Electrical Safety - Module 6

Electrical Warehouse Worker Hazards in Structural Steel Fabricating and Supply Companies

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OSHA Grant Information

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This program was developed by faculty and students in the School of Planning Design and Construction at Michigan State University in conjunction with the American Institute of Steel Construction - Safety Committee and the University of Puerto Rico

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MICHIGAN STATE UNIVERSITY

SPDC School of Planning, Design and Construction

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Learning Outcomes: Participants shall be able to:

- Demonstrate understanding of the risks of working with electricity
- Demonstrate ability to recognize electrical safety hazards
- Demonstrate understanding of safe use of cords
- Demonstrate understanding of the need for de-energizing for routine parts replacement such as changing drill bits, blades etc.
- Demonstrate understanding of the need to Lock/Tagout equipment when servicing equipment

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Special Issues for fabrication and supply companies

- Safe electrical use of all shop tools and equipment
- Routine maintenance and changing out of tools such as drill bits or punches requires de-energizing the tool.The company should have procedures to isolate energy for routine shop practices (changing bits, dies blades)
- Anything with energy potential needs to be locked out and tagged before guards can be removed
- When electrical parts are exposed the power needs to be removed and locked out
- Only qualified electricians may service electrical components
- Electricians should use PPE

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Employers are responsible for complying with:

- OSHA 1910 Subpart S

And applicable editions of:

- NFPA 70E® Standard for Electrical Safety in the Workplace
- The National Electrical Code (NEC)
- NFPA® 70B Electrical Equipment Maintenance.

http://catalog.nfpa.org/2015-NFPA-70Ereg-Standard-for-Electrical-Safety-in-the-Workplace-P1197.aspx

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What causes shocks?

- Electricity travels in circuits-normally through a conductor
- Sometimes a person's body mistakenly becomes part of the circuit causing electrical shocks

Adapted from SH-20-843-SH0

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What causes shocks?

Shocks occur when a person's body completes the current path with:

- "Both wires of an electrical circuit
- One wire of an energized circuit and the ground
- A metal part that accidently becomes energized
- Another conductor that is carrying the current"

When a person receives a shock, current flows through the body and the ground

Source OSHA 3075-2002 (Revised)

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Factors impacting severity of shock

- “Amount of current flowing through the body
- The current’s path through the body
- The length of time the body remains in the circuit
- The current frequency”
- Quality of grounding
- Working in wet conditions
- Dryness or wetness of skin

Source OSHA 3075-2002 (Revised)

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Milliamperes and Amps

- 1000 milliamperes = 1 Amp

Typical Tools and Rated Amperage

- Typical (hand held) ½ portable drill 4-7 Amps
- Industrial Drill Press 10-15 Amps
- Grinder (hand held) 15 Amps

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Effects of Electric Current and Body Reaction

"Below 1 milliamp	Generally not perceptible
1 milliamp	Faint tingle
5 milliamps	Slight shock felt; not painful but disturbing. Average individual can let go. Strong involuntary reactions can lead to other injuries.
(Women) 6–25 milliamps	Painful shock, loss of muscular control*
9–30 milliamps (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."

Source: Next slide

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Effects of Electric Current in the Human Body

"50 –150 milliamps	Extreme pain, respiratory arrest, severe muscular contractions. Death is possible.
1,000 –4,300 milliamps	Rhythmic pumping action of the heart ceases. Muscular contraction and nerve damage occur; death likely.
10,000 milliamps	Cardiac arrest, severe burns; death probable"

Source OSHA 3075-2002 (Revised)
Source: W.B. Kouwenhoven, "Human Safety and Electric Shock," *Electrical Safety Practice*s, Monograph, 112 , Instrument Society of America, p. 93. November 1968.

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Other Effects - Burns

- Electrical Burns
- Arc Flash Burns
- Thermal Contact Burns

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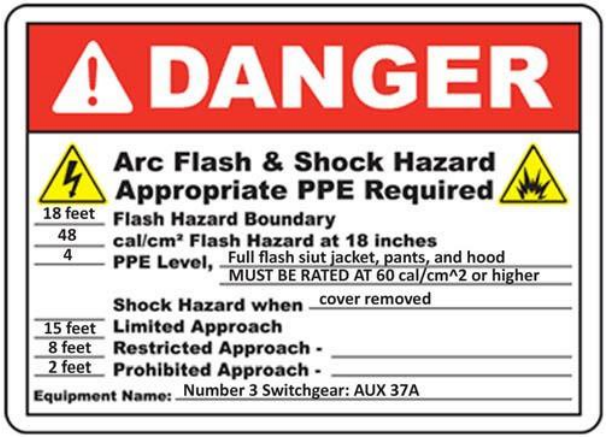
Arc Flash

“An arc flash is a short circuit through the air in an electrical panel box or any other piece of energized electrical equipment.”

“The circuit is completed through the air, the air breaks down to where it offers little-to-no resistance to the flow of electricity.”

“The tremendous amounts of energy released in an arc flash make for a very bright, very hot, and very loud explosion.”



Source SH-20999-10-60-F-21

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Arc Flash- Causes

- Dropped tools in panels, inadvertent contact during servicing of equipment, corrosion of components, moisture, animals
- Only qualified individuals should work on electrical equipment

Source SH-20999-10-60-F-21

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Arc Flash- Protective Measures

- NFPA 70E® Standard for Electrical Safety in the Workplace identifies practices which can help reduce arc flash potential and injury

Source SH-20999-10-60-F-21

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Arc Flash- Protective Measures

- Electrical Equipment should only be serviced by a qualified individual
- Wear all PPE
- De-energize the circuit
- Use Safe Work Practices
- Insulation
- Guarding
- Ground Fault Circuit Interrupters (GFCI)
- Grounding (secondary protection)
- Barricades
- Limited Approach Zones
- Restricted Approach Zones
- Prohibited Approach Zones

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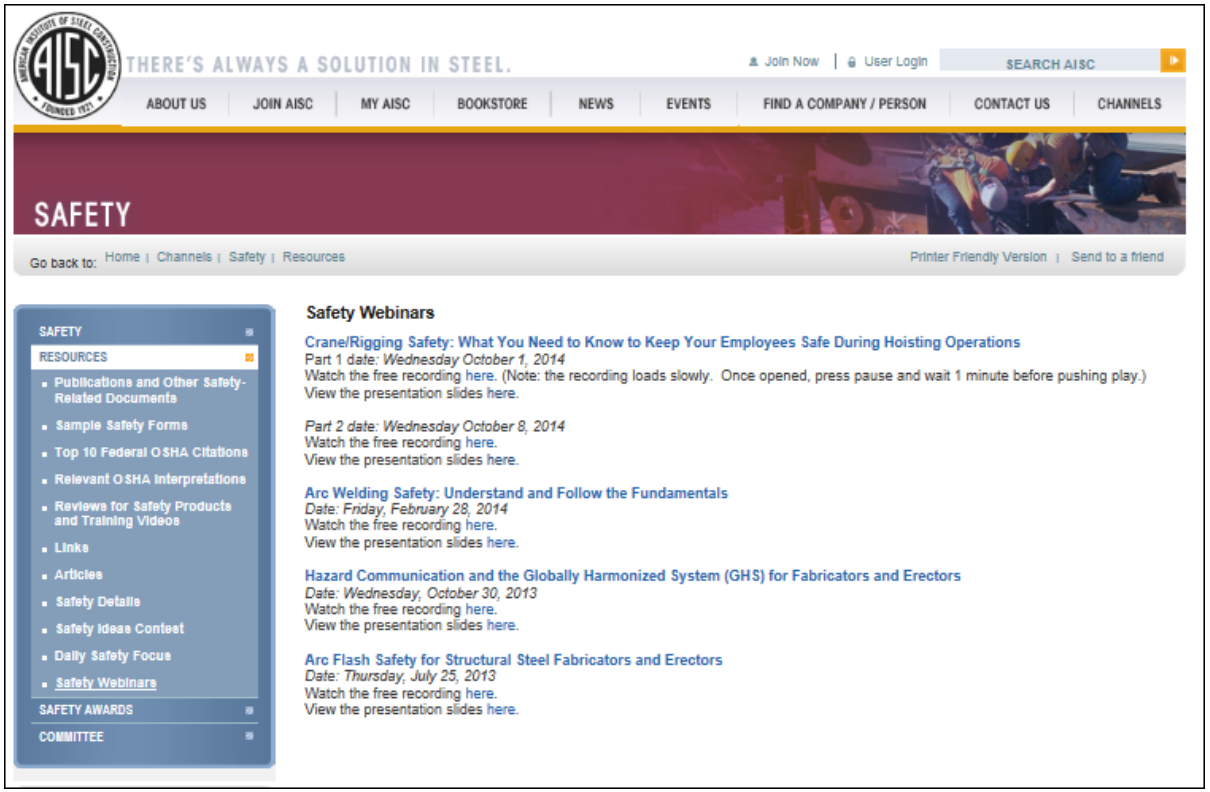
Arc Flash- Protective Measures

For more information AISC has an Arc Flash Webinar posted at its website



http://www.aisc.org/content.aspx?id=35368

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- Electricity can cause explosions and or fires if the conditions are right.

- Bad insulation, static electricity, and overloaded circuits all contribute to explosions.

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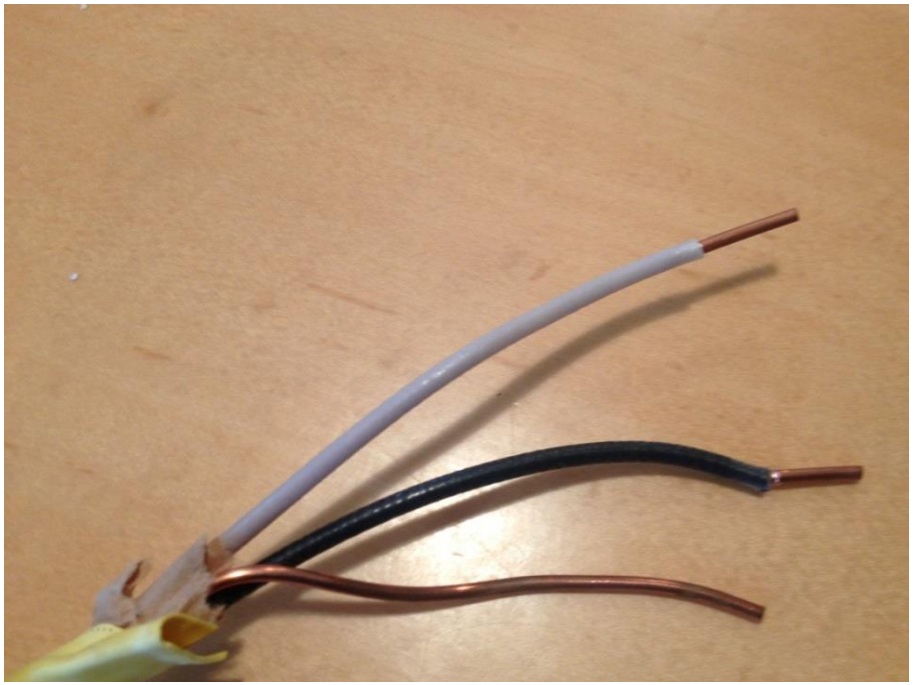
What is an electrical circuit?

- Electricity flows from a voltage source through a conductive path to a load and returns to the voltage source



Neutral

Hot wire

Grounding wire

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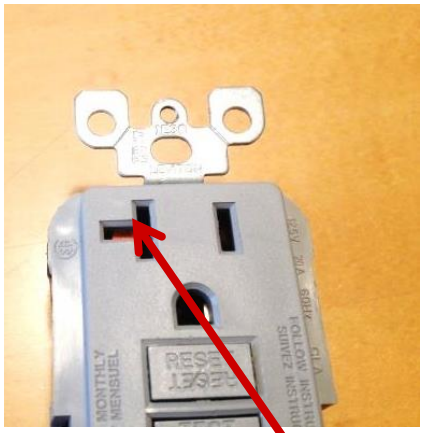
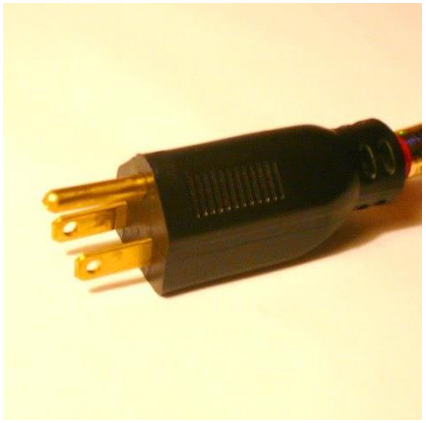
Polarity

Certain electrical using devices are sensitive to polarity so it is important that circuits be wired properly and proper plugs are used.





Larger slot and third prong limits reversing polarity

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Insulating the Conductors

- Simplest way to protect workers from energized wires is by insulation
- Rubber/plastic coatings on wires prevent shock, fires, short circuits and provide strain relief
- Must be suitable for voltage
- Check insulation on cords and equipment before using them
- Small defects in cords and equipment will allow leakage
- Insulation is subject to damage

Cover on electrical cord serves as insulation

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Types of grounding protection

Equipment is grounded through the use of a grounding conductor- usually a copper wire that is insulated with a green cover or a bare copper or stranded copper wire.

Electrical systems components such as hard wired equipment and fixture boxes are grounded back to the electrical panel which is grounded to the ground through ground rods.

Source OSHA 3075-2002 (Revised

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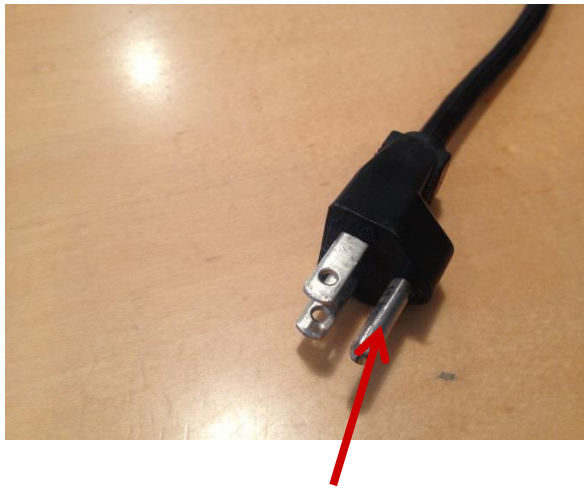
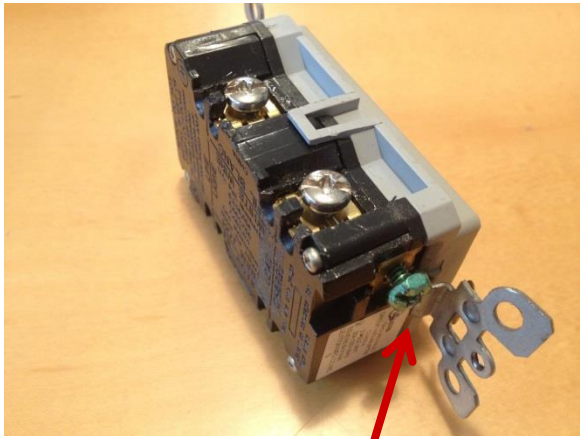
The importance of grounding protection

- Grounding a tool intentionally creates a low resistance path that connects to the earth
- Secondary protective measure that helps protect a worker
- Does not guarantee you won't get a shock-but reduces the risk

For grounding prong



Grounding prong



Ground screw

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Types of grounding protection

- Fuses
- Circuit Breakers

Located at the panel or at the device and break the circuit when too much current flows through the circuit.

- Ground - Fault Circuit Interrupters (GFCI)

Source OSHA 3075-2002 (Revised

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Ground-Fault Circuit Interrupters

1/10 of an ampere (amp) of electricity going through the body for just 2 seconds is enough to cause death.

A GFCI can sense a current differential due to a ground fault and breaks the circuit

Receptacle Type

- The Receptacle Type incorporates a GFCI device within one or more receptacle outlets. Such devices are becoming popular because of their low cost.

Portable Type

- Portable Type GFCIs come in several styles, all designed for easy transport. Some are designed to plug into existing non-GFCI outlets, or connect with a cord and plug arrangement. The portable type also incorporates a no-voltage release device that will disconnect power to the outlets if any supply conductor is open. Units approved for outdoor use will be in enclosures suitable for the environment. If exposed to rain, they must be listed as waterproof.

Cord-Connected Type

- The Cord-Connected Type of GFCI is an attachment plug incorporating the GFCI module. It protects the cord and any equipment attached to the cord. The attachment plug has a non-standard appearance with test and reset buttons. Like the portable type, it incorporates a no-voltage release device that will disconnect power to the load if any supply conductor is open.

Image from
https://www.osha.gov/SLTC/etools/construction/electrical_incidents/gfci.html

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Ground Fault Circuit Interrupters

- Can detect a change in current of 5 millamperes and shut off power in less than 1/40 of a second.
- Can be installed in the service entrance panel, receptacle, branch circuit panel, extension cord or with generators.

Source OSHA 3075-2002 (Revised)

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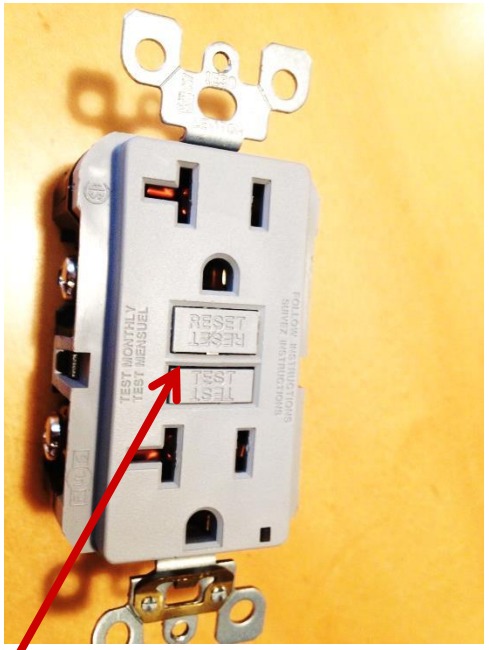
GFCI

Should be used whenever work will be done in a possibly wet environment such as outdoors, basements, garages or an other potentially wet location.



GFICI test and reset buttons

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Double-Insulated Tools

- Hand-held tools manufactured with non-metallic cases are called double-insulated. If approved, they do not require grounding under the National Electrical Code. Although this design method reduces the risk of grounding deficiencies, a shock hazard can still exist.
- Such tools are often used in areas where there is considerable moisture or wetness. Although the user is insulated from the electrical wiring components, water can still enter the tool's housing. Ordinary water is a conductor of electricity. If water contacts the energized parts inside the housing, it provides a path to the outside, bypassing the double insulation. When a person holding a hand tool under these conditions contacts another conductive surface, an electric shock occurs.
- If a power tool, even when double-insulated, is dropped into water, the employee should resist the initial human response to grab for the equipment without first disconnecting the power source.

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

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Double Insulated Tools

Double insulated drill

Double box on label
indicates double insulated tool

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

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Assured Equipment Grounding Program
OSHA 1910 Subpart S

- Alternative to GFCI protection.
- By shift inspection of cords to guarantee continuity of grounding conductor and correct connection of conductor (polarity)
- Must have daily inspection for missing pins, insulation damage, internal damage
- Inspection must be done by competent person
- Keep records

Source 1910.304

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Safe Practices-Guard Conductors

- Protect workers from energized lines by guarding/shielding the wires
- Use boxes, covers, enclosures and conduit to prevent contact with wires
- Boxes/panels must be free of missing ‘knock-outs’
- Electrical equipment operating at 50 volts or more must be guarded

Missing knockout

Open box

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Safe Practices- Using equipment-Grounding

- Use GFCIs or have an assured equipment grounding program
- Use double-insulated tools and equipment, distinctively marked.
- Visually inspect all electrical equipment before use.
- Remove from service any equipment with frayed cords, missing ground prongs, cracked tool casings, etc.
- Ground all power supply systems, circuits, and equipment.
- Do not remove ground prongs from cord
- Avoid standing in wet areas when using electrical power tool.
- Check equipment grounds- are they there and working?
- Check polarity - receptacle tester
- GFCI's? - ground fault circuit interrupter

https://www.osha.gov/SLTC/etools/construction/electrical_incidents/grounding.html
https://www.osha.gov/SLTC/etools/construction/electrical_incidents/powertools.html

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Extension Cords-Selection

- Flexible cords must be marked with type, size and # of conductors
- Select cords suitable for electrical load
- Do not use cords that are not 3-wire type, or not designed for hard-usage, or have been modified
- Should have third prong
- Use only cords, connection devices, and fittings that are equipped with strain relief.
- Use only hard use or extra hard use cords
- Remove from service and damaged cords

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

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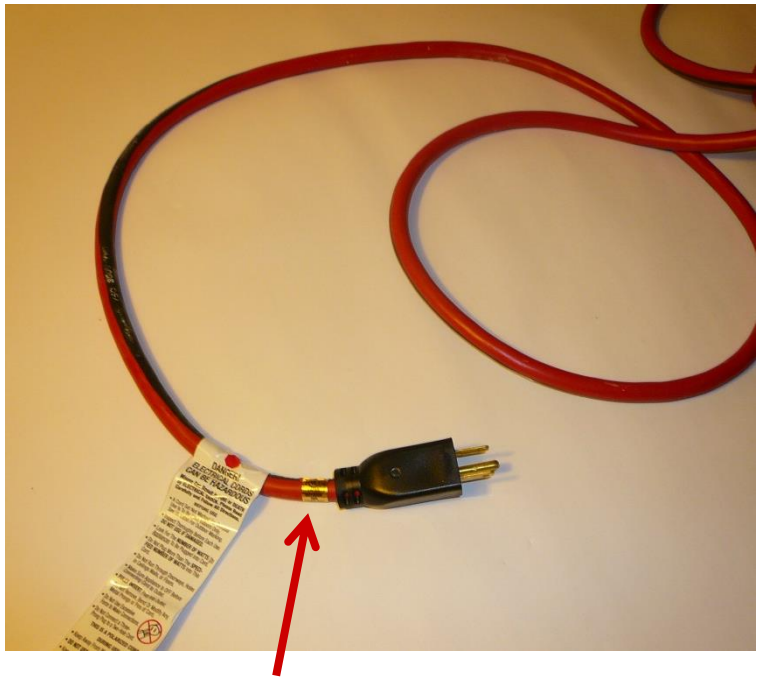
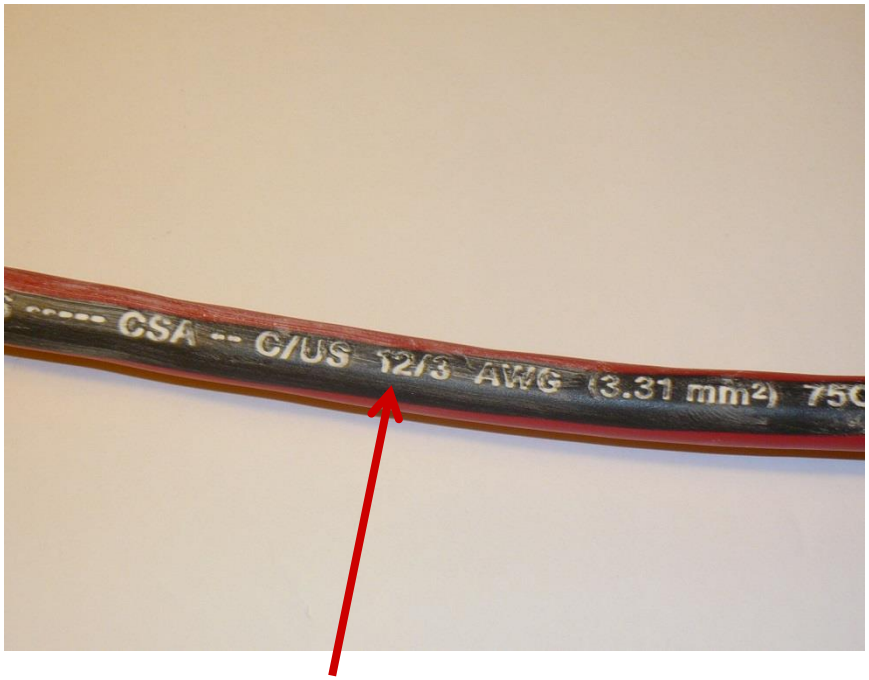
Extension Cords-Selection



3 prong electrical extension cord



Cord markings showing 3-12 gauge wires (amperage varies with cord length)

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

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Selection of cords

The National Electrical Code (NEC) has designations for extension cords

- Hard service cords (types S, ST, SO, STO)
- Junior service cords (types SJ, SJO, SJT, SJTO)

- Other designations reflect use conditions such as, for outdoor use, indoor use, oil resistant etc.

- Also reflect insulation covering materials

https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10706

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Extension Cord – Safe Use Practices

- Do not run through doors or windows
- Protect cords from sharp edges
- Do not pass cords through door ways – protect from pinch points
- Do not modify cords or use them incorrectly.
- Remove cords from receptacles by pulling on the plugs, not the cords.

Damaged cord- remove from service

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

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Extension Cords

Damaged cord

Do not pull cords this way.
It puts strain on them.

Two Layers of protection

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Lockout/tagout

- Tags identify that work is being done. Tag all controls that are to be deactivated in the course of work

- Equipment or circuits rendered inoperative and tagged at all points where they could be energized

Lockout

Photo from Certified Safety Construction Worker Compliance Training Center developed under OSHA Grant SH-20-843-SH0

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Frequently cited

Lockout/tagout ranks 6th as one of the most cited standards for fiscal year 2014

https://www.osha.gov/Top_Ten_Standards.html

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OSHA Standard

1910.147: “This standard covers the servicing and maintenance of machines and equipment in which the **unexpected energization or start up of the machines or equipment, or release of stored energy,** could harm employees. This standard establishes minimum performance requirements for the control of such hazardous energy”.

Source: 1910.147 Subpart J – General Environmental Controls

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What is Hazardous Energy?

- The unexpected startup or release of stored energy during the servicing and maintenance of machines and equipment.

- Energy sources including electrical, mechanical, hydraulic, pneumatic, chemical, thermal or other sources in machines and equipment

- Equipment should only be serviced by a qualified electrician

https://www.osha.gov/SLTC/controlhazardousenergy/

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For more information on Lockout/tagout visit OSHA's Interactive Training Program

https://www.osha.gov/dts/osta/lototraining/index.html

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Personal Protection

What personal equipment should be used?

- Rubber insulating:
  - *Gloves*
  - *Hoods*
  - *Sleeves*
  - *Matting Blankets*
  - *Line hose*
  - *(no metal hardhats)*
- All help reduce the risk of electrical accidents

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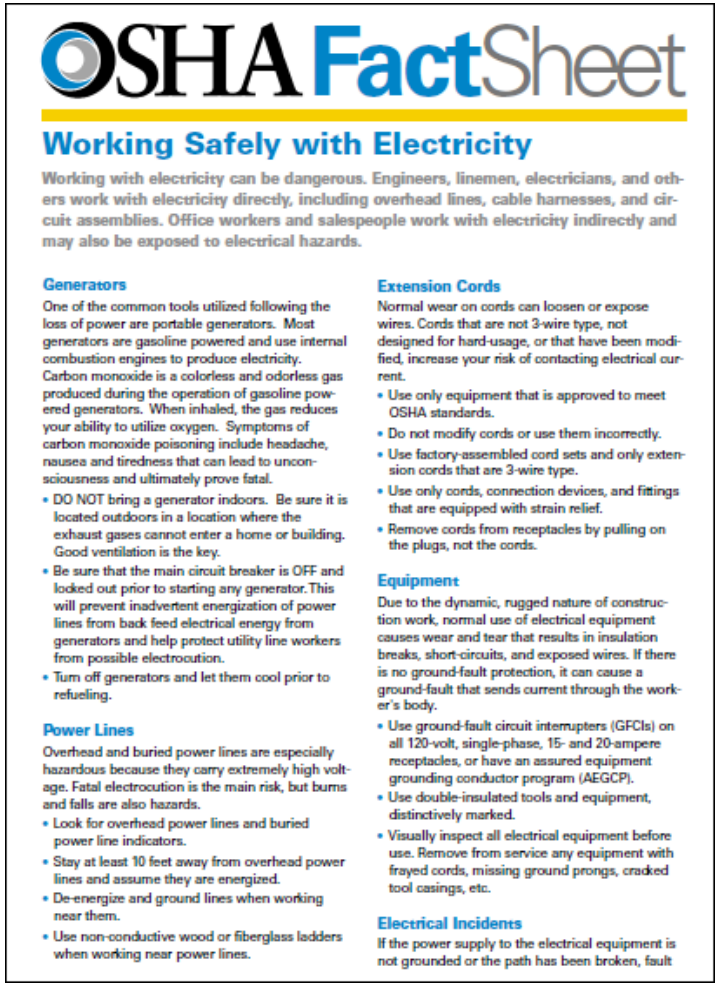
OSHA Resources



OSHA FactSheet

Working Safely with Electricity

Working with electricity can be dangerous. Engineers, linemen, electricians, and others work with electricity directly, including overhead lines, cable harnesses, and circuit assemblies. Office workers and salespeople work with electricity indirectly and may also be exposed to electrical hazards.

Generators

One of the common tools utilized following the loss of power are portable generators. Most generators are gasoline powered and use internal combustion engines to produce electricity. Carbon monoxide is a colorless and odorless gas produced during the operation of gasoline powered generators. When inhaled, the gas reduces your ability to utilize oxygen. Symptoms of carbon monoxide poisoning include headache, nausea and tiredness that can lead to unconsciousness and ultimately prove fatal.

- DO NOT bring a generator indoors. Be sure it is located outdoors in a location where the exhaust gases cannot enter a home or building. Good ventilation is the key.
- Be sure that the main circuit breaker is OFF and locked out prior to starting any generator. This will prevent inadvertent energization of power lines from back feed electrical energy from generators and help protect utility line workers from possible electrocution.
- Turn off generators and let them cool prior to refueling.

Power Lines

Overhead and buried power lines are especially hazardous because they carry extremely high voltage. Fatal electrocution is the main risk, but burns and falls are also hazards.

- Look for overhead power lines and buried power line indicators.
- Stay at least 10 feet away from overhead power lines and assume they are energized.
- De-energize and ground lines when working near them.
- Use non-conductive wood or fiberglass ladders when working near power lines.

Extension Cords

Normal wear on cords can loosen or expose wires. Cords that are not 3-wire type, not designed for hard-usage, or that have been modified, increase your risk of contacting electrical current.

- Use only equipment that is approved to meet OSHA standards.
- Do not modify cords or use them incorrectly.
- Use factory-assembled cord sets and only extension cords that are 3-wire type.
- Use only cords, connection devices, and fittings that are equipped with strain relief.
- Remove cords from receptacles by pulling on the plugs, not the cords.

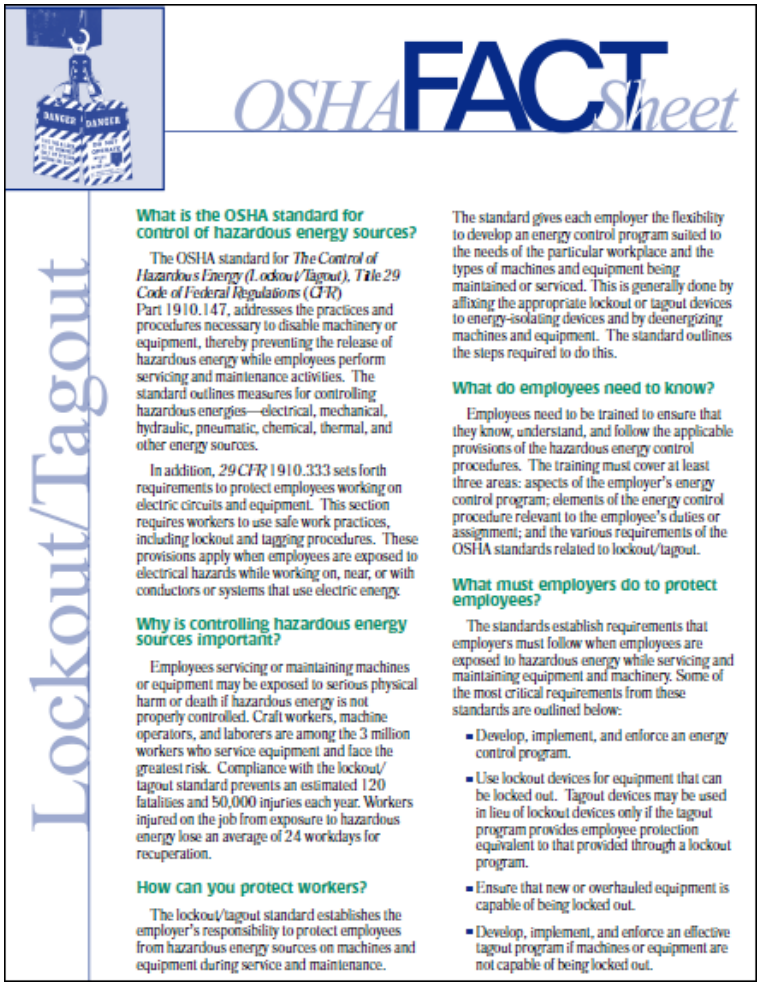
Equipment

Due to the dynamic, rugged nature of construction work, normal use of electrical equipment causes wear and tear that results in insulation breaks, short-circuits, and exposed wires. If there is no ground-fault protection, it can cause a ground-fault that sends current through the worker's body.

- Use ground-fault circuit interrupters (GFCIs) on all 120-volt, single-phase, 15- and 20-ampere receptacles, or have an assured equipment grounding conductor program (AEGCP).
- Use double-insulated tools and equipment, distinctively marked.
- Visually inspect all electrical equipment before use. Remove from service any equipment with frayed cords, missing ground prongs, cracked tool casings, etc.

Electrical Incidents

If the power supply to the electrical equipment is not grounded or the path has been broken, fault



OSHA FACTSheet

Lockout/Tagout

What is the OSHA standard for control of hazardous energy sources?

The OSHA standard for *The Control of Hazardous Energy (Lockout/Tagout), Title 29 Code of Federal Regulations (CFR)* Part 1910.147, addresses the practices and procedures necessary to disable machinery or equipment, thereby preventing the release of hazardous energy while employees perform servicing and maintenance activities. The standard outlines measures for controlling hazardous energies—electrical, mechanical, hydraulic, pneumatic, chemical, thermal, and other energy sources.

In addition, *29 CFR* 1910.333 sets forth requirements to protect employees working on electric circuits and equipment. This section requires workers to use safe work practices, including lockout and tagging procedures. These provisions apply when employees are exposed to electrical hazards while working on, near, or with conductors or systems that use electric energy.

Why is controlling hazardous energy sources important?

Employees servicing or maintaining machines or equipment may be exposed to serious physical harm or death if hazardous energy is not properly controlled. Craft workers, machine operators, and laborers are among the 3 million workers who service equipment and face the greatest risk. Compliance with the lockout/tagout standard prevents an estimated 120 fatalities and 50,000 injuries each year. Workers injured on the job from exposure to hazardous energy lose an average of 24 workdays for recuperation.

How can you protect workers?

The lockout/tagout standard establishes the employer's responsibility to protect employees from hazardous energy sources on machines and equipment during service and maintenance.

The standard gives each employer the flexibility to develop an energy control program suited to the needs of the particular workplace and the types of machines and equipment being maintained or serviced. This is generally done by affixing the appropriate lockout or tagout devices to energy-isolating devices and by deenergizing machines and equipment. The standard outlines the steps required to do this.

What do employees need to know?

Employees need to be trained to ensure that they know, understand, and follow the applicable provisions of the hazardous energy control procedures. The training must cover at least three areas: aspects of the employer's energy control program; elements of the energy control procedure relevant to the employee's duties or assignment; and the various requirements of the OSHA standards related to lockout/tagout.

What must employers do to protect employees?

The standards establish requirements that employers must follow when employees are exposed to hazardous energy while servicing and maintaining equipment and machinery. Some of the most critical requirements from these standards are outlined below:

- Develop, implement, and enforce an energy control program.
- Use lockout devices for equipment that can be locked out. Tagout devices may be used in lieu of lockout devices only if the tagout program provides employee protection equivalent to that provided through a lockout program.
- Ensure that new or overhauled equipment is capable of being locked out.
- Develop, implement, and enforce an effective tagout program if machines or equipment are not capable of being locked out.

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Look out for these unsafe conditions

- Improper grounding
- Exposed electrical parts
- Inadequate wiring
- Damaged insulation
- Overloaded circuits
- Working in wet conditions
- Inadequate PPE when working on electrical items
- Damaged tools and equipment
- Not de-energizing equipment for routine maintenance-disconnect from power supply
- Improper Lock-out/Tag-out for electrical servicing of equipment
- Unqualified personnel working on electrical equipment

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In class exercise-learning Activity on de-energizing equipment

Photo from OSHA 3686-09 2010

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Group Learning Objectives:

Participants shall be able to determine the means to de-energize various equipment

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Group Learning Activity Part A

In groups of 4-5 discuss the four scenarios and determine the process for de-energizing the equipment.

Complete the template

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Activity Materials Provided

Fact Scenarios
Question and Answer Template