Introduction

Occupational Safety and Health Administration

10 Hour Construction

Identifying Electrocution Hazards & Preventative Measures

Understanding the OSHA “Focus Four” Workplace Hazards

Introduction

- One of OSHA's construction Focus Four designed for
  - Foremen
  - Crew leaders
  - Construction Trades
  - Construction Support Staff
  - Anyone wanting general construction safety knowledge
- Engage in all interactive exercises to proceed through the training.

Introduction

Online resources

- OSHA eTools
- OSHA publications
- OSHA Quick Cards
- OSHA Safety & Health topic page
- NIOSH Safety & Health topic page
- NIOSH Fatality Assessment and Control Evaluation (FACE) program
- Electronic library of construction occupational safety and health materials developed by CPWR – The Center for Construction Research and Training

Introduction

Overview

- Recognize major electrocution hazards at construction worksites
  - What is an electrocution hazard?
  - What are the major types of electrocution hazards in construction?
  - How can I protect myself from electrocution hazards?
  - What is my employer required to do to protect workers from electrocution?

Introduction

Student handouts

- “Construction Focus Four: Electrocution, Safety Tips for Workers”
- Focus Four Toolbox Talks 1, 2, and 3 produced by IUOE National Training Fund under an OSHA grant number and
- OSHA Quick Card “Electrical Safety”

Introduction

Learning objectives

- Upon completion of this training session, the student will be able to:
  - Identify major electrocution hazards.
  - Describe types of electrocution hazards.
  - Protect him/herself from electrocution hazards.
  - Recognize employer requirements to protect workers from electrocution hazards.

Introduction

What is a hazard?

- A hazard is a situation or condition that has the potential to cause harm to:
  - Life;
  - Health;
  - Property; and the
  - Environment.
- Engineered controls protect us from known hazards.
- Dormant hazards can become active hazards when conditions change.
- Theoretical hazards are the hardest to recognize.

What is an Electrocution Hazard?

Electrical hazard examples

- Before we get much further,
  - Can you give an example of an electrical hazard on a construction site that could cause a worker to be electrocuted?
  - Look at the photos on the next slide and see if you can identify the hazards and how to mitigate them.

What is an Electrocution Hazard?

- A theoretical (what if?) hazard is a hazard that is not obvious and may take an event or series of events to occur.
- Example:
  - A worker is using an electric saw to cut metal parts. He has been working in the same area all week.
  - Suddenly it starts to rain. The worker puts on his rain gear and continues working without noticing the puddle of water forming around his electrical cord connection, and he is standing in the same puddle.
  - But “what if” he didn’t verify if a ground fault circuit interrupter (GFCI) was being used in the line?
  - If not, a dangerous electrocution hazard now exists that wasn’t apparent 30 minutes earlier.
- When conditions change, it is critical to re-evaluate your work area for obvious and theoretical hazards!

Electrocution Hazards

- Electrocution hazards account for:
  - An average of 411 deaths annually.
  - The fourth leading cause of death in construction.
  - Nine percent of all construction fatalities.
  - One arc flash-related death every day.
  - Five to 10 accidental contacts with electrical circuits every day.
  - Thousands of recordable and disabling injuries

Don’t let yourself become one of these statistics!

Electrocution Hazards

- Deaths by contact with electricity 2003-2005
  - Electrical power installers – 31.8
  - Earth drillers – 13.4
  - Helpers – 5
  - Electricians – 4.8
  - Iron workers – 3.5
  - Welders – 2.3
  - Roofers – 1.3
- Prevent becoming a statistic by identifying and mitigating electrical hazards and following safe work procedures.

Electrocution Hazards

Major types of electrocution (electricians)

- Exposure to:
  - Electrical equipment and wiring;
  - Overhead power lines; and
  - Lighting fixtures.
- Leading cause of electrocutions:
  - Failure to lock and tag out energized power source;
  - Failure to maintain safe distance from energized power source; and
  - Failure to use a ground fault circuit interrupter.

Electrocution Hazards

Major types of electrocution (nonelectricians):

- Exposure to:
  - Overhead power lines;
  - Machinery and appliances;
  - Electrical equipment and wiring; and
  - Energized objects.
- Leading cause of these electrocutions:
  - Failure to maintain a safe distance from an energized power source;
  - Failure to lock and tag out an energized power source; and
  - Failure to use a ground fault circuit interrupter.

Electrocution Hazards

- 1. No GFCI
- 2. System not grounded
- 3. Openings where conductors entered not closed
- 4. No cover on boxes
- 5. Panel boards were not dead front

Understanding Electricity

To protect yourself from electrical hazards you should know:

- Standard electrical terms;
- How electricity works and why;
- Electricity's hazardous properties and mitigations; and
- Safe work procedures.

Understanding Electricity

How electricity works

- Electrical force is called a current.
  - Pressure is measured in volts.
  - Flow (intensity) is measured in amps.
- Controlling electricity is the key to using it safely.
  - National Fire Protection Association (NFPA)
  - National Electrical Code (NEC)

Safety tip: Electricity is the flow of electricity. This movement of electric charge is known as an electric current, usually measured in amperes. Current can consist of any moving charged particles, such as electrons, but any moving charge constitutes a current.

Understanding Electricity

- Electricity:
  - Only travels in a completed circuit;
  - Always travels in the path of least resistance;
  - Always tries to travel to ground; and
  - Resists electron flow to create heat.

- Over loading of circuits can be prevented with circuit breakers.

Understanding Electricity

Electrical shock

- An electrical shock is received when current passes through the body.
- Severity of the shock depends on three things:
  - The path of current through the body;
  - The amount of current flowing through the body; and
  - The length of time the body is in the circuit.
- Low voltage does not mean low hazard.

Understanding Electricity

Electric shock

- Milliampere (milliamp or mA) — 1/1,000 of an ampere
- Severity of shock depends on current flow.
  - Current flow at voltage depends on resistance.
  - Low voltage (< 600 volts) causes most injuries.
- Resistance of human body:
  - Dry, clean, unbroken skin: ≥ 100,000 ohms
  - Wet or broken skin: may be only 1,000 ohms
  - Current may increase 100 times with wet skin.

Understanding Electricity

Electricity's effect on the body

- 1 milliamp = Shock is hardly noticeable
- 5 milliamps = Slight shock, not typically painful, most can control muscles
- 6 to 30 milliamps = Painful shock, loss of muscular control lost
- 50 to 150 milliamps = Extremely painful shock, breathing stops, severe muscular contractions
- Exposure to as little as 0.05 amperes can cause death and often does.

Safety tip: 120 volt, 15 amp electrical circuits are the most common and found in most U.S. households. These same common electrical circuits are responsible for the highest total number of electrocutions in the U.S.

Understanding Electricity

Fatal shock illustration

- How easy can a person receive a fatal shock?
  - The most common U.S. voltage is 120 volts.
  - The average working human resistance is about 1000-ohms (measured hand to hand).
  - According to Ohm's Law, current equals voltage divided by resistance. So, 120/1000= 0.12 amperes or 120 milliamps.

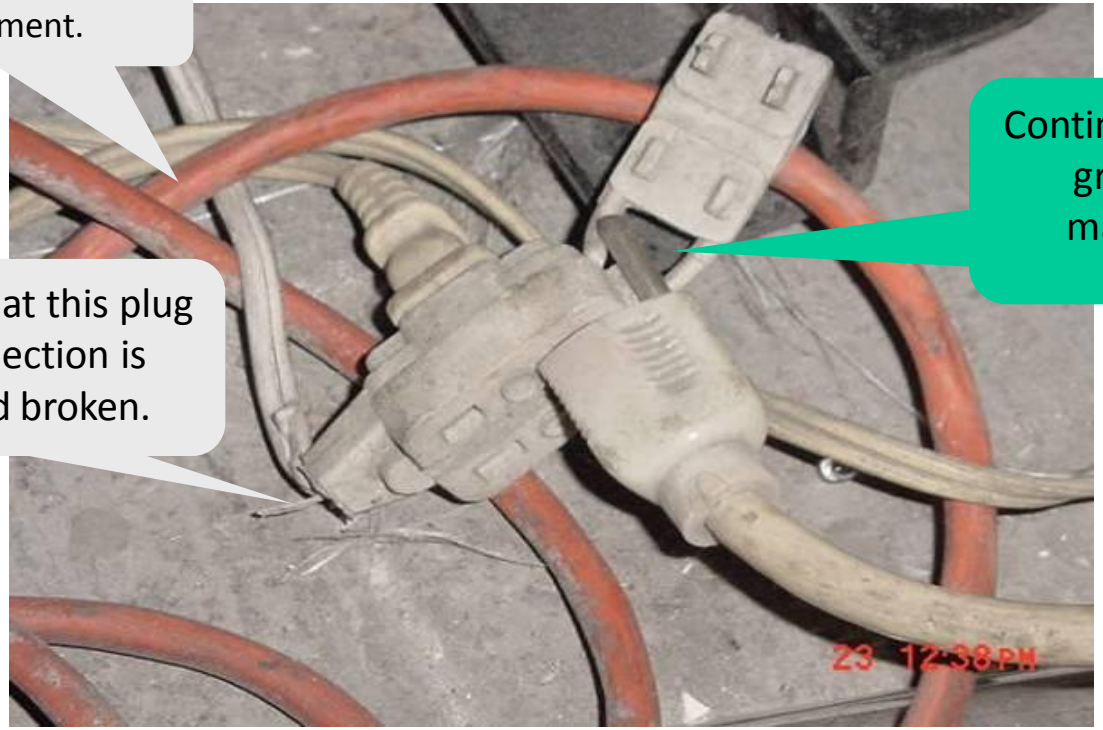
Understanding Electricity

Major energized sources contact grounding

- 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.

Electrical Hazards

Multiple cords used for fixed equipment.



Continuous path to ground not maintained.

It appears that this plug wire connection is frayed and broken.

Electrical Hazards

General electrical hazards

- Electrical hazards can be found everywhere.
- Most hazards are mitigated when installed to National Electrical Code requirements and safety standards.
- Many are not installed to code and are hazardous.
- Others fall into an unsafe state of disrepair.

Electrical Hazards

Electrical hazards by category:

- **BESAFE**
  - **B**urns
  - **E**lectrocution
  - **S**hock
  - **A**rc flash
  - **F**ire
  - **E**xplosions

Electrical Hazards

BESAFE

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
- 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.

Electrical Hazards

BESAFE

E = Electrocution:

- Electrocution means death caused by electricity and is always fatal.
  - It means to kill with electricity.
  - Electrocution results when a human is exposed to a lethal amount of electrical energy.

Electrical Hazards

BESAFE

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.

Electrical Hazards

BESAFE

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;
  - Gives off thermal radiation (heat) and bright, intense light that can cause burns;
  - Can reach temperatures as high as 35,000 degrees; and
  - Can also produce considerable pressure waves by rapidly heating the air and creating a blast.

Electrical Hazards

BESAFE

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.

Electrical Hazards

BESAFE

E = Explosions:

- An explosion can occur when electricity ignites an explosive mixture of material in the air.

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

Electrical Hazards

Tri-Fold Brochure

- "Construction Focus Four: Electrocution, Safety Tips for Workers"
  - Tri-fold brochure packed with helpful information. Topics include:
    - Effects of Electric Current in the Human Body;
    - General Rules for Construction Electrical Safety;
    - Electrical Safety Overview;
    - General Rules for Electrical Work; and
    - Condensed Electrical Glossary.

TIP: It is important to read and become familiar with these tips as they can be helpful in answering questions in the module correctly but more importantly protecting you and your co-workers from electrical shock, electrocution and other hazards resulting from electrical incidents.

Electrocution Hazards in Construction

Major electrocution hazards

- Leading causes of death include:
  - Contact with overhead and buried power lines;
  - Contact with energized sources; and
  - Improper use of extension and flexible cords.

Electrocution Hazards in Construction

Overhead power lines

- Any overhead power line should be considered energized unless the entity owning or operating the electrical utility supplying the line certifies that it is:
  - Not energized;
  - Visibly grounded; and
  - Tested for zero energy.
- Verification of LOTO must be made and a system must be in place to prevent unauthorized energization.

Electrocution Hazards in Construction

Overhead electrocution hazards

- Overhead power lines carry extremely high voltage.
- Physical contact does not need to be made to cause electrocution.
- Burns and falls from elevations are also hazards.
- Cranes are not the only equipment that are at risk.

Electrocution Hazards in Construction

Overhead electrocution hazards

- Working on ladders and rooftops increase the risk of electrocution.
- Most power lines are unprotected and uninsulated.
- Working on ladders, rooftops, man baskets, boom lifts, forklifts, scissor lifts, scaffolds, etc., increase the potential for contacting overhead power lines.

Electrocution Hazards in Construction

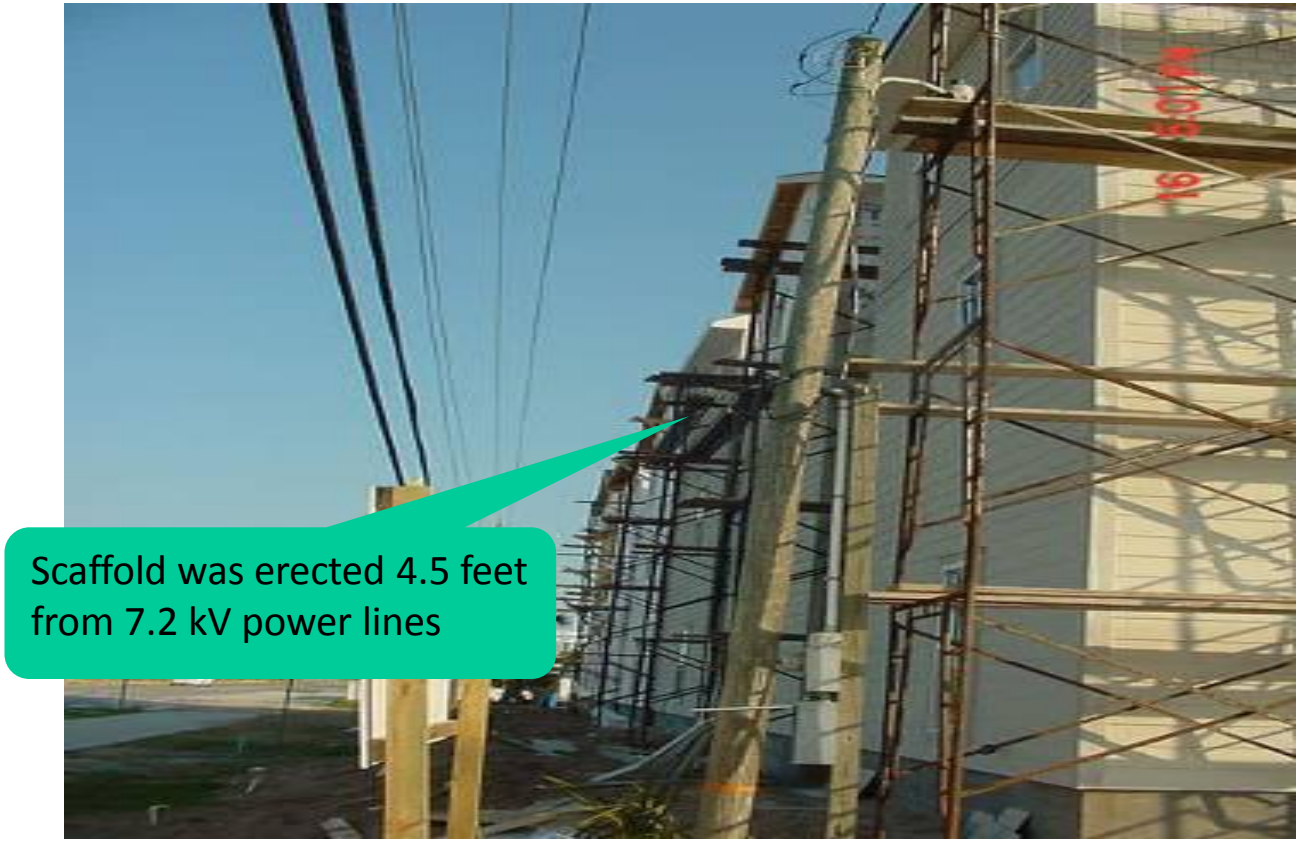
Overhead electrocution hazards

- Safe distances
  - Maintain a safe distance from overhead power lines.
  - Staying away from power lines is the best option.
  - Follow “minimum safe distances” on the table included that shows the safe power line clearance distance for various line voltages.

Electrocution Hazards in Construction

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)

Electrocution Hazards in Construction



Electrocution Hazards in Construction

Classroom exercise #2

- 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 that 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.

- How would you have prevented this from happening?

Electrocution Hazards in Construction

Classroom exercise #2

Findings:

- 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 should have been prevented.

Incident prevention recommendations:

- Guards or barriers must be erected as necessary to adjacent energized lines (29 CFR 1926.950(d)(1)(v)).
- 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)).
- 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)).

Electrocution Hazards in Construction

Underground electrical hazards

- High probability of contact:
  - Can be very difficult to find the exact location;
  - Can run many lines parallel and not be detected; and
  - Can be damaged and full of water, increasing hazard;
  - Backhoe operators are most at risk for electrical contact.
  - Laborers using hand tools such as jackhammers and pick axes can have fatal results.
    - The attached photo shows the result of a jackhammer penetrating a 13,000 volt buried electrical cable.

Electrocution Hazards in Construction

Work practices

- Locate underground hazards before digging.
  - Notify utility locators.
  - Hand dig or pothole.
  - Hand dig within 24 inches of utilities.
  - Always use a trained spotter.

Safety tip: You must call your local utility service locator such as Underground Service Alert, Dig Safe, or Miss Utility. Dial 811 for direct connection. Visit this link for more information: http://www.constructionweblinks.com/Industry_Topics/Specifications__Technical_Data/Specifications_and_Technical_D/Earthwork_and_Site_Work__Speci/underground_alert_centers/underground_alert_centers.html

Electrocution Hazards in Construction

- Typical construction activities most at risk:
  - Construction excavation, regardless of depth;
  - Jack-hammering/shoveling;
  - Well drilling;
  - Landscaping;
  - Trenching and drilling for piping; and
  - Fence installation.

- Always locate and pot hole before using mechanical means to excavate.

Electrocution Hazards in Construction

Crossing electrical line must be supported, protected or removed to safeguard workers

Electrocution Hazards in Construction

Underground electrical hazards

Preventative measures

- New and improved technologies include:
  - Nonconductive backhoe buckets;
  - Nonconductive tools;
  - New ground penetrating radar; and
  - 3-D underground imaging.

Electrocution Hazards in Construction

Overloaded circuits

- Electrical exposure hazards can be caused by:
  - Too many devices plugged into a circuit;
  - Damaged tools overheating;
  - Lack of overcurrent protection; and
  - Wire insulation melting wires.
- Each of these can result in fire, exposed electrical current and electrocution.

Electrocution Hazards in Construction

Wet conditions

- Common in construction
  - Weather or plumbing leaks
- Water conducts electricity
- GFCIs
  - Protect you and others from electrocution
  - Can prevent customer power interruptions

Electrocution Hazards in Construction

Wet conditions

- Touching a live wire or other electrical component while standing in even a small puddle of water will probably cause a shock, or much worse.
- Damaged insulation, equipment, or tools can expose you to live electrical parts.
- Improperly grounded metal switch plates and ceiling lights are especially hazardous in wet conditions.
- Wet clothing, high humidity, and perspiration increase your chances of being electrocuted.

Electrocution Hazards in Construction

Temporary power

- OSHA requires GFCIs (preferred) or an assured equipment grounding (AEG) program on construction sites with temporary power.
- Competent person inspection required for:
  - Electrical cord sets;
  - Temporary receptacles; and
  - Equipment connected by cord and plug.

Safety tip: Equipment found damaged or defective during inspection and testing must be tagged as “defective” and not used until repaired or replaced. Inspections must be recorded.

Protection from Electrical Hazards

GFCI

- First type: Receptacle GFCI
  - Receptacle GFCIs are found on construction work sites, outdoor areas, and other locations where damp conditions 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.
  - If the current 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 needs to be contacted to properly wire or replace the GFCI device.

Safety Tip: Equivalent to qualified electrician is a licensed, certified, and/or registered electrician.

Protection from Electrical Hazards

GFCI

- Second type: Temporary/portable GFCI
- A portable GFCI is an extension cord combined with a GFCI.
- These should be tested prior to each and every use by:
  - Visually inspecting the device for obvious defects and/or broken parts.
  - Plugging in a test light/tool to the extension cord.
  - Pushing “Reset” button on the GFCI device.
  - Pushing “Test” button to verify no voltage at outlet (e.g., the light or tool shuts off).
  - Pushing “Reset” button to verify power is restored.

Protection from Electrical Hazards

GFCI

- Third type: 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 panel.
  - One GFCI circuit breaker can protect the entire circuit.
  - This type of GFCI is installed in panel boxes to give protection to multiple circuits.

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

Protection from Electrical Hazards

Case Study

- “No GFCI in use”.
  - 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.
  - 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.

Protection from Electrical Hazards

Inspection

- Inspecting Extension Cords & Tools
  - Workers need to inspect extension cords prior to their use for:
    - Cuts or abrasion
    - Damaged insulation
    - Strain Relief
- 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.

Protection from Electrical Hazards

Inspection

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

Protection from Electrical Hazards

Power Tools/Equipment

- Use power tools and equipment as designed
  - Tool safety tips include:
    - 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.

Safety Tip: What are the OSHA requirements?

- 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)]

Protection from Electrical Hazards

The drill's flexible cord was spliced to a non-flexible conductor with damaged insulation.

Protection from Electrical Hazards

Preventative Measures

- 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, and
    - tools and materials used are nonconductive.

Protection from Electrical Hazards

Preventative Measures

- Ladders
  - ALWAYS use nonconductive ladders and be sure to retract them before moving. You never know when you will encounter stray electrical current.
  - NEVER put yourself at extreme risk of electrocution as the person has in this photo.

Protection from Electrical Hazards

Case Study

- Fatal Fact No. 17, Boom crane truck close to a power line
  - In this incident: 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.

Protection from Electrical Hazards

Controlling Hazardous Energies

Lockout/Tagout:

- Is an essential safety procedure that protects workers from injury while working on or near electrical circuits and equipment.
- Prevents contact with operating equipment parts such as blades, gears, shafts, etc.
- Prevents the unexpected release of hazardous gases, fluids, or solid matter in areas where workers are present.

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

Protection from Electrical Hazards

Controlling Hazardous Energies

- Lock Out – The practice of using locks to prevent unwanted activation of mechanical or electrical equipment
- Tag Out – The practice of using tags **with** locks to increase visibility and awareness that the lock is protecting someone's life

Protection from Electrical Hazards

Controlling Hazardous Energies

- Authorized Person - Someone who locks out or tags out machines or equipment in order to perform servicing or maintenance
- Affected Person – Someone who operates equipment on which maintenance is performed under lock out/tag out; or an employee that works in an area where servicing and maintenance is being performed

Protection from Electrical Hazards

Verify ZERO ENERGY!

- Verify system is de-energized
  - After you have effectively locked and tagged out the equipment, try to start the equipment to verify it won’t start.
  - Use test equipment to test the circuits and electrical parts for voltage and current.

Protection from Electrical Hazards

Lockout/Tagout Checklist

- Identify all sources of hazardous energy for the equipment or circuits in question.
- Identify backup energy sources such as generators and batteries.
- Identify all shut-offs for each energy source found.

Protection from Electrical Hazards

Lockout/Tagout Checklist

- Notify all personnel that equipment and circuitry must be shut off, locked out, and tagged out.
- Shut off energy sources and lock controls in the OFF position.
- Each worker MUST apply his/her individual lock and the individual keys kept with each worker.
- Test equipment and circuitry to ensure zero energy exists.
  - This must be done by a qualified person.

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

Protection from Electrical Hazards

Lockout/Tagout Checklist

- Deplete stored energy (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.

Protection from Electrical Hazards

Five Major Causes of Lockout/Tagout Injuries:

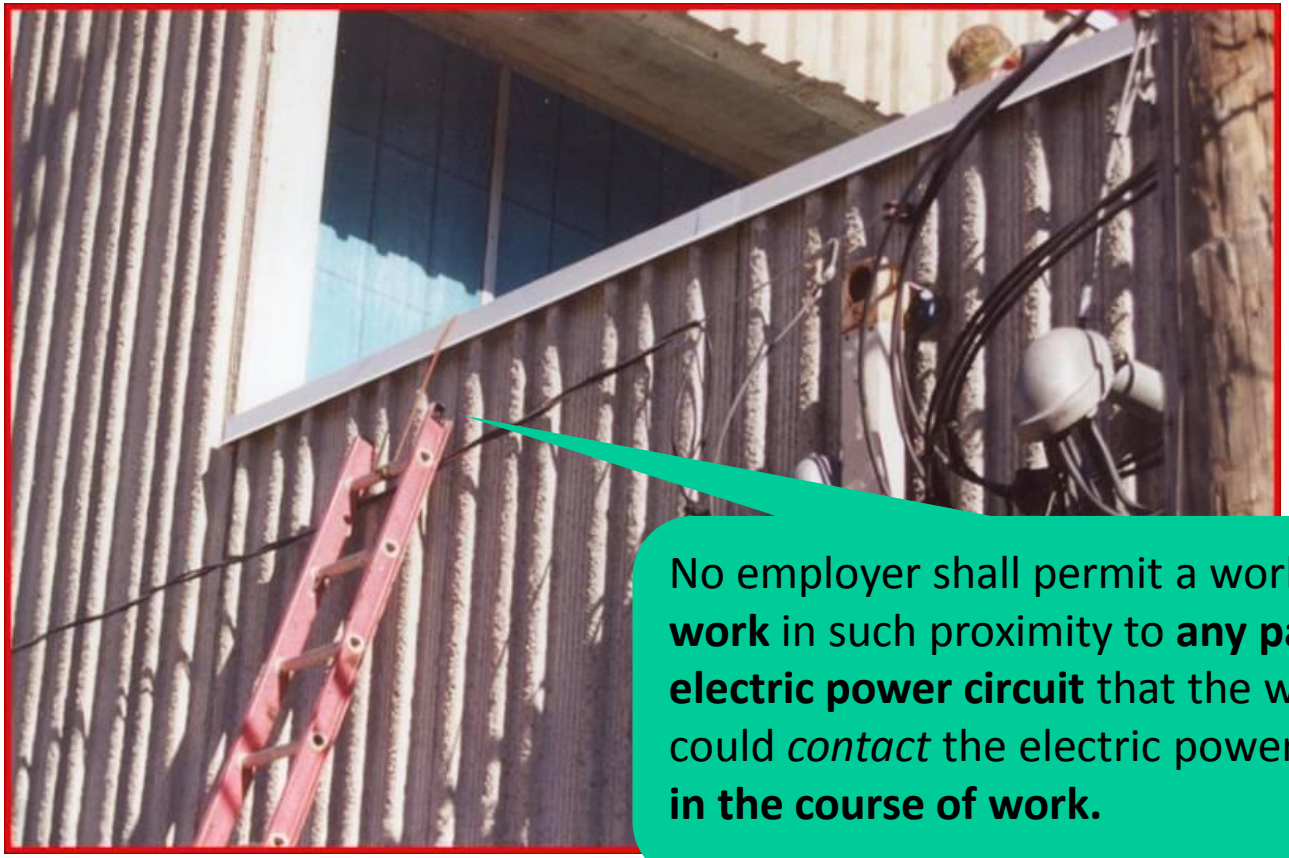
- Accidental restarting of equipment (50%)
- Failure to release residual energy (25%)
- Failure to disconnect from power source (10%)
- Failure to clear work areas before restarting (10%)
- Failure to stop equipment (5%)

Protection from Electrical Hazards

Warning Others

- Use barricades to prevent or limit access to work areas with un-insulated energized conductors or circuit parts.
- Use safety signs, safety symbols, or accident prevention tags to warn others about electrical hazards which may endanger them.
- If signs and barricades do not provide sufficient warning and protection from electrical hazards, an attendant shall be stationed to warn and protect employees.

Protection from Electrical Hazards



No employer shall permit a worker to **work** in such proximity to **any part of an electric power circuit** that the worker could *contact* the electric power circuit **in the course of work.**

Protection from Electrical Hazards

Qualified Persons

- Only qualified persons may work on
  - Electric circuit parts or equipment that has not been de-energized.
    - 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.

Protection from Electrical Hazards

Case Study

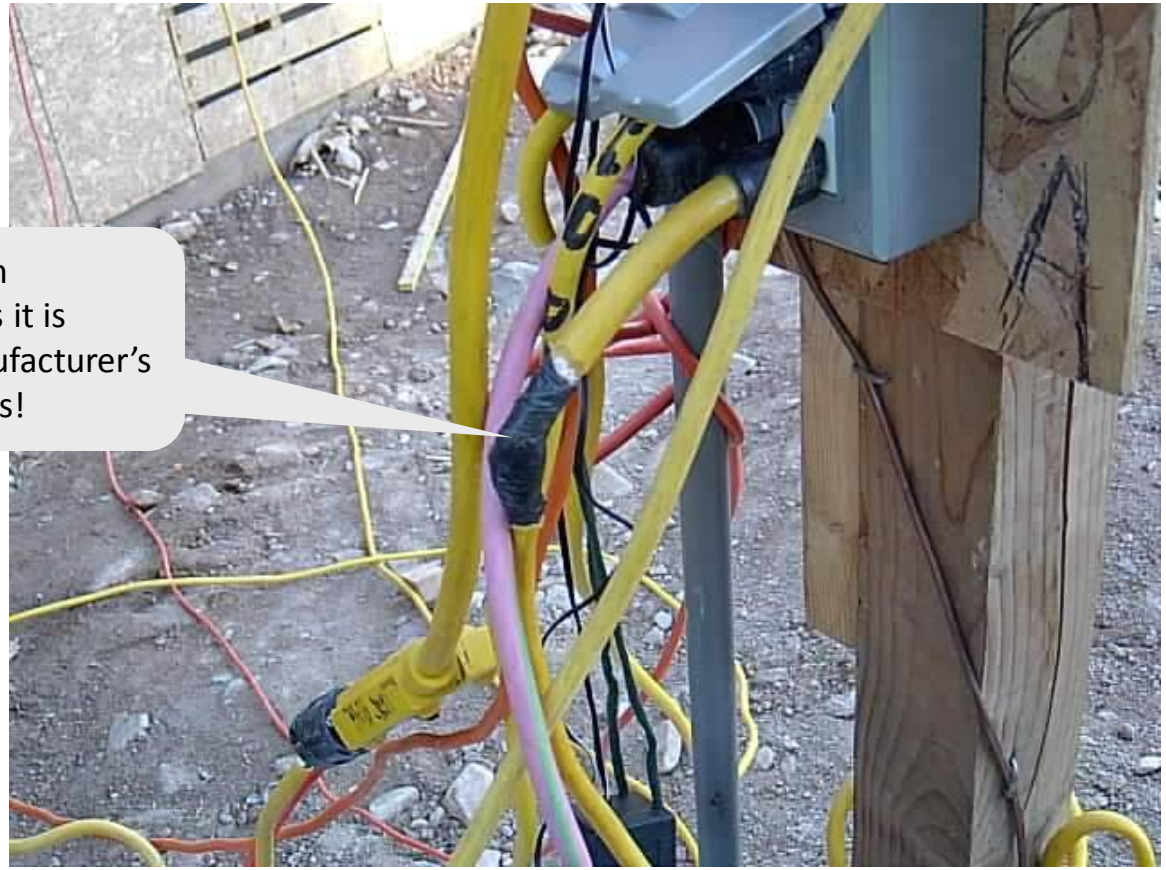
- Fatal Fact Accident Summary No. 30.
  - An electrician was removing a metal fish tape from a hole at the base of a metal light pole. (A fish tape is used to pull wire through a conduit run.)
  - The fish tape became energized, electrocuting him.

Protection from Electrical Hazards

Extension/Flexible Cords:

- 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.

Protection from Electrical Hazards



You can not repair an electrical cord unless it is repaired to the manufacturer's original specifications!

Protection From Electrical Hazards

- Power Cord Hazards
  - Don’t cause tripping hazards or create pinch points for cords.
  - If you must run a cord temporarily across the floor, protect your co-workers by covering the cord appropriately.
  - Metal doorways can cause damage to the insulation of the cord when opening and closing, creating an electrocution hazard.

Protection from Electrical Hazards

Permissible Use of Flexible Cords

- DO NOT use flexible wiring where frequent inspection would be difficult or where damage would be likely.
- Flexible cords must not
- Run through holes in walls, ceilings, or floors;
- Run through doorways, windows, or similar openings (unless physically protected);
- Be hidden in walls, ceilings, floors, conduit or other raceways.

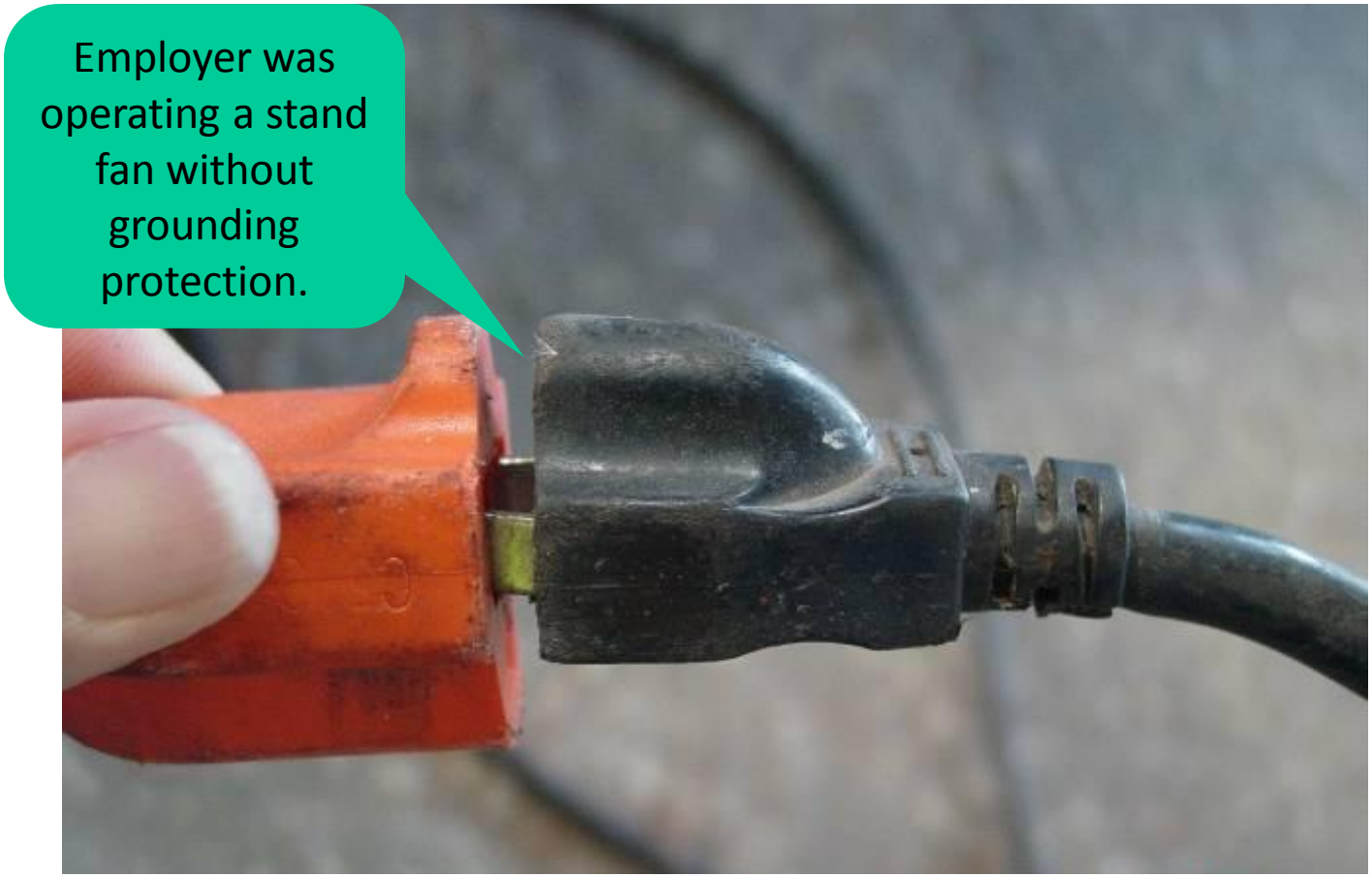
Protection from Electrical Hazards

Classroom Exercise

- 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 that 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.

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

Protection from Electrical Hazards



Protection From Electrical Hazards

Preventing Cord Damage

- OSHA requires all power cords to be protected from mechanical damage and environmental deterioration. This includes:
  - All vehicle and equipment traffic
  - Sharp materials, edges, doorways
  - Excessive sunlight & weather

Protection from Electrical Hazards

Topic 3.

- How can I protect myself from electrocution hazards?
  - Use ground-fault circuit interrupters (GFCI).
  - Maintain a safe distance from overhead power lines.
  - Inspect portable tools and extension cords.
  - Use power tools and equipment as designed.
  - Follow lockout/tagout procedures.

Protection Part 4

Fuses and Circuit Breakers

- Fuses and circuit breakers are intended primarily for the protection of conductors and equipment.
- They prevent over-heating of wires and components that might otherwise create hazards for operators.
- They also open the circuit under certain hazardous ground-fault conditions.

Protection From Electrical Hazards

Personal Protective Equipment

- Foot protection
  - Footwear will be marked “EH” if it’s approved for electrical work.
  - EH = Electrical Hazard
  - Footwear must be kept dry, even if it is marked “EH”

Protection From Electrical Hazards

Personal Protective Equipment

- Head protection
  - Hard hat (insulated - nonconductive)
  - Class B & E.
  - Always wear your hat with the bill forward.
  - Do not store anything in the top of your hat while wearing it.

Protection From Electrical Hazards

Personal Protective Equipment

- Hand protection
  - Rubber insulating gloves
  - Classified by the level of voltage and protection they provide
  - Should always be worn over rubber insulating gloves to provide the mechanical protection needed against cuts, abrasions, and punctures.

Protection From Electrical Hazards

- Personal Protective Equipment
  - Use, store and maintain your electrical PPE in a safe, reliable condition.
  - Wear nonconductive head protection wherever there is a danger of head injury from electric shock or burns due to contact with exposed energized parts.
  - Wear protective equipment for the eyes or face wherever there is danger of injury to the eyes or face from electric arcs or flashes or from flying objects resulting from electrical explosion.

Protection From Electrical Hazards

Safe Work Practices

- Working safely with electric equipment requires safe work practices.
  - Planning your work with co-workers
    - allows you to coordinate your work and take advantage of the knowledge of others.
    - helps identify all hazards associated with your task
    - allows a collective response on how to safely mitigate all hazards.
    - ensures good safety communication between co-workers.

Protection From Electrical Hazards

Safe Work Practices

- Do not work in wet conditions.
- Avoid overhead power lines.
  - You should stay at least 10 feet away from high-voltage transmission lines.
  - You do not need to contact high voltage lines to be electrocuted as electricity can “jump” air gaps.
- Use proper wiring and connectors
  - Avoid overloading circuits.
  - Test GFCIs monthly.
  - Make sure switches and insulation are in good condition.
  - Never use a plug with the ground prong removed.

Protection From Electrical Hazards

How to Respond/Report a Problem

- Do not panic; remain calm.
- In the event of an unsafe condition or personal injury:
  - Contact Emergency Services immediately.
    - 911 or Facilities Emergency number
  - If a person is being shocked, Do Not Touch Them!
    - Try to safely turn off the source of electricity; or
    - Using non-conductive material, try to remove the person away from the electrical source.

Employer Requirements

Topic 4

- What is my employer required to do to protect workers from electrocutions?
  - We will now discuss the requirements that employers are mandated to implement and enforce to ensure and maintain a safe and healthful work environment for all of their employees.

Employer Requirements

Power lines

- Ensure overhead power line safety.
  - Overhead power lines must be de-energized and grounded by the owner or operator of the lines, or
  - Other protective measures must be provided before work is started such as PPE.
  - Protective measures must be designed to prevent contact with the lines.

TIP: 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

Employer Requirements

Power lines

- Three major ways employers should control power line hazards:
  - Maintaining a safe distance from lines;
  - Having the power company de-energize and ground the power line(s) with a power company representative at the site; and
  - Having the power company install insulated sleeves (also known as “eels”) over power lines.

Employer Requirements

Isolate Electrical Parts

- 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.

TIP: For more information refer to OSHA 29 CFR 1926.405

Employer Requirements

- The employer's responsibility is to provide either
  - GFCI on construction sites for receptacle outlets in use and not part of the permanent wiring of the building or structure; or
  - 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.

Employer Requirements

Assured Equipment Grounding Conductor Program (AEGCP)

- The AEGCP 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.

TIP: 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

Employer Requirements

Assured Equipment Grounding Conductor Program

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

Employer Requirements

Tool Maintenance

- 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 ensure 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.

Tip: 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

Employer Requirements

Provide Training

- Workers must be trained in and familiar with the safety-related work practices that pertain to their respective job assignments. Train employees working with electric equipment in safe work practices to:
  - de-energize electric equipment before inspecting or repairing.
  - use cords, cables, and electric tools that are in good repair.
  - practice lockout/tagout recognition and procedures.
  - use appropriate protective equipment.

Employer Requirements

LOTO Enforcement

- It is critical that employers Enforce LOTO safety-related work practices. Critical enforcement issues include:
  - Equipment or circuits that are de-energized shall be rendered inoperative and all points where such equipment or circuits can be energized must be locked and tagged out and zero energy verified, before work begins. No Exceptions!
  - Tags shall be placed to plainly identify the equipment or circuits being worked on, and ideally, the person doing the work.

TIP: See OSHA standards 29 CFR 1926.416 and .417

Employer Requirements

Flexible Cords

- Ensure the proper use of flexible cords.
  - The OSHA construction standard requires flexible cords to be rated for hard or extra-hard usage.
  - These ratings are required to be permanently marked about 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 will allow the grounding of tools and equipment
  - Limit exposure to moisture by using watertight or sealable connectors.

TIP: Also see OSHA standards 29 CFR 1926.405(g) and 1926.951

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.

Summary

Thank you so much for your time, attention, and involvement in the session.

- Important references/sources for this course can be found by clicking on the Safety Tip.
- These references and sources of information can be helpful as you continue your pursuit of construction safety and health and electrocution hazards and prevention.