Safe Practice Electrical Safety

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Safe Practice for Electricity

Introduction

- An average of one worker is electrocuted on the job every day
- There are four main types of electrical injuries:
  - Electrocution (death due to electrical shock)
  - Electrical shock
  - Burns
  - Falls

OSHA Issues Revisions to

Electrical Terminology

- Current – the movement of electrical charge
- Resistance – opposition to current flow
- Voltage – a measure of electrical force
- 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

Electrical Shock

• Received when current passes through the body

• Severity of the shock depends on:

• Path of current through the body

• Amount of current flowing through the body

• Length of time the body is in the circuit

LOW VOLTAGE DOES NOT MEAN LOW HAZARD

Electrical Hazards

Every year between 300 and 500 people are fatally electrocuted in U. S.

Workplaces. Many of those people, including office workers and operators, work

only indirectly with electricity

Electricity, as a raw source of power, presents as many hazards as it does benefits.

Safe Practice Electrical Safety

To handle electricity safely, persons need to know:

- How it acts
- How it can be controlled
- How to manage its hazards

OSHA Quick Card (https://www.osha.gov/Publications/electrical_safety.html)

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

- Assume that all overhead wires are energized at lethal voltages. Never assume that a wire is safe to touch even if it is down or appears to be insulated.
- Never touch a fallen overhead power line. Call the electric utility company to report fallen electrical lines.
- Stay at least 10 feet (3 meters) away from overhead wires during cleanup and other activities. If working at heights or handling long objects, survey the area before starting work for the presence of overhead wires.
- If an overhead wire falls across your vehicle while you are driving, stay inside the vehicle and continue to drive away from the line. If the engine stalls, do not leave your vehicle. Warn people not to touch the vehicle or the wire. Call or ask someone to call the local electric utility company and emergency services.
- Never operate electrical equipment while you are standing in water.
- Never repair electrical cords or equipment unless qualified and authorized.
- Have a qualified electrician inspect electrical equipment that has gotten wet before energizing it.
- If working in damp locations, inspect electric cords and equipment to ensure that they are in good condition and free of defects, and use a ground-fault circuit interrupter (GFCI).
- Always use caution when working near electricity.

Included:

How Electricity works

Understanding Ohm's Law

Understanding the purpose of a ground fault circuit interrupter

Describing various electrical hazards

Providing and understanding the need of Personal Protective Equipment (PPE)

How to avoid electrical accidents

Recognizing potential electrical violations in the work environment

Understanding Electricity - How Electricity Works

Think of electricity as a waterworks. Operating as electric switch is like turning

on a water faucet. Behind the faucet there must be a source of water, a means of

transport and a force to make it flow.

In the case of water, the source is a reservoir of pumping station; the means of transport is a network of pipes; and the force to make it flow is provided by a pump.

In the case for actual electricity, the source is the power generating station;

- **Current** travels through electric conductors, wires for mast cases; and the force to make it flow which is **voltage**, measured in volts (it is provided by a generator)
- Resistance is a term that describes the forces that oppose the flow of electricity through a material
- The way to measure resistance is in "Ohms," named after George Ohm, who is 1827 discovered the relationship between current, voltage and resistance

Georg Simon Ohm
1789 - 1854

Ohm's Law

Governs the three basic components of electricity

1. Voltage (E)

2. Current (I)

3. Resistance (R)

Voltage (E) = Current (I) [Amperes] X Resistance (R) E=IR

If the current is 5 amps and the resistance is 20 ohms, what is the applied voltage?

E = (5) R 5 X 20 or E = 100 Volts

If the voltage is 100 volts and the resistance is 25 ohms, what is the current in the

circuit?

I = E / R 100/4 or I = 4 Amps

If the current is 2 AMPS and the applied voltage is 100, what is the resistance?

R=11/2 R = 50 OHMS

Conductors and Insulators

Conductors:

- They permit electrons to flow freely from atom to atom and from molecule to molecule
- Conductors are "electricity friendly"

Insulators:

- Insulators are not electricity friendly
- Insulators impede the free flow of electrons
- Insulators include: Rubber, porcelain and dry wood

What is Grounding?

Defective bonding strap shows poor maintenance

Proper Ground

Secondary grounding to radio tower ground plus remote earth best practice

Grounding can make the difference between life and death. Anything conductive

touching an electrical current and the ground at the same time is "Grounded." The object

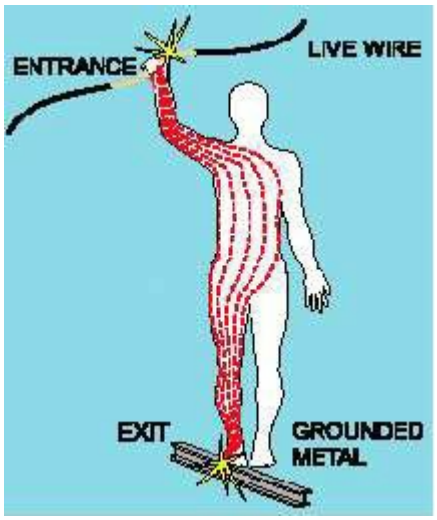
providing the connection between the current and the ground is referred to as the "path to

ground."

If the power source being used is ungrounded, and someone comes in contact with the

electrical current, they may provide what is called a "path to ground." This means that

they become a conductor, allowing electrical current to pass through their body.



There are two kinds of electrical grounds: both are required by OSHA Standards:

System or Service Ground:

1. In this type of ground, a wire called the neutral conductor is grounded at the

transformer, and again at the service entrance to the building. This is primarily designed

to protect machines, tools, and insulation against damage.

Equipment Ground:

2. This is intended to offer enhanced protection to the workers themselves. If a

malfunction causes the metal frame on a tool to become energized, the equipment ground

provides another path for the current to flow through the tool to the ground. (This is also

known as secondary or backup protection in the event of a primary ground fault break or

breach)

Consider the following situations:

1. What if there is a break in the grounding system that the user doesn't know about?

How could this happen?

- There is a 3 prong plug that is correctly attached to a 3 prong receptacle, but the receptacle is not correctly grounded to a lightening rod?
- The extension cord grounding has a break unknown to the user

2. What if someone provided a shorter path to ground than the existing grounding

system?

How could this happen?

· Properly functioning grounded extension cord is accidently cut with a sharp

ungrounded object

· Wet user connects two wet extension cords and provides a path to ground

GFCI is the answer to keep those situations from becoming fatal or a hazard

* What is a GFCI? A ground fault circuit interrupter. A GFCI works by comparing

the amount of current returning from the device along the electrical conductors.

* GFCIs can shut off electrical power in as little as 1/40 of a second, greatly

increasing the likelihood of survival

*UL (Underwriters Laboratories) recommends testing GFCIs once a month or after severe thunderstorms to verify they are working properly.

Something to think about

When someone provides a path to ground, the electrical current takes the shortest path

through their body. That means there is a greater chance of survival is the current if the

current passes through their foot to the ground. If a hot wire hits their hand it will pass

from their hand through their body (more likely to affect the heart and other organs) then

out through their feet.

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

• Beware of power lines when you work with ladders and scaffolding

The Hazards of Electricity

Electricity may seem harmless however no one should ever become complacent

There are three (3) primary hazards posed by electricity:

1. Shock

2. Arc-flash

3. Arc-blast

There are also secondary injuries that can result from electrical mishaps

Electrical Shock

Received when current passes through the body - Persons actually become part of the

circuit. Electrical shock normally occurs in one of three ways

When an individual is in contact with the ground and then comes into contact with:

1. Both wires of an electrical circuit

2. One wire of an electrical circuit

3. A metallic part that has become energized through contact with an energized

conductor.

The severity of an electrical shock varies according to:

· The amount of current measured in amps

· The path through the body

· The length of time the body is part of the circuit

Below are some values of current. Their relationship to injury is not exact but they

are generally accepted as the resulting injury for a 60-cycle current, hand to foot

shock lasting for 1 second.

- 1 Millampere (mA)- Perception level: just a faint tingle
- 5 Millamperes - Slight shock felt, not painful but disturbing. The average individual can let go. However, strong involuntary reactions in this range can lead to injuries.
- 6-25 Millamperes - Painful shock, muscular control lost. This is called the freezing current of "let go" range for women.
- 9-30 Millamperes - Painful shock, muscular control lost. This is called the freezing current or "let go" range for men
- 50-150 Millamperes - Extreme pain, respiratory arrest, severe muscular contractions. Individual s cannot let go. Death is possible
- 1,000-4,300 Millamperes (1.43 amps) - Ventricular fibrillation (The rhythmic pumping of the heart ceases) Muscular contraction and nerve damage occur. Death is likely.
- 10,000 Millamperes (10 amps) Cardiac arrest and probable death

ARC-flash

Electric Arc-flash is a short circuit through the air when working on or near energized

equipment, resulting in a phase-to-ground or a phase-to-phase fault.

In order to provide a understanding of the intensity of an arc-flash

During an arc-flash, temperatures may exceed 35,000 degrees F (the sun surface is 9,000

degrees F)

- **An electric arc flash can:**
- **Ignite or melt clothing on skin causing severe burns**
- **Damage vision, sometimes resulting in blindness**
- **Knock a person over**
- **Make no mistake about it - lives can be changed in a flash**

ARC-Blast

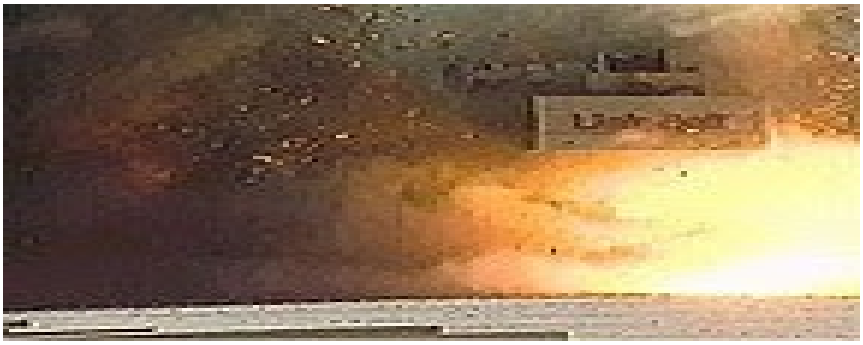
The third electrical hazard, arc-blast occurs as a result of the second hazard arc-flash

Arc-blast produces a pressure wave (141.5 decibels and 2,160 pounds per square

foot)

· The pressure wave can rupture ear drums and collapse lungs

· The blast contains projectiles



Secondary Electrical Shock Injuries

- **Electrical burn is the most common shock related, non-fatal injury that often occurs when an invidual touches faulty electrical wiring or equipment that has been improperly used or maintained**
- **Typically the injuries occur on the hands**

Very serious injuries that require immediate attention and first aid can include:

- · Bruises
- · Bone Fractures
- · Collisions of falls possibly resulting in death
- Arc-flashes may:
- · Generate fires
- · Cause explosions when in close proximity to flammable gasses, vapors or combustible dust

Consensus Standards:

Consensus Standards help determine safe work practices

Occupational Safety and Health Administration (OSHA)

Regulation 1910:333: States workers should not work on live equipment unless one of

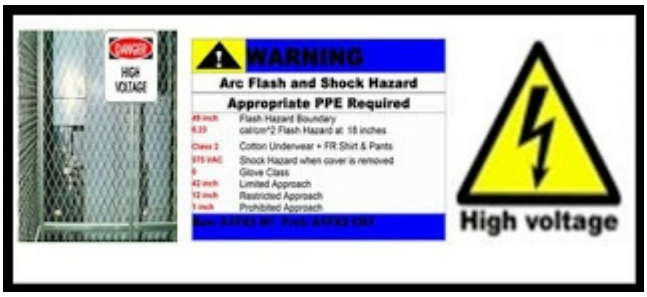
the following conditions is met:

1. The deenergization introduces additional or increased hazards to the worker

2. It is infeasible due to equipment design or operational limitations

National Standards

- National Electrical Safety Code (NESC)
- National Fire Protection Association (NFPA)
- NFPA 70, National Electric Code (NEC)
- NFPA 70E Standard for electrical safety in the workplace
- American National Standards Institute
- ASTM 1506 - Fire resistance of fabric
- ASTM F2178 - face shield tint specifications



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

NFPA 70E Standard

There are standards when workers are required to work on potentially "live" electrical

components, such as Trouble-shooting an electrical panel or maintaining a substation.

Workers must be skilled and trained for "live electrical" work

1. Workers must have the ability to distinguish between exposed live parts and other

parts for electrical equipment

2. Workers must have the skills and techniques necessary to determine the nominal

voltage of exposed live parts.

3. Workers must possess the working clearances and approach boundaries as

outlined by the National Fire Protection Association's (NFPA) 70E code.

The NFPA 70E Standard

- The NFPA 70E Standard for electrical Safety in the workplace also contains consensus standards for performing a flash hazard analysis, to be carried out whenever working with electricity.
- A flash hazard analysis allows an employer to properly calculate the real level of risk involved when working on a specific energized component. The results of that analysis enables a qualified worker to reference a table in the NFPA 70E
- Standard and determine safe approach boundaries and working clearances as well as situation-appropriate personnel protective equipment.

Know your Boundaries (NFPA 70E)

There are 3 approach boundaries:

1. Limited

2. Restricted

3. Prohibited

1. The Limited Boundary applies to unqualified personnel. This boundary is as close as unqualified workers are allowed to get to the live work. Even at this point, they must be accompanied by a qualified worker to ensure their safety

2. The Restricted Boundary should be crossed only by qualified persons properly outfitted with the necessary personnel protective equipment, or PPE.

3. The Prohibited Boundary is the closest boundary to the source. Only qualified personnel wearing PPE who have a documented plan justifying the need to perform this work may get this close.

Many experts see no difference between crossing the prohibited boundary and actually

contacting the exposed energized part.

More can be found about the approach boundaries themselves by

referring to NFPA 70E Table 2-1.3.4

The NFPA 70E Standard requires that "Qualified" electrical workers must also

wear clothes made from natural fibers.

- **Approved fibers are Cotton and Wool (man-made fibers will melt and burn)**
- **Voltage-rated rubber gloves, insulated sleeves and tinted face shields**
- **Hoods, bib overalls and special jackets**

Arc Blast PPE Micro Flex approved gloves ARC Blast Coat

How to be protected from Electrical Hazards :

1. Know the Distance: Commonly used with regard to power lines.

2. Isolate & Guard: Restrict access, to high voltage power distribution equipment.

3. Enclose all electric parts: Electrical wiring, all connections made in junction box.

4. Grounding: Required for all non-current carrying exposed metal parts, unless isolated or

guarded as above. (corded tools may be either grounded or be double-insulated).

5. Insulation: Intact insulation allows safe handling of everyday electrical equipment,

including corded tools, insulated mats and sleeves.

6. DE-Energizing & Grounding: Compliant method used by electrical utilities and also in

conjunction with electrical lockout/tagout.

7. Personal Protection Equipment (PPE): Using insulated gloves and other apparel to work on or

around energized equipment, limited to qualified and trained personnel working under

limited circumstances.

Safe Practice Electrical Safety

Electrical Accidents

1. Electrical accidents usually result from three factors

2. Unsafe equipment and or installation

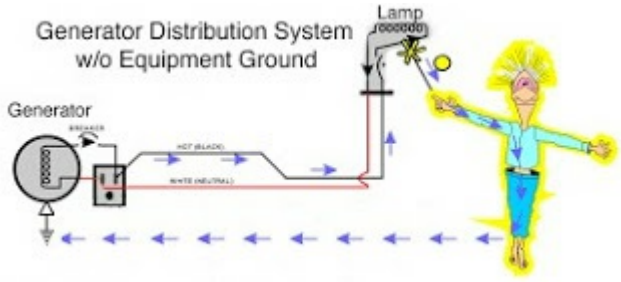
3. Work places made unsafe by environmental factors, such as dampness

4. Unsafe work practices

Preventing Electrical Accidents

- Insulation - Ensure that there are no exposed wires
- Guarding - Live parts of 50 volts or more must be guarded against accidental
- contact. Installations over 600 volts must be controlled by a metal enclosure oflock, and marked with caution signs.
- Grounding - A low-resistance path to the earth is intentionally created. The ground does not guarantee that there will be no shock, injuries or fatalities, but it does reduce the possibilities.

Installed Safe Guards



GFCI

Switches

Circuit Protection Devices

AFCI

- GFCI or Ground Fault Circuit Interrupter - is designed to shut off electric power within as little as 1/40 of a second, by comparing the amount of current returning from the device along the circuit conductors.
- Switches - Always shut down equipment with the switch
- Circuit Protection Devises are designed to automatically limit or shut off the flow f electricity. In the event of a ground fault, overload or short circuit in the wiring system. These can be fuses or circuit breakers.
- Arc Fault Circuit Interrupter (AFCI) is designed to reduce the likelihood of fire caused by electrical arcing faults; required in bedroom receptacles.

Safe Work Practices

- De-Energize Electrical Equipment
- Turn off, unplug and, if appropriate, lock out systems

- **Use properly functioning tools:**
  Use tools that are Inspected, Maintained, UL approved

  Use Good Judgment:
  - Have the line de-energized
  - Ensure that the line remains de-energized by using lockout / tag out
  - Keep a safe distance from energized lines

  Use protective equipment
  - Use appropriate electrical protection for the level of potential electrical danger
  - Use required PPE

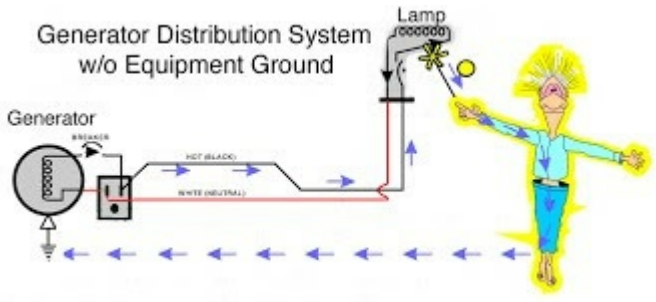
  Electrical Violations - Every workplace has them

Electrical Violations - Every workplace has them

It is not a matter of if - - - - It is a matter of when

- Recognize them early
- Address them with urgency
- Inadequate Wiring
- Make sure that anyone doesn't use just any extension cord.
- All users must first consider whether the size of the cord's wire is too small to handle the current that the tool or machine will draw from the power source.
- The tool may draw more current than the cord can handle, causing overheating and a potential fire before tripping the circuit breaker
- The breaker may not be rated for a smaller-wire extension cord.
- Overload
- Sometimes there may be more plugs than outlets
- If the circuit breakers or fuses are too big - their current rating is too high - for the wires they are suppose to protect, an overload in the circuit will not be detected and the current will not shut off.
- Plan ahead to determine how many power sources will typically be needed in each work week area and make sure there are ample electrical outlets for those sources.

Faulty Grounding Path

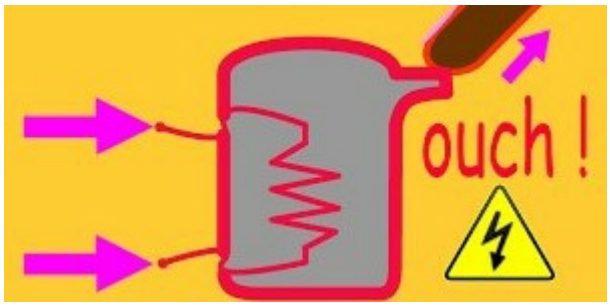


- It was mentioned earlier that a good ground path is critical to maintaining the integrity of an electrical circuit. One of the more common violations found in the work place occurs when grounding prongs are either damaged or missing altogether.
- Why this is so common is Apathy - - pure and simple. Think of it this way: Tony starts to plug in a cord. He notices that the neutral prong has broken off the plug. If he tries to plug it in without the prong the cord won't work and is useless. At that point Tony takes the time to replace the cord and plug with a good one. If the scenario changed and Tony found the ground plug was missing instead of the neutral prong, he would be faced with an additional option: He could go ahead and use the cord. The cord will typically still work when the ground is missing. It just won't work safely.
- If there's a fault in the electrical system, Tony could be severely shocked after handling the cord.

Defective Electric Tools

- Inspect tools before each use.
- Ensure that the plug housing isn't cracked
- Test any interlocking safety switches
- Monitor the condition of the cord (current as small a 10 milliamps can paralyze, or "freeze" muscles).
- Ordinary power drills use 30 times more current than the amount necessary for a fatal shock.

Improper Guarding of Live Parts



OSHA REG: Guard live parts of electrical equipment operation at 50 volts or

higher against accidental contact by following some of these steps:

- Use approved cabinets and enclosures
- Make the equipment accessible to only qualified people,
- Elevate live parts eight or more feet above the floor or working surface.
- Always marks entrances to guarded locations with conspicuous OSHA approved signs.
- When wiring or live electrical components are located in an area that might sustain damage perhaps due to a process flow or forklift traffic, they are to be protected against possible damage.

Substandard Cabinets, Boxes and Fittings

- Junction boxes, pull boxes and fittings must have approved covers
- Unused openings in cabinets, boxes and fittings must be closed
- Blocked Electrical Panels
- An often overlooked violation centers on and around the electrical panels and disconnects switches. Ample clearance is to be maintained in order to provide access, at least 30 inches.
- For the same reason emergency exits should never by blocked, electrical panels and disconnect switches should remain accessible. If an electrical fire broke out or an employee was shocked, every second would count.
- It is vital that the panels and switches be easily reached in order to turn he power off

Inadequate Strain Relief on Cords and Conductors

- The primary function of wiring is NOT to support the weight of the components.
- The primary function or wiring is NOT to be use as a place to pull when unplugging from a receptacle.

It is necessary to keep rigid junctions and cord insulation intact

- When violations like these are found, address them as soon as possible. In the meantime, do not use any equipment found in violation.
- Improper Marking or Electrical Equipment
- Electrical equipment is manufactured for a very specific purpose: to safely house and direct electricity. Electrical equipment may not be used unless the manufacturer's name, trademark or other descriptive information is listed on the equipment itself.
- Additional markings such as voltage, current or other ratings should be listed as necessary.
- Markings are to be durable enough to withstand the anticipated workplace environmental conditions.

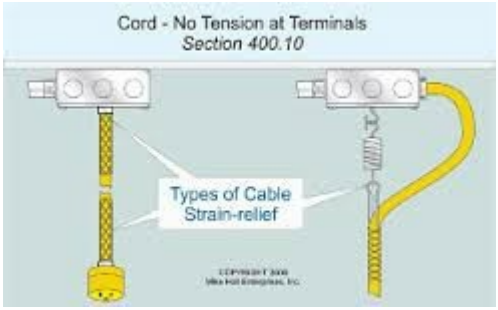
The reason marking so important is:

If two pieces of equipment rated for different voltage are connected, they will attempt to perform their intended functions, but the smaller of the two will eventually overheat and fail. Occurrences such as this can cause burns to employees and spark fires.

Failure to Mark Disconnecting Means and Circuits

- It is also required that equipment be clearly matched to its corresponding disconnect switch and circuit. Each service, feeder and branch circuit, as its disconnecting means or overcurrent device, needs to be legible marked to indicate its purpose.
- A disconnecting means is a switch that is used to disconnect the conductors for a circuit from the source of electrical current. If each switch is clearly identified with regards to what equipment that it controls, workers are better protected.

Improper use of Flex Cords

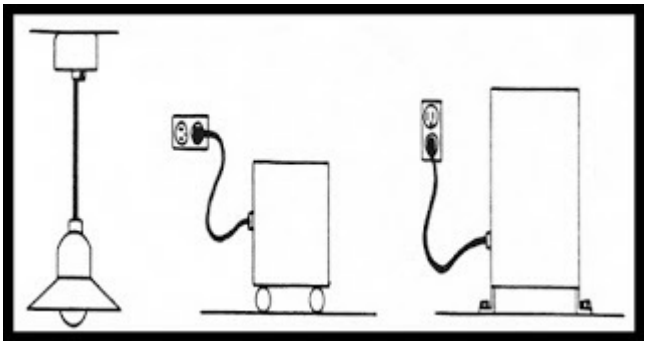


- Flexible cords are handy, but have definite limitations
- Always seek a permanent wiring solution first
- A flexible cord is more vulnerable to damage
- Aging has a direct affect to a flexible cord

A flex cord is vulnerable to abrasions for a variety of sources

- Proper use of a Flexible Cord
- A flexible cord can be used as fixture or pendant lighting
- A flexible cord can be used to power portable lamps, tools and appliances
- A flexible cord can be used to power appliances whose fastening means and mechanical connections are designed to permit removal for maintenance and repair

Uses of a Flexible Cord that is an Electrical Violation



- A Flexible cord cannot be used as a substitute for fixed wiring
- A Flexible cord cannot be run through walls, ceilings, floors and windows.
- A Flexible cord cannot be concealed behind or attached to building surfaces, if this was done any abrasions, frays or damage would not be detected.

Allowable Flexible cord Use

NON Compliant Flexible Cord Use

Clues that Electrical Hazards Exist

- Tripped circuit breakers or blown fuses
- Warm tools, wires, cords, connections, or junction boxes
- GFCI that shuts off a circuit
- Worn or frayed insulation around wire or connection

Summary

Hazards

- Inadequate wiring
- Exposed electrical parts
- Wires with bad insulation
- Ungrounded electrical systems and tools
- Overloaded circuits
- Damaged power tools and equipment
- Using the wrong PPE and tools
- Overhead power lines
- All hazards are made worse in wet conditions
- Protective Measures
- Proper grounding
- Using GFCI's
- Using fuses and circuit breakers
- Guarding live parts
- Proper use of flexible cords
- Training

Protective Measures

- **Proper grounding**
- **Using GFCI's**
- **Using fuses and circuit breakers**
- **Guarding live parts**
- **Proper use of flexible cords**
- **Training**

Resources: OSHA.gov, Free Stock Photos, Carla J Mattingly articles and trainings