• Electrical Safety and LOTO
  – Introduce electrical safety concepts, identify hazardous electrical energy sources, explain electrical hazards, explain the concept of lock-out/tag-out and provide solutions for the control of hazardous electrical energies.
  – Estimated time: 60 minutes
  – Audience: Employees, supervisors, and managers who work with electrical equipment.
Introduction

- Objectives
  - Given current OSHA and industry information regarding workplace illnesses, injuries and fatalities, and the OSHA requirements for protecting the health & safety of employees, the student will be able to understand and recognize hazards associated with electricity.
  - Specifically, the student will be able to:
    - 1: Identify major hazards associated with electricity
    - 2: Describe the types of electrical hazards and their effect on the human body
    - 3: Protect themselves from exposure to electrical hazards
    - 4: Recognize employer requirements to protect workers from electrical hazards
Introduction

• References

• Primary references include:
  – 29 CFR 1910 Subpart S
  – 29 CFR 1910.147, Lockout/Tagout
  – OSHA Training Institute (Electrical)
  – Illustrated Guide to Electrical Safety, American Society of Safety Engineers

Links: 29 CFR 1910 Subpart S:

29 CFR 1910.147
Electrical Safety

• Introduction
  – Electrical hazards:
    • 300 electrocutions every year in the U.S.
    • Leading cause is insufficient training.
    • ALL were preventable.
    • Do you know the difference between electric shock and electrocution? Click on each to find out:
      • Electric shock
      • Electrocution
Basics of Electricity

- Electrical Hazards
- Electricity is a serious workplace hazard.
- It can cause shock, falls resulting from shock, electrocution, burns, fires and explosions.
- Electricity is one of the most common causes of fire in homes and workplaces. Explosions have also resulted from electrical sources.
- To work on electrical equipment, you must be trained on the specific hazards of that equipment and understand how to control the hazards.

Tip: Electrical injuries consist of four main types: electrocution (fatal), electric shock, burns, and trauma from falls caused as a result of contact with electrical energy.
Basics of Electricity

• Definitions
  – Current – the movement of electrical charge, expressed in amps or amperes.
  – Resistance – opposition to current flow, expressed in ohms.
  – Voltage – a measure of electrical force, expressed in volts.
Basics of Electricity

• Definitions
  – Conductors – substances, such as metals, that have little resistance to electricity.
  – Insulators – substances, such as wood, rubber, glass, and bakelite, that have high resistance to electricity.
  – Grounding – a conductive connection to the earth which acts as a protective measure.
Basics of Electricity

• Definitions
• Bonding- The process of connecting various pieces of conductive equipment together to keep them at the same potential. Static sparking cannot take place between objects that are the same potential.
• Breakdown- A condition that occurs when insulation fails and the insulation conducts the electrical current through the path of least resistance.
• Double insulation- Equipment housing which is designed to protect the user from electrical currents.

Tip: Double insulated 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.
Basics of Electricity

• Definitions

• Ground Fault Circuit Interrupter- An electrical/mechanical device which will automatically disconnect and interrupt a circuit when a difference in current is detected. Usually called a GFCI.

• Short circuit- A condition that exists when a conductor comes into contact with another conductor.

• Static electricity- A build-up of electrical charge between two surfaces.
Basics of Electricity

• How Electricity Works
  – Created by a generator.
  – Electrical current flows through conductors or wires.
  – Pressure measured in Volts.
  – Flow measured in Amps.
  – NFPA & NEC adopts standards & regulations.

Safety Tip: NFPA 70E is a standard developed by the National Fire Protection Association (NFPA) to provide rules and guidance to protect against the effects of arc flash, arc blast, and direct current (dc) hazards, and to provide information on recent developments in electrical design and Personal Protective Equipment (PPE).
Basic Electrical Safety

- Electrical Accidents
- Electrical accidents can occur when the body becomes part of the electrical circuit.
- This can occur three ways:
  - Electric shock occurs when current passes directly through the body.
  - Electric arc occurs when current passes through vaporized material.
  - Electric blast occurs when air and vaporized metal are instantaneously heated.

Tip: Working with electricity can be dangerous. Engineers, electricians, and other professionals work with electricity directly, including working on overhead lines, cable harnesses, and circuit assemblies. Others, such as office workers and salespeople, work with electricity indirectly and may also be exposed to electrical hazards. Click on the link shown to learn more about electrical hazards and electrical safety: http://www.osha.gov/SLTC/electrical/index.html
Basic Electrical Safety

• Types of Injury from Electricity
• Shock
• Burns:
  • Electrical burns
  • Thermal contact burns
  • Arc burns
• Indirect injuries - such as fractures and bruises from falls.
Basic Electrical Safety

• Basic Wiring
• When two wires have different potential voltages, current will flow if they are connected together.
  – In most household wiring, the black wires are at 110 volts relative to ground.
  – The white wires are at zero volts because they are connected to ground.
• If you come into contact with an energized (live) black wire, and you are also in contact with the white grounded wire, current will pass through your body and YOU WILL RECEIVE A SHOCK.
Basic Electrical Safety

- Arc Flash
- Arc flash can occur at all energies but is of greatest risk above 600 kV to ground.
- Based on voltage, NFPA 70E establishes approach distances to exposed conductors (for systems that are 600 volts or less), the flash protection boundary is established at 4 feet; no unprotected or unqualified personnel are allowed inside this boundary when conductors are exposed.
- Violating approach distances may result in an explosive arc, particularly if proper PPE is not worn.
- There are also marking requirements for panels, MCCs, etc.
Basic Electrical Safety

• Arc Flash
• The appropriate level of electrical PPE is dependent on the type of exposure and the voltage level; for example:
  – Locked out or below 50 volts- no PPE.
  – Resetting starters up to 600 volts- Class 0 or 00 gloves with a face shield over safety eyewear and non-conductive tools.
  – Other tasks include: testing and troubleshooting; work on exposed conductors; insertion or removal of buckets; and a variety of others (refer to NFPA 70E for specific application).
  – Always take appropriate precautions for arc flash protection around exposed conductors.

Note that NFPA 70E is a consensus standard and is non regulatory; however, it is considered best practice and more and more large corporations are implementing these practices.
Basic Electrical Safety

- Shock
- The Most Common Injury is Shock. Shock occurs:
  - When a person comes in contact with both wires of a live electrical circuit.
  - When a person touches an energized conductor and the ground such as a conductive surface, such as wet pavement.
  - A metallic part that has become energized by contact with an energized conductor.

Basic Electrical Safety

• Shock

• 240 volt circuit:
  – You can even receive a shock when you are not in contact with a ground.
  – Contact with both energized wires of a 240-volt cable will deliver a shock. This type of shock can occur because one live wire may be at +120 volts while the other is at –120 volts during an alternating current cycle, which is a potential difference of 240 volts.
Basic Electrical Safety

- Shock
- The severity of a shock depends on:
  - The amount of current passing through the body.
  - The path of the current through the body.
  - The amount of time the body is in the electrical path.
  - The frequency of the current.
  - The phase the heart is in (contracting or relaxing).
  - The general health of the person.
Basic Electrical Safety

• Shock

• The effects of shock can range between a barely perceptible tingle to immediate cardiac arrest.

• All shocks, no matter how minor, should be reported to your supervisor.
Basic Electrical Safety

• Shock
• Low voltage does not mean low hazard.
• A small current that passes through the trunk of the body (heart and lungs) is capable of causing severe injury or electrocution.
• Low voltages can be extremely dangerous because, all other factors being equal, the degree of injury increases the longer the body is in contact with the circuit.
Basic Electrical Safety

- Shock
- Low voltage does not mean Low hazard
- Currents of about 60 mA can cause ventricular fibrillation (rapid, ineffective heartbeat). mA = 1/1000 ampere.
- Will cause death in a few minutes unless a defibrillator is used.
- 60 mA is not much current – a small power drill uses 30 times as much.

Tip: Data from the U.S. Bureau of Labor Statistics show that, in 1999, electrocution was the third-ranking cause of death in construction, after falls to a lower level and highway traffic injuries. Electrocutions caused 11% of the 1,228 construction worker deaths.
Electrical Hazards

• Inadequate Wiring Hazards
• A hazard exists when a conductor is too small to safely carry the current.
• Example: using a portable tool with an extension cord that has a wire too small for the tool.
  – The tool will draw more current than the cord can handle, causing overheating and a possible fire without tripping the circuit breaker.
  – The circuit breaker could be the right size for the circuit but not for the smaller-wire extension cord.
Electrical Hazards

- Inadequate Wiring Hazards: Wire-gauge size is inversely related to the diameter of the wire. No. 12 flexible cord has a larger diameter wire than a No. 14 flexible cord. Wire size must handle the total current. Remember: The larger the gauge number, the smaller the wire!

- American Wire Gauge (AWG)
  - Wire size  Handles up to
  - #10 AWG  30 amps
  - #12 AWG  25 amps
  - #14 AWG  18 amps
  - #16 AWG  13 amps

Safety Tip: Wire gauge is similar to shotgun gauge. For example, a 12 gauge shotgun is bigger than a 20 gauge shotgun.
Electrical Hazards

- Overload Hazards
- If too many devices are plugged into a circuit, the current will heat the wires to a very high temperature, which may cause a fire.
- If the wire insulation melts, arcing may occur and cause a fire in the area where the overload exists, even inside a wall.
Electrical Protective Devices

These devices shut off electricity flow in the event of an overload or ground-fault in the circuit.

Include fuses, circuit breakers, and ground-fault circuit-interrupters (GFCIs).

Fuses and circuit breakers are overcurrent devices.

- When there is too much current:
  - Fuses melt
  - Circuit breakers trip open
Electrical Protective Devices

The basic idea of an overcurrent device is to make a weak link in the circuit.

– Fuse is destroyed before another part of the system is destroyed.
– Circuit breaker: A set of contacts opens the circuit. Unlike a fuse, a circuit breaker can be re-used by re-closing the contacts.
– Fuses and circuit breakers are designed to protect equipment and facilities, and in so doing, they also provide considerable protection against shock in most situations.
– The only electrical protective device whose sole purpose is to protect people is the ground-fault circuit-interrupter.
Electrical Hazards

- Grounding Hazards
- Some of the most frequently violated OSHA standards.
- If metal parts of an electrical wiring system are at zero volts relative to ground, no current will flow if our body completes the circuit between these parts and ground.
- Metal parts of an electrical wiring system that we touch (switch plates, ceiling light fixtures, conduit, etc.) should be at zero volts relative to ground.
- Housings of motors, appliances or tools that are plugged into improperly grounded circuits may become energized.
- If you come into contact with an improperly grounded electrical device, YOU WILL BE SHOCKED.
Electrical Hazards

• Overhead Power Line Hazards
• Most people don’t realize that overhead power lines are usually not insulated.
• Power line workers need special training and personal protective equipment (PPE) to work safely.
• Do not use metal ladders – instead, use fiberglass ladders, they are far less conductive.
• Beware of power lines when you work with ladders and scaffolding.

Tip: According to the BLS, in 1999, for non-electrical workers, the main cause of electrocution was contact with overhead power lines. Failure to lock out or tag out machinery and appliances before working on them and lack of ground fault circuit interrupters caused many of the other electrocutions.
Electrical Hazards

- Overhead Power Line Hazards
- OSHA Standards.
  - When an unqualified person is working in an elevated position near overhead lines, maintain minimum distances from overhead power lines:
    - For voltages to ground 50kV or below - 10 feet.
    - For line voltage of 50kV or more:
      - Each increase of 10kV requires an extra 4” distance.
    - Danger of arcing requires caution.

Tip: To learn more about overhead power line hazards, click on the link shown: http://www.osha.gov/SLTC/etools/construction/electrical_incidents/powerlines.html
Safe Work Practices

- Safe Work Practices
- Follow these rules to avoid shock:
- Be qualified to work on electrical equipment before you start.
- Make sure all electrical equipment is in good working condition.
  - Use only properly grounded tools and other equipment.
  - Watch for wires and connectors that are broken, worn or damaged.
  - Use equipment that has a UL, FM, or equivalent markings.
- Test equipment for voltage leakage prior to working on it.
- Don’t work on live equipment, unless absolutely necessary.

NRTL
Safe Work Practices

- Safe Work Practices
- Follow these rules to avoid shock:
- Use lock-out/tag-out procedures when working on de-energized equipment.
- Maintain proper clearances when working with energized circuitry, e.g. body, ladders, and tools.
- Use appropriate personal protective equipment.
- Use electrical protective devices as necessary, such as:
  - Electrical mats, non-conductive tools, and electrical blankets.
- Always use Ground Fault Circuit Interrupters for portable equipment.
Safe Work Practices

- Safe Work Practices
- Follow these rules to avoid shock:
  - Grasp the plug and not the cord when unplugging a cord.
  - Never use a metal ladders when working on or near electrical equipment.
- Do not use water on any electrical fire.

Tip: to learn more about electrical hazards and hazard prevention, check out the NIOSH publication “Preventing Worker Deaths from Uncontrolled Release of Electrical, Mechanical, and Other Types of Hazardous Energy” by clicking on the link shown:  http://www.cdc.gov/niosh/99-110.html  done
Safe Work Practices

• Working Space
• Sufficient access and working space must be provided and maintained around all electric equipment to permit safe operation and maintenance of equipment.
• Working space may not be used for storage.
• When normally enclosed live parts are exposed for inspection or servicing in a passageway or general open space, the working space must be suitably guarded.
Safe Work Practices

• Guarding of Live Parts

• In locations where electric equipment would be exposed to physical damage, enclosures or guards must be strong enough and be arranged in a way that prevents such damage.

• Entrances to rooms and other guarded locations containing exposed live parts must be marked with conspicuous warning signs forbidding unqualified persons to enter.
Safe Work Practices

• Guarding of Live Parts
  – Live parts of electric equipment operating at 50 volts or more must be guarded against accidental contact by approved cabinets or other forms of approved enclosures, or by:
    – Location in a room, vault, or similar enclosure that is accessible only to qualified persons.
    – Location on a suitable balcony, gallery, or platform.

Safety Tip
Entrances to rooms or locations with exposed parts should be locked.
Safe Work Practices

• Guarding of Live Parts
• Suitable permanent partitions or screens arranged that only qualified persons will have access to the space within reach of the live parts.
• Elevation of 8 feet or more above the floor or other working surface.
• Grounding

• There are two kinds of grounding:
  – Electrical circuit or system grounding.
  – Electrical equipment grounding.

• Electrical system grounding is accomplished when one conductor of the circuit is intentionally connected to earth.

• System grounding protects the circuit should lightning strike or other high voltage contact occur and stabilizes the voltage in the system under normal conditions.
Safe Work Practices

• Grounding

• Equipment grounding is accomplished when all metal frames of equipment and enclosures containing electrical equipment or conductors are grounded by means of a permanent and continuous connection or bond.

• The equipment grounding conductor provides a path for fault current to return to the system ground at the supply source of the circuit when an insulation failure occurs, thus enabling protective devices, such as circuit breakers and fuses, to operate.
Safe Work Practices

- Equipment Grounding Conductors
- Are circuit conductors that are connected to earth through the system ground, commonly referred to as the NEUTRAL.
- Must be marked or color coded in a way that allows employees to identify them and tell them apart from each other and from the other conductors in the circuit.
- White for system ground.
- Green for equipment ground.
Safe Work Practices

- Equipment Grounding Conductors
- Act as safeguards against insulation failure or faults in the other circuit conductors, and are not an energized conductor under normal conditions.
- Are energized ONLY if there is a leak or fault in the normal current path, and direct this current back to the source enabling protective devices, such as circuit breakers or fuses, to operate.
Safe Work Practices

• Grounding Path

• The path to ground from circuits, equipment, and enclosures must:
  – Be permanent and continuous.
  – Have capacity to safely conduct any fault current likely to be imposed on it.
  – Have sufficiently low impedance to limit the voltage to ground, and to facilitate the operation of circuit protective devices.
Safe Work Practices

• Grounding Path

• For a safe grounding path:
  – When a metallic raceway system is used, the metallic system must be continuous and permanent.
  – When a metallic raceway system is not used, a green or bare equipment-grounding conductor close to the supply conductors must be used to assure that all enclosures are bonded together and to the source.
Safe Work Practices

• Polarity
• Polarity is an electrical condition determining which direction current will flow.
• Reversed polarity is a condition when the identified circuit conductor (the grounded conductor or neutral) is incorrectly connected to the ungrounded or "hot" terminal of a plug, receptacle, or other type of connector.
• No grounded conductor may be attached to any terminal or lead so as to reverse designated polarity.
Safe Work Practices

Polarity

• Improper connection of conductors is most prevalent on the smaller branch circuit typically associated with standard 120 volt receptacle outlets, lighting fixtures, and cord and plug connected equipment.

• When plugs, receptacles, and connectors are used in an electrical branch circuit, correct polarity between the ungrounded (hot) conductor, the grounded (neutral) conductor, and the grounding conductor must be maintained.

Safety Tip: Older outlets are not visually polarized and can have equipment improperly plugged. With polarized plugs and outlets, improper use should not be possible.
Safe Work Practices

• Cord and Plug Grounding
• Exposed non current-carrying metal parts of cord-and-plug connected equipment must be grounded if they are:
  – Located in a potentially flammable or explosive atmosphere.
  – Operated at over 150 volts to ground, except for guarded motors and metal frames of electrically heated appliances if the appliance frames are permanently and effectively insulated from ground.
Safe Work Practices

• Cord and Plug Grounding
  – Grounding of metal parts is not required where the equipment is supplied through an isolating transformer with an ungrounded secondary of not over 50 volts or if portable tools are protected by an approved system of double insulation.
  – If such a system is employed, the equipment will be distinctively marked to indicate that the tool or appliance uses an approved system of double insulation (Underwriter’s Lab(UL), Factory Mutual (FM)).

Tip: 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. done
Safe Work Practices

• Bonding
  – Static electricity is generated when air, fluids or objects rub against each other.
  – Electrically connecting (bonding) containers allows static charges between them to equalize.
  – To prevent injury, bonding is important when:
    • Pouring flammable liquids from one container to another.
    • Charging wet cell batteries, which can generate flammable hydrogen gas.
Case Study

• Electrocution
  – Steelworker fatally injured.
  – Reversed polarity and faulty equipment.
Case Study

• Electrocution

– On the day of the incident:
  • Day shift (7:00 a.m. to 3:00 p.m.) of the steel-making department in which the victim worked, was conducting normal daily operations.
  • Crew of 4 workers including the victim, had been performing maintenance on a tundish.
  • At about 9:50 a.m., the crew decided to take a break. The crew took a 15-minute break once an hour due to the hot working environment.
Case Study

- Electrocution
- The victim walked to the lunch room and sat on a wooden bench next to a floor-model air conditioner, which was approximately 30 inches tall. A toaster oven was on top of the air conditioner and plugged into a 120-volt electrical circuit.
- The victim, who was sweating profusely and wearing a short sleeved shirt, rested his right forearm on top of the air conditioner. The victim's right arm contacted the casing of the toaster oven, which was energized, while his right calf was in contact with the grounded air-conditioning unit.
Case Study

- Electrocution
- The victim began to shake which attracted the attention of the co-workers. A co-worker, suspecting the victim was being shocked, knocked the toaster oven off the air conditioner, disconnecting the plug from the receptacle. Current had traveled through the victim and exited at the point of contact between the victim's right leg and the grounded casing of the air conditioner.
- The plant EMS team provided advanced cardiac life support. The victim received additional treatment from the local emergency medical service which transported him to the local hospital where he was pronounced dead on arrival.
Case Study

- Electrocution
- Investigators learned that the toaster oven's power cord had a non-polarized plug which, sometime prior to the incident, had been inversely inserted into a polarized receptacle. The heating element in the toaster oven had been previously damaged and was in contact with the oven casing. Reverse insertion of the plug in the polarized receptacle created a condition known as reversed polarity. Electrical current flowed through the heating element without the switch being turned to the ON position and energized the toaster oven casing.
Case Study

• Electrocution

• You may have heard the statement from co-workers that 120 volt circuits won’t hurt you. This is a common misconception. This is a good example where an employee worked safely in a high hazard work environment, but was tragically killed in a seemingly innocuous setting.
Case Study

• Electrocution
• In order to prevent future occurrences, employers should:
  – Periodically inspect all areas of the facility for electrical hazards and implement appropriate controls.
  – Adopt a policy requiring that all appliances brought into their facility be tested for electrical integrity by qualified persons before they are used.
  – Periodically re-evaluate safety programs and reinforce training related to worker recognition, avoidance, and reporting of hazards.
  – Provide cardiopulmonary resuscitation (CPR) training to all workers, both management and labor.

Safety Tip: CPR is the proper treatment for electrical shock. An automated external defibrillator or AED is a portable electronic device that automatically diagnoses the potentially life threatening cardiac arrhythmias of ventricular fibrillation and ventricular tachycardia in a patient and is able to treat them through defibrillation, the application of electrical therapy which stops the arrhythmia, allowing the heart to reestablish an effective rhythm. AEDs are designed to be simple to use for the layman, and the use of AEDs is taught in many first aid, first responder and basic life support (BLS) level CPR classes.
Circuit Protection Devices

Circuit protection devices are designed to automatically shut off the flow of electricity in the event of a short circuit or overload.

There are three basic types of circuit protection devices:

- Circuit breaker
- Fuse
- Ground fault circuitinterrupter (GFCI)
Circuit Protection Devices

– Circuit Breakers and Fuses
– Operate when the current in a circuit exceeds a certain value.
– Prevent overheating of the components, conductors and equipment.
– ARE NOT DESIGNED TO PROTECT WORKERS FROM ELECTRIC SHOCK OR CURRENT FLOW.
Circuit Protection Devices

- Ground Fault Circuit Interrupters
- A ground fault circuit interrupter is not an overcurrent device like a fuse or circuit breaker.
- GFCI's are designed to sense an imbalance in current flow over the normal path by measuring magnetic field around each wire in the circuit when current is flowing.

Safety Tip: GFCI protection is required for any outlet within 6 feet of a water source by the NEC.
Circuit Protection Devices

• Ground Fault Circuit Interrupters
• The GFCI will open the circuit within 1/40 th of a second when:
  – The current flow in the two wires differs by more than 5 mA
  – More than 5 mA of current returns to the service entrance by any path other than the intended white (grounded) conductor.
• A GFCI is designed to shut off and protect a worker from current flow when a faulty tool is used.
Circuit Protection Devices

• Types of GFCIs

• Circuit-breaker:
  – The circuit-breaker type combines the functions of a standard circuit breaker with the additional functions of a GFCI.
  – It is installed in a panel board and can protect an entire branch circuit with multiple outlets.
  – It is a direct replacement for a standard circuit breaker of the same rating.
Circuit Protection Devices

• Types of GFCIs
• Receptacle:
  – The receptacle style GFCI incorporates, within one device, one or more receptacle outlets protected by the GFCI.
  – Most are of the duplex receptacle configuration and can provide GFCI protection for additional non-GFCI type receptacles connected "down stream" from the GFCI unit.
  – Such devices are becoming very popular because of their low cost.
Circuit Protection Devices

• Types of GFCIs

• Permanently-mounted:
  – The permanently mounted types are mounted in an enclosure and designed to be permanently wired to the supply.
  – They are frequently used in areas near water such as: swimming pools, kitchens, bathrooms, and garages.
Circuit Protection Devices

• Types of GFCIs

• Portable:
  – Portable GFCIs contain one or more integral receptacle outlets protected by the GFCI module and can be easily transported.
  – Only units designed and designated for outdoor use should be used in environments exposed to weather conditions.
• Types of GFCIs
• Cord-connected type:
  – Consists of an attachment plug which incorporates the GFCI module.
  – Provides protection for the cord and any equipment attached to it.
  – Equipped with test and reset buttons within the attachment plug.
  – Incorporates a no-voltage release device which will disconnect power to the load if any supply conductor is open.
Circuit Protection Devices

- Testing of GFCIs
  - GFCIs have a built-in test circuit that imposes an artificial ground fault on the load circuit to assure that the ground-fault protection is still functioning. Test and reset buttons are provided for testing.
- Ground Fault Circuit Interrupters must be tested:
  - Monthly for permanently wired devices.
  - Before each use for portable type GFCIs.
Equipment Design

• Protecting Conductors

• Since conductors can be damaged by rubbing against the sharp edges of cabinets, boxes, or fittings, they must be protected where they enter by use of some type of clamp or rubber grommet.

• The device used must close the hole through which the conductor passes as well as provide protection from abrasion.
Equipment Design

- Protecting Conductors
- If conductor is in a conduit and the conduit fits tightly in the opening, additional sealing is not required.
- Knockouts in cabinets, boxes, and fittings should be removed only if conductors are to be run through them.
- If a knockout is missing or if there is another hole in the box, the opening must be closed with a device equivalent to the manufacturer’s knockout.
Equipment Design

- Flexible Cords
- More vulnerable than fixed wiring.
- Do not use if one of the recognized wiring methods can be used instead.
- Flexible cords can be damaged by:
  - Aging
  - Door or window edges
  - Staples or fastenings
  - Abrasion from adjacent materials
  - Activities in the area
- Improper use of flexible cords can cause shocks, burns or fire.

Tip: 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.
Equipment Design

- **Flexible Cords**
  
  - Pendant, or Fixture Wiring
  - Portable lamps, tools or appliances
  - Stationary equipment—to facilitate interchange
Equipment Design

• Flexible Cords

• Prohibited uses:
  – Substitute for fixed wiring
  – Run through walls, ceilings, floors, doors, or windows
  – Concealed behind or attached to building surfaces
  – Not to be daisy-chained to other power strips or connected to extension cords
Equipment Design

- Covers and Canopies
- All pull boxes, junction boxes, and fittings must be provided with approved covers.
- If metal covers are used, they must be grounded.
- In completed installations, each outlet box must have a cover, faceplate, or fixture canopy.
Equipment Design

• Covers and Canopies
• Covers of outlet boxes having holes through which flexible cord pendants pass must have bushings or smooth, well-rounded surfaces to protect the flexible cords.
• Employees
• For employees who work on electrical equipment there are several types of Personal Protective Equipment (PPE) which can be worn.
• Non-conductive footwear, gloves and sleeves.
• Non-conductive hard hats, safety glasses/face-shield.
Protective Equipment

• Tools and Equipment
• There are several pieces of equipment that are designed to protect personnel from shock and injury.
• Non-conductive tools
• Double-insulated tools
• Rubber mats
• Insulated blankets

Tip: 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.
Control of Hazardous Energy

– COHE Program
– All facilities and operations that service and/or maintain...
  • machines,
  • equipment and/or
  • processes
  • that can unexpectedly release injury-causing energy must establish and maintain a written Control of Hazardous Energy (lockout/tagout) program.
Control of Hazardous Energy

• What is COHE?
  – Control of Hazardous Energies Program.
    • Also called Lockout/Tagout (LOTO).
    • Designed to protect employees from injury that can occur during an unexpected release of energy.

Tip: "Lockout/Tagout (LOTO)" refers to specific practices and procedures to safeguard employees from the unexpected energization or startup of machinery and equipment, or the release of hazardous energy during service or maintenance activities. Learn more at the website shown: http://www.osha.gov/SLTC/controlhazardousenergy/index.html
Control of Hazardous Energy

• Lockout/Tagout
  – Most common means of isolating hazardous energy in the workplace.
  – Lockout: Physical placement of a locking device to isolate any and all energy and to prevent equipment from being operated.
  – Tagout: Placing a written warning “Tag” on the energy isolation device which clearly indicates that the equipment may not be operated until the tagout device is removed.
Control of Hazardous Energy

• Energy Control Program (ECP)
  – Energy control procedures.
  – Employee training, periodic inspections.
  – Ensure any machine/equipment where unexpected energizing, startup or release of stored energy could occur and cause injury has been isolated from the energy source and rendered inoperative before any employee performs maintenance or services it.
Control of Hazardous Energy

• What is a Zero Energy State?
  – A zero energy state - No hazardous energies exist.
  – Verifying zero electrical energy is accomplished through a process called testing and metering.
  – Try to start equipment before you work on it.
  – REMEMBER: LOCK/TAG/TRY
  – Your life may depend on it!
Control of Hazardous Energy

• Electrical: What to Know Before LOTO
  – Zero energy state must be verified before work begins.
  – Verify that ALL electrical energy has dissipated.
  – Look for capacitors or secondary electrical sources.
Control of Hazardous Energy

• LOTO

• A disconnecting means is often a switch or a breaker that disconnects the conductor from the generator.

• Once a disconnecting means has been identified for the piece of equipment, it must be clearly labeled.
Control of Hazardous Energy

- LOTO
  - Determine the proper isolation point from which to control electrical energy.
  - Use the closest electrical disconnect for the LOTO control point.
  - All electrical energy in excess of 50 volts must be de-energized unless you can demonstrate that de-energizing introduces increased hazards or is infeasible due to equipment designs or operational limitations.
Control of Hazardous Energy

- LOTO
- The most common cause of electrical shock and electrocution for workers is the failure to properly lock and tag out electrical energy.
- ALL electrical work should be de-energized before work is performed to prevent electrical shock.
- LOTO can eliminate the electrical hazard for your task.
Methods of Isolation

- Energy Control Devices
- Electrical energy control devices typically consist of a lock that is dedicated to one employee. Each lock must have only one key that is available only to the employee whom it is intended to protect.
- One key in the hands of the employee who is performing the work.
- Lockout devices are available from standard safety supply vendors or your supervisor.
Methods of Isolation

- Energy Control Devices
  - Identifying proper lock/out device depends on:
    - Hazards
    - Process
    - Energy involved
Methods of Isolation

• Multiple Lock Systems
  – Multi-lock hasp/group lock:
    • Multiple locks
    • One Lock - one key per worker
  – By using a multiple lock hasp or a group lock system, a crew of workers can safely work on one system at the same time.
  – Ensures all work has been completed (and all employees are out of the exposure area) before the equipment is re-energized.
Methods of Isolation

• Isolation Device Integrity
  – Lockout device:
    • Substantial enough to withstand excessive force (metal cutting tools, bolt cutters).
  – Tagout device:
    • Both Tag and attachment devices must prevent accidental removal.
    • Must be made from non-reusable material.
    • Must have an unlocking strength of 50 lbs.
Methods of Isolation

• Standardization
  – Lockout/tagout devices: Should be a standard color, shape and size.
  – Tagout devices should be standardized by print and format.
  – Constructed to withstand exposure to weather.
  – Must identify employee applying the device.
  – Tags must have written statements such as DO NOT START, DO NOT OPEN, or DO NOT OPERATE.
Methods of Isolation

- Tagout

- Tag out alone can only be used when machine or equipment is not capable of lockout system.
  - NOTE: If capable of being locked out, a lockout system is mandatory.

- All machine and equipment that is newly installed, replaced, repaired, renovated or modified must be designed to accept a lockout device.
Energy Control Program

• Periodic Inspection
  – Supervisors must ensure that lockout/tagout programs are evaluated annually for effectiveness.
  – Any identified deficiencies must be corrected immediately.
Energy Control Program

• Personnel
  – Three critical personnel:
    • Authorized employee, affected employee, and other employee.
    • Authorized employee implements LOTO to perform service and maintenance.
Energy Control Program

• Personnel
  – Critical Personnel:
    • Affected Employee:
      – Operates equipment on which service or maintenance is performed.
    • Other employees:
      – Employees working in area of LOTO operations.
Energy Control Program

• Training
  – Training is...
    • Necessary for the authorized, affected and other employee to ensure that the purpose and function of the energy control program are understood and that the knowledge and skills required for the safe application, usage, and removal of the energy controls are acquired.
• Training
  – Authorized Employee: Recognize hazardous energy sources, understand type and magnitude of energy, know methods and means to isolate and control.
  – Affected Employee: Understand purpose and use of the Energy Control Procedure.
  – Other Employees: Understand importance of procedure, know prohibition to attempt to restart or reenergize if locked out or tagged out.
Energy Control Program

- Employee Re-training
  - Re-training must occur whenever:
    - Job or equipment changes.
    - There are changes to the energy control procedures.
  - Employee understanding must be documented.

Tip: check out the link shown to learn about one publication that can be useful in providing electrical safety training to employees: http://www.cdc.gov/niosh/docs/2002-123/pdfs/02-123.pdf
Energy Control Program

- Equipment
- Repair and installation activities:
  - Some repair and installation activities require that work be performed while the electrical power sources are still connected. This should be done only if it is determined that the work must be done live, you have been trained to perform the work safely, and proper protective equipment and procedures are used.
  - Use LOTO whenever possible.
  - Your life can depend on it!

Safety Tip: Only “Qualified” personnel can work on energized equipment.
Working With Electricity

- More Safe Work Practices
- DOs and don’ts when working with or around electricity.
- Some of these will review what we have covered, others may be new to you.
- Many of these work practices are required by the OSHA standards, some are merely smart practices learned by tradesmen over the years.
Working With Electricity

• More Safe Work Practices
• Some don’ts:
  – Don’t hang extension cords over sharp objects or leave them exposed to traffic. Excessive wear or cutting will shorten life and create hazards.
  – Don’t overload circuits. Overloads will weaken and break down insulation resulting in hazards now or at some later time.
  – Don’t bridge fuses.
  – Don’t use electrical equipment while standing in water or on a wet surface.
Working With Electricity

• More Safe Work Practices
  – More don’ts:
    • Don’t ignore even the slightest shock. A tingle is a warning that something is wrong. With better contact to ground or lower resistance the next time, the shock might be major. Find and correct the problem immediately.
    • Don’t hold energized electrical equipment with wet or bleeding hands. Resistance to electrical flow will be very low. Remember, even perspiration can reduce electrical resistance.
    • Don’t abuse electrical cords. Don’t use them when insulation becomes cracked, brittle or frayed.
Working With Electricity

• More Safe Work Practices
  – Don’ts:
  • Avoid wearing rings, metallic watchbands or other conductive items. These can increase your exposure to shock.
  • Never use water on an electrical fire. Know where to find and use a Class C or ABC fire extinguisher for use on energized electrical equipment.
  • Don’t use electric cords as clothes hangers, never place anything on the lines.
  • Also, do not kink or place in a sharp bend as it will break down the insulation.
Working With Electricity

• More Safe Work Practices
  – Unless you have personally tested or locked out and tagged electrical equipment or circuits, assume that wiring or equipment is energized.
  – Whenever possible use only one hand when working on circuits or control devices.
  – When touching electrical equipment (example, checking for hot motor), use the back of the hand, so that if shock were to occur, involuntary muscle contraction would cause your hand to move away from the device and not grip or freeze onto it.
Working With Electricity

• More Safe Work Practices
  – When working on circuit, be sure it has been de-energized. Follow company lockout/tagout procedures.
  – If you see tag on switch do not activate circuit without permission from person who placed tag there.
  – Check extension cords for burned spots and bare wires. Do not use, discard immediately.
  – Use GFCIs whenever possible on a construction site or anywhere you are using temporary power, extension cords, etc.
Working With Electricity

• More Safe Work Practices
  – Examine your equipment, such as cords, plugs, tools, etc. prior to use.
  – If electric equipment doesn’t immediately start up, don’t keep trying to start it. Something is wrong – you’ll likely make it worse.
  – Don’t try to repair tools by taking them apart unless you are a qualified electrician. Turn them in for repair.
More Safe Work Practices

- Service panels:
  - It is always wise to disconnect power to a service panel before performing work on it, such as changing fuses.
  - In fact, all cartridge-type circuit fuses accessible to unqualified employees must be equipped with a disconnect means.
  - In addition, where cartridge-type fuses are located in systems with over 150 volts to ground, a disconnect means is required regardless of the qualifications of the person having access.
Working With Electricity

• More Safe Work Practices
  – Report any unusual conditions such as sparking, arcing, smoke, odors or unusual noises coming from electrical equipment.
  – Obtain first aid for, and report any shocks or burns you receive from electrical equipment, etc. Electrical burns are often worse than they first appear.

Tip: Click on the link shown to review and download OSHA’s Electrical Safety Quick Card. A great quick reference to electrical safety and safe work practices.
• Inspection Procedures
  – General:
    • Now let’s review guidelines that can assist in early recognition of electrical hazards. Simple inspections of wiring, equipment, switches, lamps, etc. Inspections should be performed by someone on a regular basis. If you don’t know that it is being done, perform inspections yourself on the equipment and wiring you use. These guidelines are not all inclusive but are simply meant to provide some tips on what to look for.
Working With Electricity

• Inspection Procedures
  – Motors and generators:
    • Check motors and generators for dirt or damage.
    • Look and listen for excessive vibration or misalignment.
    • Look for worn insulation, sparking, or overloading.
    • Be sure vents are free of dirt or debris.
    • Be sure there are fuses, breakers or some form of overload protection in the circuit.
• Inspection Procedures
  – Check wiring:
    • For damp or wet wires.
    • For oil, grease, corrosive solutions or other chemicals that could damage the wires.
    • For evidence of deteriorated insulation, broken fittings or enclosures.
    • For sharp bends in wires, and wires resting on sharp edges that could cut them.
    • For evidence that additional loads may have been placed on circuits without compensating with heavier wiring, etc. if needed.
    • In hazardous locations, such as with possible flammable atmospheres. Electrical installations in such areas need to be rated for the classification.
• Inspection Procedures
  – Check switches and controllers for:
    • Loose connections at terminals that could cause arcing or overheating.
    • Loose parts that could cause shorts or ground faults. Loose or missing covers on switch boxes. Can they be properly secured?
    • Missing knockouts.
    • Unusual noises from switch.
    • Excessive heat from a switch or junction box.
    • Short circuits: Leakage of water, oil or conductive dusts into switch enclosures.
    • Inadequate fuses or breakers.
Working With Electricity

• Inspection Procedures
  – Jobsite work areas:
    • Are working spaces and walkways kept clear of cords?
    • Are proper warning signs posted where electrical hazards exist, such as high voltage switch gear?
    • Extension cords fastened with staples, hung from nails, or suspended by wire?
    • Overhead lines that may become a hazard if work is performed in their vicinity?
Summary

During this course:

– We have discussed the basics of electricity, electrical safety concepts.
– We have identified hazardous electrical energy sources and electrical hazards; we have discussed ways to control those hazards.
– We have explained the concept of lock-out/tag-out and have provided solutions for the control of hazardous electrical energies.
Summary

• Summary

• Let’s review some of the most important concepts:
  – Do not work on live electrical equipment unless you are specifically trained to do so.
  – Make sure your equipment is in good condition and that all circuits are properly grounded.
  – Avoid overloading circuits.
  – Ensure that electrical protection devices are in place and serviceable.
• Summary

• Review:
  – Avoid overhead power line hazards.
  – Make sure live electrical parts are properly guarded or protected.
  – Always use proper PPE.
  – Use lockout/tagout when working on de-energized electrical equipment.
  – Do not remove locks or tags unless you affixed them.