Line Work
Size of Work Crew:	2
Collective Bargaining	Yes
Competent Safety Monitor on Site:	Yes
Safety and Health Program in Effect:	No
Was the Worksite Inspected Regularly:	No
Training and Education Provided:	No
Employee Job Title:	Lineman
Age & Sex:	44-Male
Experience at this Type of Work:	11 Months
Time on Project:	6 Weeks



BRIEF DESCRIPTION OF ACCIDENT

A lineman was electrocuted while working on grounded de-energized lines. He was working from a defective basket on an articulated boom aerial lift when the basket contacted energized lines which ran beneath the de-energized lines. The defective basket permitted current to pass through a drain hole cut into the body of the basket, then through the employee, and to ground via the de-energized line.

INSPECTION RESULTS

OSHA cited the company for two serious violations and one other than serious violation of its construction standards. Had barriers been erected to prevent contact with adjacent energized lines, the electrical shock might have been prevented.

ACCIDENT PREVENTION RECOMMENDATIONS

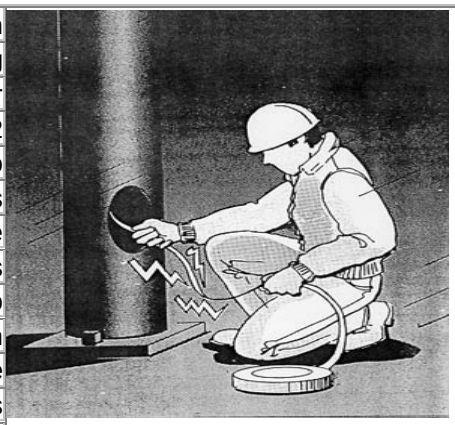
1. Guards or barriers must be erected as necessary to adjacent energized lines (29 CFR 1926.950(d)(1)(v)).
2. Existing conditions of mechanical equipment, energized lines, equipment, conditions of poles, and location of circuit must be determined by an inspection or test before starting work. (29 CFR 1926.950(b)(1) and.952(a)(1)).
3. Employees must be instructed on how to recognize and avoid unsafe conditions and on regulations that apply to their work environment (29 CFR 1926.21(b)(2)).

NOTE: *The Fatal Facts were selected as being representative of fatalities caused by improper work practices. No special emphasis or priority is implied nor is the case necessarily a recent occurrence. The legal aspects of the incident have been resolved, and the case is now closed. Current as of: 11/01/2001.*

ACCIDENT REPORT FATAL FACTS

ACCIDENT SUMMARY No. 30

Accident Type:	Electrocution
Weather Conditions:	Raining
Type of Operation:	Electrical Contractor
Size of Work Crew:	2
Collective Bargaining	No
Competent Safety Monitor on Site:	Yes
Safety and Health Program in Effect:	Inadequate
Was the Worksite Inspected Regularly:	Yes
Training and Education Provided:	No
Employee Job Title:	Journeyman Electrician
Age & Sex:	39-Male
Experience at this Type of Work:	16 Years
Time on Project:	1 Day



BRIEF DESCRIPTION OF ACCIDENT

An electrician was removing metal fish tape from a hole at the base of a metal light pole. The fish tape became energized, electrocuting him.

INSPECTION RESULTS

As a result of its inspection, OSHA issued a citation for three serious violations of the agency's construction standards. Had requirements for de-energizing energy sources been followed, the electrocution might have been prevented.

ACCIDENT PREVENTION RECOMMENDATIONS

1. Ensure all circuits are de-energized before beginning work (29 CFR 1926.416(a)(3)).
2. Controls to be deactivated during the course of work on energized or de-energized equipment or circuits must be tagged (29 CFR 1926.417(a)).
3. Employees must be instructed to recognize and avoid unsafe conditions associated with their work (29 CFR 1926.21(b)(2)).

NOTE: *The Fatal Facts were selected as being representative of fatalities caused by improper work practices. No special emphasis or priority is implied nor is the case necessarily a recent occurrence. The legal aspects of the incident have been resolved, and the case is now closed. Current as of: 11/01/2001.*

ACCIDENT REPORT FATAL FACTS

ACCIDENT SUMMARY No. 40

Accident Type:	Electrocution
Weather Conditions:	Sunny/Clear
Type of Operation:	Fence Construction
Size of Work Crew:	5
Collective Bargaining	No
Competent Safety Monitor on Site:	No
Safety and Health Program in Effect:	Yes
Was the Worksite Inspected Regularly:	No
Training and Education Provided:	No
Employee Job Title:	Laborer
Age & Sex:	25-Male
Experience at this Type of Work:	3 Months
Time on Project:	1 Day

BRIEF DESCRIPTION OF ACCIDENT

Five employees were constructing a chain link fence in front of a house and directly below a 7200-volt energized power line. They were installing 21-foot sections of metal top rail on the fence. One employee picked up a 21-foot section of top rail and held it up vertically. The top rail contacted the 7200-volt line, and the employee was electrocuted.

INSPECTION RESULTS

Following its inspection, OSHA determined that the employee who was killed had never received any safety training from his employer nor any specific instruction in avoiding the hazards posed by overhead power lines. The agency issued two serious citations for the training deficiencies.

ACCIDENT PREVENTION RECOMMENDATIONS

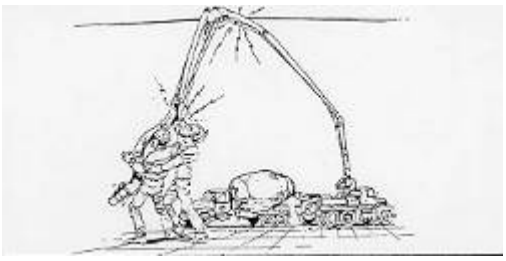
1. Employers must instruct employees to recognize and avoid unsafe conditions applicable to their work environment [29 CFR 1926.21(b)(2)].
2. Employers must not permit employees to work in proximity to any part of an electrical power circuit when the employee could contact it during the course of work, unless the employee is protected against electric shock by de-energizing the circuit and grounding it or by guarding it effectively by insulation or other means [29 CFR 1910.416(a)(1)].

***NOTE**: The case here described was selected as being representative of fatalities caused by improper work practices. No special emphasis or priority is implied nor is the case necessarily a recent occurrence. The legal aspects of the incident have been resolved, and the case is now closed.*

ACCIDENT REPORT FATAL FACTS

ACCIDENT SUMMARY No. 49

Accident Type:	Electrical Shock
Weather Conditions:	Clear/Hot
Type of Operation:	Masonry Contractor
Size of Work Crew:	6
Collective Bargaining	No
Competent Safety Monitor on Site:	No
Safety and Health Program in Effect:	Inadequate
Was the Worksite Inspected Regularly:	Yes
Training and Education Provided:	No
Employee Job Title:	Cement Finisher
Age & Sex:	34-Male
Experience at this Type of Work:	10 Years
Time on Project:	1 Day



BRIEF DESCRIPTION OF ACCIDENT

Two employees were spreading concrete as it was being delivered by 1 concrete pumper truck boom. The truck was parked across the street from the worksite. Overhead power lines ran perpendicular to the boom on the pumper truck. One employee was moving the hose (elephant trunk) to pour the concrete when the boom of the pumper truck came in contact with the overhead rover line carrying 7,620 volts. Employee received a fatal electric shock and fell on the other employee who was assisting him. The second employee received massive electrical shock and burns. * Safety training requirement was not being carried out at time of accident.

INSPECTION RESULTS

OSHA cited the employer for not instructing each employee to recognize and avoid unsafe conditions which apply to the work and work areas. Employer was also cited for operating equipment within ten feet of an energized electrical, ungrounded transmission lines rated 50 kV or less and not erecting insulating barriers.

ACCIDENT PREVENTION RECOMMENDATIONS

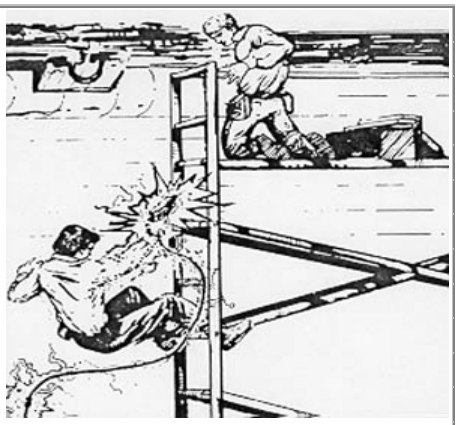
1. Train employees to recognize and avoid unsafe conditions which apply to the work environment [28 CFR 1926.21(b)(2)].
2. Avoid operating equipment within ten feet of electrical distribution or transmission lines rated 50 kV or less unless the line has been de-energized and visually grounded, or unless insulating barriers -- not part of or attached to the equipment -- are provided [29 CFR 1926.600(a)(6)].

NOTE: *The Fatal Facts were selected as being representative of fatalities caused by improper work practices. No special emphasis or priority is implied nor is the case necessarily a recent occurrence. The legal aspects of the incident have been resolved, and the case is now closed. Current as of: 11/01/2001.*

ACCIDENT REPORT FATAL FACTS

ACCIDENT SUMMARY No. 57

Accident Type:	Electrocution
Weather Conditions:	Clear/Hot/Humid
Type of Operation:	Window Shutter Installers
Size of Work Crew:	2
Collective Bargaining	N/A
Competent Safety Monitor on Site:	No
Safety and Health Program in Effect:	Partial
Was the Worksite Inspected Regularly:	No
Training and Education Provided:	Some
Employee Job Title:	Helper
Age & Sex:	17-Male
Experience at this Type of Work:	One Month
Time on Project:	One Month



BRIEF DESCRIPTION OF ACCIDENT

One employee was climbing a metal ladder to hand an electric drill to the journeyman installer on a scaffold about five feet above him. When the victim reached the third rung from the bottom of the ladder he received an electric shock that killed him. The investigation revealed that the extension cord had a missing grounding prong and that a conductor on the green grounding wire was making intermittent contact with the energizing black wire thereby energizing the entire length of the grounding wire and the drill's frame. The drill was not double insulated.

INSPECTION RESULTS

As a result of its investigation, OSHA issued citations for violations of construction standards.

ACCIDENT PREVENTION RECOMMENDATIONS

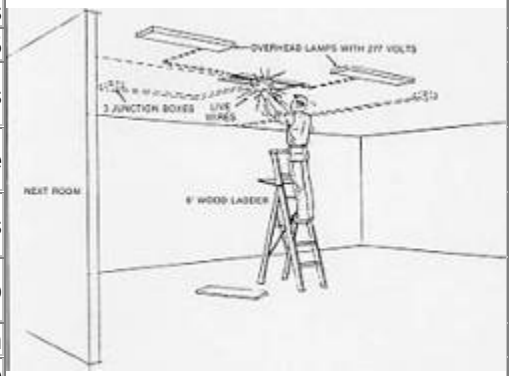
1. Use approved ground fault circuit interrupters or an assured equipment grounding conductor program to protect employees on construction sites [29 CFR 1926.404(b)(1)].
2. Use equipment that provides a permanent and continuous path from circuits, equipment, structures, conduit or enclosures to ground [29 CFR 1926.404(d)(6)].
3. Inspect electrical tools and equipment daily and remove damaged or defective equipment from use until it is repaired [29 CFR 1926.404(b)(iii)(c)].

NOTE: *The Fatal Facts were selected as being representative of fatalities caused by improper work practices. No special emphasis or priority is implied nor is the case necessarily a recent occurrence. The legal aspects of the incident have been resolved, and the case is now closed. Current as of: 11/01/2001.*

ACCIDENT REPORT FATAL FACTS

ACCIDENT SUMMARY No. 60

Accident Type:	Electrocution
Weather Conditions:	Indoor Work
Type of Operation:	Installing and Trouble-shooting overhead lamps
Size of Work Crew:	15
Competent Safety Monitor on Site:	Yes
Safety and Health Program in Effect:	Inadequate
Was the Worksite Inspected Regularly:	Yes
Training and Education Provided:	No
Employee Job Title:	Electrician
Age & Sex:	53-Male
Experience at this Type of Work:	Journeyman
Time on Project:	1 Month



BRIEF DESCRIPTION OF ACCIDENT

The employee was attempting to correct an electrical problem involving two non-operational lamps. He proceeded to the area where he thought the problem was. He had not shut off the power at the circuit breaker panel nor had he tested the wires to see if they were live. He was electrocuted when he grabbed the two live wires with his left hand and then fell from the ladder.

INSPECTION RESULTS

As a result of its investigation, OSHA Issued citations alleging three serious violations. OSHA's construction standards include several requirements which, if they had been followed here, might have prevented this fatality.

ACCIDENT PREVENTION RECOMMENDATIONS

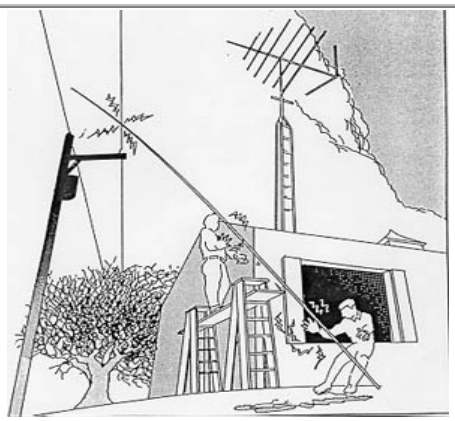
1. The employer should not allow work to be done on electrical circuits unless an effective lock-out/tag-out program is implemented [29 CFR 1926.416(a)(1)].
2. The employer should not allow work to be done on energized electrical circuits or circuits which are not positively de-energized or tagged out [29 CFR 1926.417(a) and.417(c)].

NOTE: *The case here described was selected as being representative of fatalities caused by improper work practices. No special emphasis or priority is implied nor is the case necessarily a recent occurrence. The legal aspects of the incident have been resolved, and the case is now closed.*

ACCIDENT REPORT
FATAL FACTS

ACCIDENT SUMMARY No. 11

Accident Type:	Electrocution
Weather Conditions:	Wet Ground
Type of Operation:	Remodeling
Size of Work Crew:	2
Collective Bargaining	No
Competent Safety Monitor on Site:	Yes
Safety and Health Program in Effect:	No
Was the Worksite Inspected Regularly:	Yes
Training and Education Provided:	No
Employee Job Title:	Carpenter
Age & Sex:	33-Male
Experience at this Type of Work:	30 Days
Time on Project:	3 Days



BRIEF DESCRIPTION OF ACCIDENT

Two employees were installing aluminum siding on a farmhouse when it became necessary to remove a 36-foot high metal pole CB antenna. One employee stood on a metal pick board between two ladders and unfastened the antenna at the top of the house. The other employee, who was standing on the ground, took the antenna to lay it down in the yard. The antenna made electrical contact with a 7200-volt power transmission tine 30 feet 10 inches from the house and 23 feet 9 inches above the ground. The employee handling the antenna received a fatal shock and the other employee a minor shock.

INSPECTION RESULTS

Following its investigation, OSHA issued one citation for two alleged serious violations of its construction standards. Had these standards been adhered to, the fatality might have been prevented.

ACCIDENT PREVENTION RECOMMENDATIONS

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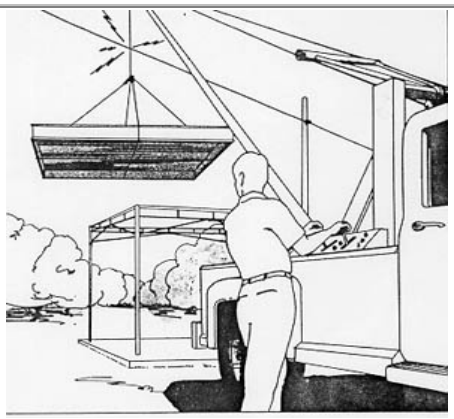
ACCIDENT REPORT
FATAL FACTS

ACCIDENT SUMMARY No. 17

Accident Type:	Electrocution
Weather Conditions:	Sunny, Clear
Type of Operation:	Steel Erection
Size of Work Crew:	3
Collective Bargaining	No
Competent Safety Monitor on Site:	Yes - Victim
Safety and Health Program in Effect:	No
Was the Worksite Inspected Regularly:	Yes
Training and Education Provided:	No
Employee Job Title:	Steel Erector Foreman
Age & Sex:	43-Male
Experience at this Type of Work:	4 months
Time on Project:	4 Hours



BRIEF DESCRIPTION OF ACCIDENT

Employees were moving a steel canopy structure using a "boom crane" truck. The boom cable made contact with a 7200 volt electrical power distribution line electrocuting the operator of the crane; he was the foreman at the site.

INSPECTION RESULTS

As a result of its investigation. OSHA issued citations for four serious violations of its construction standards dealing with training, protective equipment, and working too close to power lines. OSHA's construction safety standards include several requirements which, If they had been followed here. might have prevented this fatality.

ACCIDENT PREVENTION RECOMMENDATIONS

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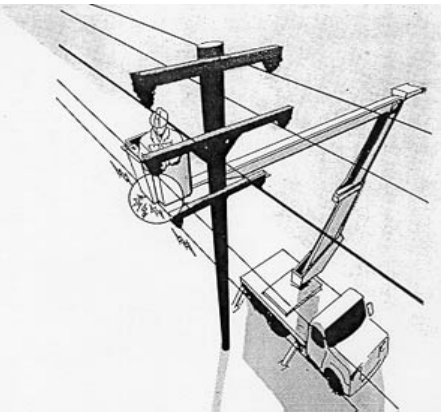
NOTE: *The Fatal Facts were selected as being representative of fatalities caused by improper work practices. No special emphasis or priority is implied nor is the case necessarily a recent occurrence. The legal aspects of the incident have been resolved, and the case is now closed. Current as of: 11/01/2001.*

ACCIDENT REPORT
FATAL FACTS

ACCIDENT SUMMARY No. 28

Accident Type:	Electrocution
Weather Conditions:	Clear
Type of Operation:	Power Line Work
Size of Work Crew:	2
Collective Bargaining	Yes
Competent Safety Monitor on Site:	Yes
Safety and Health Program in Effect:	No
Was the Worksite Inspected Regularly:	No
Training and Education Provided:	No
Employee Job Title:	Lineman
Age & Sex:	44-Male
Experience at this Type of Work:	11 Months
Time on Project:	6 Weeks



BRIEF DESCRIPTION OF ACCIDENT

A lineman was electrocuted while working on grounded de-energized lines. He was working from a defective basket on an articulated boom aerial lift when the basket contacted energized lines which ran beneath the de-energized lines. The defective basket permitted current to pass through a drain hole cut into the body of the basket, then through the employee, and to ground via the de-energized line.

INSPECTION RESULTS

OSHA cited the company for two serious violations and one other than serious violation of its construction standards. Had barriers been erected to prevent contact with adjacent energized lines, the electrical shock might have been prevented.

ACCIDENT PREVENTION RECOMMENDATIONS

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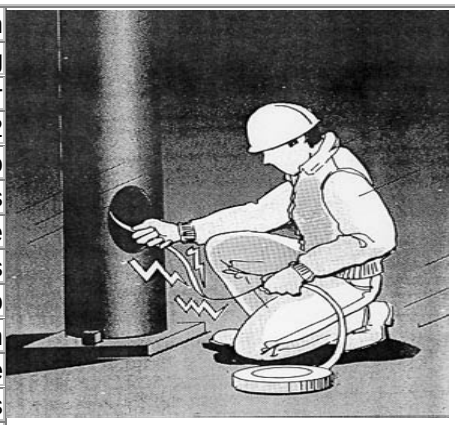
NOTE: *The Fatal Facts were selected as being representative of fatalities caused by improper work practices. No special emphasis or priority is implied nor is the case necessarily a recent occurrence. The legal aspects of the incident have been resolved, and the case is now closed. Current as of: 11/01/2001.*

ACCIDENT REPORT
FATAL FACTS

ACCIDENT SUMMARY No. 30

Accident Type:	Electrocution
Weather Conditions:	Raining
Type of Operation:	Electrical Contractor
Size of Work Crew:	2
Collective Bargaining	No
Competent Safety Monitor on Site:	Yes
Safety and Health Program in Effect:	Inadequate
Was the Worksite Inspected Regularly:	Yes
Training and Education Provided:	No
Employee Job Title:	Journeyman Electrician
Age & Sex:	39-Male
Experience at this Type of Work:	16 Years
Time on Project:	1 Day



BRIEF DESCRIPTION OF ACCIDENT

An electrician was removing metal fish tape from a hole at the base of a metal light pole. The fish tape became energized, electrocuting him.

INSPECTION RESULTS

As a result of its inspection, OSHA issued a citation for three serious violations of the agency's construction standards. Had requirements for de-energizing energy sources been followed, the electrocution might have been prevented.

ACCIDENT PREVENTION RECOMMENDATIONS

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NOTE: *The Fatal Facts were selected as being representative of fatalities caused by improper work practices. No special emphasis or priority is implied nor is the case necessarily a recent occurrence. The legal aspects of the incident have been resolved, and the case is now closed. Current as of: 11/01/2001.*

ACCIDENT REPORT
FATAL FACTS

ACCIDENT SUMMARY No. 40

Accident Type:	Electrocution
Weather Conditions:	Sunny/Clear
Type of Operation:	Fence Construction
Size of Work Crew:	5
Collective Bargaining	No
Competent Safety Monitor on Site:	No
Safety and Health Program in Effect:	Yes
Was the Worksite Inspected Regularly:	No
Training and Education Provided:	No
Employee Job Title:	Laborer
Age & Sex:	25-Male
Experience at this Type of Work:	3 Months
Time on Project:	1 Day

BRIEF DESCRIPTION OF ACCIDENT

Five employees were constructing a chain link fence in front of a house and directly below a 7200-volt energized power line. They were installing 21-foot sections of metal top rail on the fence. One employee picked up a 21-foot section of top rail and held it up vertically. The top rail contacted the 7200-volt line, and the employee was electrocuted.

INSPECTION RESULTS

Following its inspection, OSHA determined that the employee who was killed had never received any safety training from his employer nor any specific instruction in avoiding the hazards posed by overhead power lines. The agency issued two serious citations for the training deficiencies.

ACCIDENT PREVENTION RECOMMENDATIONS

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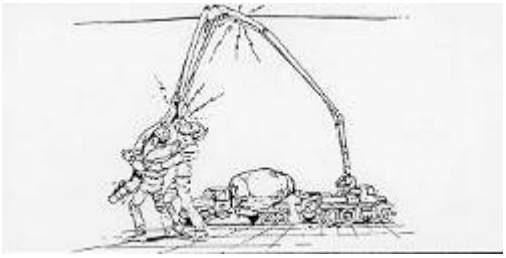
NOTE: *The Fatal Facts were selected as being representative of fatalities caused by improper work practices. No special emphasis or priority is implied nor is the case necessarily a recent occurrence. The legal aspects of the incident have been resolved, and the case is now closed. Current as of: 11/01/2001.*

ACCIDENT REPORT
FATAL FACTS

ACCIDENT SUMMARY No. 49

Accident Type:	Electrical Shock
Weather Conditions:	Clear/Hot
Type of Operation:	Masonry Contractor
Size of Work Crew:	6
Collective Bargaining	No
Competent Safety Monitor on Site:	No
Safety and Health Program in Effect:	Inadequate
Was the Worksite Inspected Regularly:	Yes
Training and Education Provided:	No
Employee Job Title:	Cement Finisher
Age & Sex:	34-Male
Experience at this Type of Work:	10 Years
Time on Project:	1 Day



BRIEF DESCRIPTION OF ACCIDENT

Two employees were spreading concrete as it was being delivered by 1 concrete pumper truck boom. The truck was parked across the street from the worksite. Overhead power lines ran perpendicular to the boom on the pumper truck. One employee was moving the hose (elephant trunk) to pour the concrete when the boom of the pumper truck came in contact with the overhead rover line carrying 7,620 volts. Employee received a fatal electric shock and fell on the other employee who was assisting him. The second employee received massive electrical shock and burns. * Safety training requirement was not being carried out at time of accident.

INSPECTION RESULTS

OSHA cited the employer for not instructing each employee to recognize and avoid unsafe conditions which apply to the work and work areas. Employer was also cited for operating equipment within ten feet of an energized electrical, ungrounded transmission lines rated 50 kV or less and not erecting insulating barriers.

ACCIDENT PREVENTION RECOMMENDATIONS

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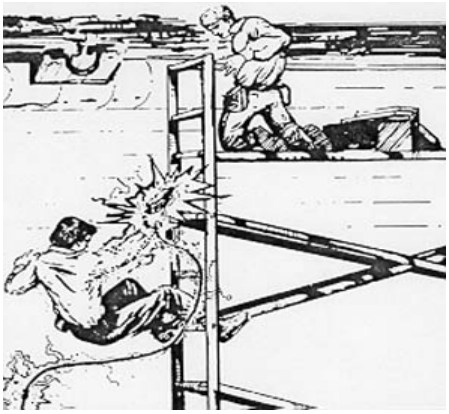
NOTE: *The Fatal Facts were selected as being representative of fatalities caused by improper work practices. No special emphasis or priority is implied nor is the case necessarily a recent occurrence. The legal aspects of the incident have been resolved, and the case is now closed. Current as of: 11/01/2001.*

ACCIDENT REPORT FATAL FACTS

ACCIDENT SUMMARY No. 57

Accident Type:	Electrocution
Weather Conditions:	Clear/Hot/Humid
Type of Operation:	Window Shutter Installers
Size of Work Crew:	2
Collective Bargaining	N/A
Competent Safety Monitor on Site:	No
Safety and Health Program in Effect:	Partial
Was the Worksite Inspected Regularly:	No
Training and Education Provided:	Some
Employee Job Title:	Helper
Age & Sex:	17-Male
Experience at this Type of Work:	One Month
Time on Project:	One Month



BRIEF DESCRIPTION OF ACCIDENT

One employee was climbing a metal ladder to hand an electric drill to the journeyman installer on a scaffold about five feet above him. When the victim reached the third rung from the bottom of the ladder he received an electric shock that killed him. The investigation revealed that the extension cord had a missing grounding prong and that a conductor on the green grounding wire was making intermittent contact with the energizing black wire thereby energizing the entire length of the grounding wire and the drill's frame. The drill was not double insulated.

INSPECTION RESULTS

As a result of its investigation, OSHA issued citations for violations of construction standards.

ACCIDENT PREVENTION RECOMMENDATIONS

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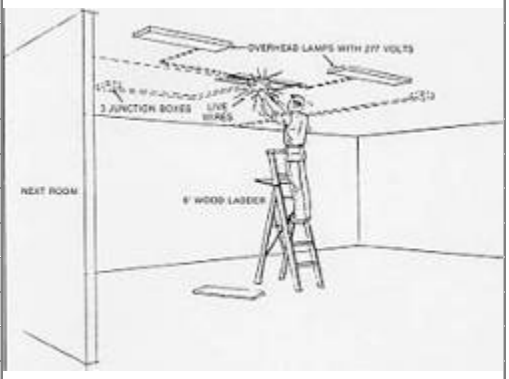
NOTE: *The Fatal Facts were selected as being representative of fatalities caused by improper work practices. No special emphasis or priority is implied nor is the case necessarily a recent occurrence. The legal aspects of the incident have been resolved, and the case is now closed. Current as of: 11/01/2001.*

ACCIDENT REPORT
FATAL FACTS

ACCIDENT SUMMARY No. 60

Accident Type:	Electrocution
Weather Conditions:	Indoor Work
Type of Operation:	Installing and Trouble-shooting overhead lamps
Size of Work Crew:	15
Competent Safety Monitor on Site:	Yes
Safety and Health Program in Effect:	Inadequate
Was the Worksite Inspected Regularly:	Yes
Training and Education Provided:	No
Employee Job Title:	Electrician
Age & Sex:	53-Male
Experience at this Type of Work:	Journeyman
Time on Project:	1 Month



BRIEF DESCRIPTION OF ACCIDENT

The employee was attempting to correct an electrical problem involving two non-operational lamps. He proceeded to the area where he thought the problem was. He had not shut off the power at the circuit breaker panel nor had he tested the wires to see if they were live. He was electrocuted when he grabbed the two live wires with his left hand and then fell from the ladder.

INSPECTION RESULTS

As a result of its investigation, OSHA Issued citations alleging three serious violations. OSHA's construction standards include several requirements which, if they had been followed here, might have prevented this fatality.

ACCIDENT PREVENTION RECOMMENDATIONS

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***NOTE*:** *The case here described was selected as being representative of fatalities caused by improper work practices. No special emphasis or priority is implied nor is the case necessarily a recent occurrence. The legal aspects of the incident have been resolved, and the case is now closed.*

Appendix D: Student Handouts

Contents:

- "Construction Focus Four: Electrocution, Safety Tips for Workers" tri-fold brochure format
- Focus Four Toolbox Talks 1, 2, and 3 produced by IUOE National Training Fund under OSHA grant number SH-16591-07-06-F-11
- OSHA Quick Card™ "Electrical Safety"

General Rules for Construction Electrical Safety

MAJOR PROTECTIVE METHODS FROM ELECTRICAL HAZARDS

Protection from electrical hazards generally includes the following methods:

1. **DISTANCE:** Commonly used with regard to power lines.
2. **ISOLATION AND GUARDING:** Restricting access, commonly used with high voltage power distribution equipment.
3. **ENCLOSURE OF ELECTRICAL PARTS:** A major concept of electrical wiring in general, e.g., all connections are made in a box.
4. **GROUNDING:** Required for all non-current carrying exposed metal parts, unless isolated or guarded as above. (However, corded tools may be either *grounded* **OR** be *double-insulated*.)
5. **INSULATION:** Intact insulation allows safe handling of everyday electrical equipment, including corded tools. Category also includes insulated mats and sleeves.
6. **DE-ENERGIZING AND GROUNDING:** Protective method used by electrical utilities and also in conjunction with electrical lockout/tagout.
7. **PERSONAL PROTECTIVE EQUIPMENT (PPE):** Using insulated gloves and other apparel to work on energized equipment, limited to qualified and trained personnel working under very limited circumstances.

Effects of Electric Current in the Human Body

Current / Reaction *(1,000 milliamperes = 1 amp; therefore, 15,000 milliamperes = 15 amp circuit)*
Below 1 milliampere Generally not perceptible
1 milliampere Faint tingle
5 milliampere Slight shock felt; not painful but disturbing. Average individual can let go. Strong involuntary reactions can lead to other injuries.
6-25 milliamperes (women) Painful shock, loss of muscular control
9-30 milliamperes (men) The freezing current or " let-go" range. Individual cannot let go, but can be thrown away from the circuit if extensor muscles are stimulated.
50 150 milliamperes Extreme pain, respiratory arrest, severe muscular contractions. Death is possible.
1,000 - 4,300 milliamperes Rhythmic pumping action of the heart ceases. Muscular contraction and nerve damage occur; death likely.
10,000 milliamperes Cardiac arrest, severe burns; death probable

OSHA®

Construction Focus Four: Electrocution
Directorate of Training and Education
2020 S. Arlington Heights Rd.
Arlington Heights, IL 60005

Some content adapted from: Central New York COSH, 2007, Construction Safety & Health Electrocution hazards Grantee module, Grant Number SH-16586-07-06-F-36 from OSHA.

www.osha.gov

Construction Focus Four: Electrocution

Safety Tips for Workers

Contents:

Electrical Safety Overview

1. **CORD AND PLUG OPERATED** electric tools with exposed metal parts must have a *three-prong grounding plug* – **AND** *be grounded* – or else be *double-insulated.*

2. **EQUIPMENT GROUNDING** *only works when there is a permanent and continuous electrical connection between the metal shell of a tool and the earth.*

3. **PROPER POLARITY IN ELECTRICAL WIRING IS IMPORTANT:** *hot to hot, neutral to neutral, equipment ground to equipment ground. Polarized plugs have a wider neutral blade to maintain correct polarity.* ***Reversed polarity can kill.***

4. **CIRCUITS MUST BE EQUIPPED WITH FUSES OR CIRCUIT BREAKERS** *to protect against dangerous overloads. Fuses melt, while circuit breakers trip to turn off current like a switch.* ***Overcurrent protection devices protect wiring and equipment from overheating and fires.*** *They may, or may not, protect you.*

5. **MOST 120 VOLT CIRCUITS** *are wired to deliver up to 15 or 20 amps of current. Currents of* ***50 – 100 milliamperes*** *can kill you. (1 mA = 1/1,000 of 1 Amp.)*

6. **WET CONDITIONS LOWER SKIN RESISTANCE,** *allowing more current to flow through your body. Currents* ***above 75 milliamps*** *can cause* ***ventricular fibrillation,*** *which may be fatal. Severity of a shock depends on: path of current, amount of current, duration of current,* voltage level, moisture and your general health.

7. **A GROUND FAULT CIRCUIT INTERRUPTER (GFCI)** protects from a ground-fault, the most common electrical hazard. GFCIs detect differences in current flow between hot and neutral. They trip when there is current leakage – such as through a person – of about 5 milliamperes and they act within 1/40 of a second. Test a GFCI every time you use it. It must "Trip" and it must "Reset."

8. **EXTENSION CORD WIRES MUST BE HEAVY ENOUGH** for the amount of current they will carry. For construction, they must be UL approved, have strain relief and a 3-prong grounding plug, be durable, and be rated for hard or extra-hard usage.

9. **OVERHEAD POWER LINES CAN KILL.** The three major methods of protection are: maintaining a *safe distance, de-energizing AND grounding lines,* having the power company install *insulating sleeves.* Have a power company rep on the site.

10. **UNDERGROUND POWER LINES CAN KILL.** Call before you dig to locate all underground cables. Hand dig within three feet of cable location!

General Rules for Electrical Work

- ***Non-conductive PPE is essential for electricians. NO METAL PPE! Class B hard hats provide the highest level of protection against electrical hazards, with high-voltage shock and burn protection (up to 20,000 volts). Electrical hazard, safety-toe shoes are nonconductive and will prevent the wearers' feet from completing an electrical circuit to the ground.***
- ***Be alert to electrical hazards,*** especially when working with *ladders, scaffolds and other platforms.*
- ***Never bypass electrical protective*** systems or devices.
- ***Disconnect cord tools*** when not in use and when changing blades, bits or other accessories.
- ***Inspect all tools*** before use.
- ***Use only grounded extension cords.***
- ***Remove damaged*** tools and damaged extension cords from use.
- ***Keep working spaces and walkways clear*** of electrical cords.

RULES FOR TEMPORARY WIRING AND LIGHTING

- ***Use Ground Fault Circuit Interrupters (GFCIs)*** on all 15-Amp and 20-Amp temporary wiring circuits.
- ***Protect temporary lights*** from contact and damage.
- ***Don't suspend temporary lights by cords,*** unless the temporary light is so designed.

Condensed Electrical Glossary

AMPERE OR AMP: The unit of electrical *current* (flow of electrons). • One *milliamp (mA)* = 1/1,000 of 1 Amp.

CONDUCTORS: Materials, such as metals, in which electrical current can flow.

ELECTRICAL HAZARDS can result in various effects on the body, including: • SHOCK – The physical effects caused by electric current flowing in the body. • ELECTROCUTION – Electrical shock or related electrical effects resulting in death. • BURNS – Often occurring on the hands, thermal damage to tissue can be caused by the *flow of current* in the body, by *overheating* of improper or damaged *electrical components,* or by an *arc flash.* • FALLS – A common effect, sometimes caused by the body's reaction to an electrical current. A non-fatal shock may sometimes result in a fatal fall when a person is working on an elevated surface.

EXPOSED LIVE PARTS: Energized electrical components not properly enclosed in a box or otherwise isolated, such that workers can touch them and be shocked or killed. Some of the common hazards include: missing knockouts, unused openings in cabinets and missing covers. Covers must not be removed from wiring or breaker boxes. Any missing covers must be replaced with approved covers.

INSULATORS: Materials with high electrical resistance, so electrical current can't flow.

LOCKOUT/TAGOUT: The common name for an OSHA standard, *"The control of hazardous energy (lockout /tagout)."* ***Lockout*** is a means of controlling energy during repairs and maintenance of equipment, whereby energy sources are *de-energized, isolated,* and then *locked out* to prevent unsafe start-up of equipment which would endanger workers. *Lockout* includes – but is not limited to – the control of electrical energy. ***Tagout*** means the placing of warning tags to alert other workers to the presence of equipment that has been locked out. Tags alone DO NOT LOCK OUT equipment. ***Tagout is most effective when done in addition to lockout.***

OHM or Ω: The unit of *electrical resistance* (opposition to current flow).

OHM'S LAW: A mathematical expression of the relationship among *voltage* (volts), *current* (amps) and *resistance* (ohms). This is often expressed as: $E = I \times R$. In this case, E = volts, I = amps and R = ohms. (The equation, Amps = Volts/Ohms, as used in this curriculum, is one form of Ohm's Law.)

VOLT: The unit of *electromotive force (emf)* caused by a *difference in electrical charge or electrical potential* between one point and another point. **The presence of voltage is necessary before current can flow in a** *circuit* (in which *current* flows from a *source* to a *load* – the equipment using the electricity – and then back to its source).

WET CONDITIONS: Rain, sweat, standing in a puddle – all will decrease the skin's electrical resistance and increase current flow through the body in the event of a shock. **Have a qualified electrician inspect any electrical equipment that has gotten wet before energizing it.**

Focus Four [Electrocution] Toolbox Talks 1:

What increases your risk of electrocution?

[Ask the following questions and give time for answers.]

What are the hazards? Bodily contact with electricity

What are the results? Shock, fire, burns, falls or death

What should we look for? Damaged equipment, faulty wiring, improper cord use, no GFCIs, wet conditions, reverse polarity, potential arc flash areas, lack of assured equipment grounding conductor program

[Relate this incident or, better, one you know.]

Actual Incident: A 40-year-old male plumber died after lying on his work light while installing plumbing under a house being remodeled. The victim was crawling under the house carrying the work light with him. The wire inside the work light's conduit became bare and energized the light's housing. Investigation of the incident showed a damaged work light was used with no GFCI. Also, the home's electrical system was not properly grounded.

[Ask the following question and ensure every item is covered.]

How do we prevent these results?

- Inspect all electrical equipment before use.
- Use GFCI with all power tools.
- Use intact and properly rated cords (i.e. correct AWG).
- Do not use damaged equipment - take it out of service.
- Institute an assured equipment grounding conductor program.
- Do not work in wet conditions with electricity.

[Ask the following questions about this site and ensure every item is covered.]

Let's talk about this site now.

- What factors increase your chance of being electrocuted?
- Can someone demonstrate how to inspect this tool for electrical safety? (If possible, provide a tool)
- What are some areas on the site that could use attention pertaining to electrical hazards?

What are the hazards show in these photos?

[Record questions below that you want to ask about this site.]

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Focus Four [Electrocution] Toolbox Talks 2:

What protective devices and procedures can you use to prevent electrocution?

[Ask the following questions and give time for answers.]

What are the hazards? Bodily contact with electricity due to faulty equipment, ungrounded or damaged equipment, wet conditions, etc.

What are the results? Shock, fire, burns, falls or death

What should we look for? Proper training in using engineering controls (e.g. GFCIs, proper cords), assured equipment grounding conductor written program, electrical testing meters

[Relate this incident or, better, one you know.]

Actual Incident: A 29-year- old male welder was electrocuted and died when he contacted an energized receptacle end of an extension cord. It was found that the welding unit and cord were incompatible; however, both the welding cord and extension cord were damaged allowing them to be used together. The result was an ungrounded system that killed a worker.

American Wire Gauge (AWG)	
Cord Size	Handles Up To
#10 AWG	30 amps
#12 AWG	25 amps
#14 AWG	18 amps
#16 AWG	13 amps

[Ask the following question and ensure every item is covered.]

How do we prevent these results?

- Inspect all electrical equipment before use.
- Use GFCI with all power tools.
- Use intact and properly-rated cords (i.e. correct AWG).
- Do not use damaged equipment - take it out of service.
- Institute an assured equipment grounding conductor program.
- Use testing meters, where appropriate, if you are trained to do so.

[Ask the following questions about this site and ensure every item is covered.]

Let's talk about this site now.

- Can someone explain how a GFCI works? (If possible, provide a GFCI to use).
- Who has read this site's assured equipment grounding conductor program?
- What are some of the requirements?

[Record questions below that you want to ask about this site.]

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Focus Four [Electrocution] Toolbox Talks 3:

How can we prevent electrocutions while using power tools?

[Ask the following questions and give time for answers.]

What are the hazards? Bodily contact with electricity

What are the results? Shock, fire, burns, falls or death

What should we look for? Tools that aren't double-insulated, damaged tools and cords, incorrect cords, wet conditions, tools used improperly

[Relate this incident or, better, one you know.]

Actual Incident: A 45-year-old male electrician was electrocuted when he contacted an energized 1/2" electric drill casing. The victim was working in wet conditions and using a single insulated drill attached to damaged extensions cords run through water.

[Ask the following question and ensure every item is covered.]

How do we prevent these results?

- Get proper training on manufacturers' tool use and specs.
- Inspect tool before each use according to manufacturers' instructions.
- Do not use damaged tools, remove them from service.
- Use only battery-powered tools in wet conditions.
- Use with GFCI.
- Use with properly sized and intact cords.

[Ask the following questions about this site and ensure every item is covered.]

Let's talk about this site now.

- What can lead to an electrocution while using power tools? *Non double-insulated tools, damaged cord, wet conditions*
- Have you seen or used any defective power tool?
- What should you do if you find a defective power tool?

[Record questions below that you want to ask about this site.]

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OSHA QUICK CARD™

Electrical Safety

Electrical hazards can cause burns, shocks and electrocution (death).

Safety Tips

- 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 (3 meters) 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.

For more complete information:

OSHA Occupational Safety and Health Administration

U.S. Department of Labor

www.osha.gov (800) 321-OSHA

OSHA 3259-09N-05