Electrical Safety

FROM: OSHA OFFICE OF TRAINING AND EDUCATION

OSHA'S ELECTRICAL SAFETY-RELATED WORK PRACTICE REQUIREMENTS ARE CONTAINED IN 29 CFR 1910.331-.335.

TRAINING SUMMARY

This training addresses OSHA's General Industry electrical standards contained in 29 CFR 1910 Subpart S. OSHA also has electrical standards for construction and maritime, but recommends that employers in these industries follow the general industry electrical standards whenever possible for hazards that are not addressed by their industry-specific standards.

Suitability of electrical equipment for an identified purpose may be evidenced by listing or labeling by a nationally recognized testing laboratory which makes periodic inspections of equipment production and states that such equipment meets nationally recognized standards or tests to determine safe use in a specified manner.

Electricity is one of the most common causes of fire in homes and workplaces. Explosions have also resulted from electrical sources.

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

Operating an electric switch is like turning on a water faucet.

Behind the faucet or switch there must be a source of water or electricity with something to transport it, and with a force to make it flow. In the case of water, the source is a reservoir or pumping station; the transportation is through pipes; and the force to make it flow is provided by a pump. For electricity, the source is the power generating station; current travels through electric conductors (wires); and the force to make it flow - voltage, measured in volts, is provided by a generator.

Electrical Terminology

Current – the movement of electrical charge

Resistance – opposition to current flow

- Dry skin has a fairly high resistance, but when moist, resistance drops radically, making it a ready conductor.
- Measured in ohms.

Voltage – a measure of electrical force

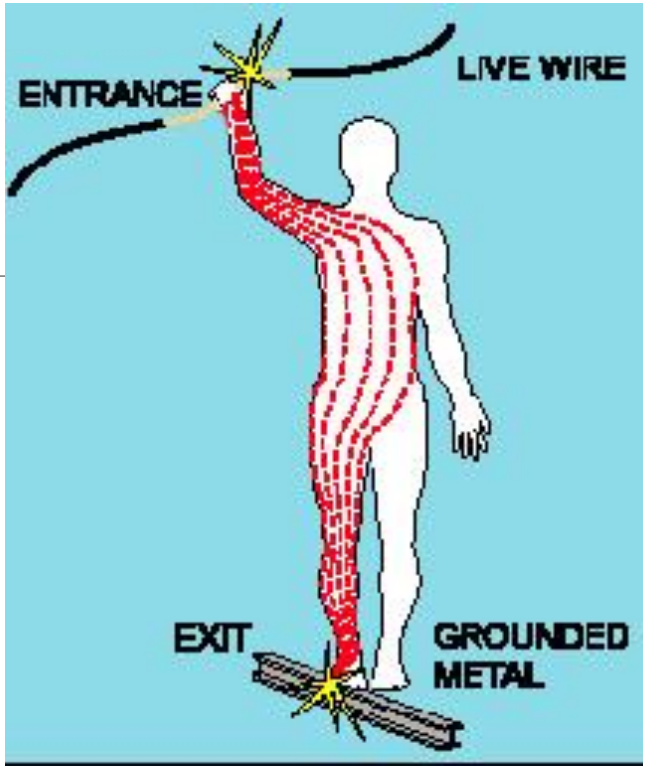
Conductors – substances, such as metals, that have little resistance to electricity

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 which is at zero volts

Use extra caution when working with electricity when water is present in the environment or on the skin. Pure water is a poor conductor, but small amounts of impurities, such as salt and acid (both are contained in perspiration), make it a ready conductor.

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

- 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.

Dangers of Electrical Shock

Currents greater than 75 mA* can cause ventricular fibrillation (rapid, ineffective heartbeat).

Will cause death in a few minutes unless a defibrillator is used.

75 mA is not much current – a small power drill uses 30 times as much.

* mA = milliampere = 1/1,000

How is an electrical shock received?

- Electricity travels in closed circuits, and its normal route is through a conductor.
- Electric shock occurs when the body becomes a part of the circuit.
- Electric shock normally occurs in one of three ways - when an individual is in contact with the ground and contacts:
  1. Both wires of an electric circuit, or
  2. One wire of an energized circuit and the ground, or
  3. A metallic part that has become energized by contact with an energized conductor.

The metal parts of electric tools and machines may become energized if there is a break in the insulation of the tool or machine wiring.

A worker using these tools and machines is made less vulnerable to electric shock when there is a low-resistance path from the metallic case of the tool or machine to the ground. This is done through the use of an equipment grounding conductor—a low-resistance wire that causes the unwanted current to pass directly to the ground, thereby greatly reducing the amount of current passing through the body of the person in contact with the tool or machine.

How is an electrical shock received? (cont.)

When two wires have different potential differences (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.***

How is an electrical shock received? (cont.)

If you are in contact with an energized wire or any energized electrical component, and also with any grounded object, YOU WILL RECEIVE A SHOCK and possibly be electrocuted.

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.

Electrical Burns

Most common shock-related, nonfatal injury.

Occurs when you touch electrical wiring or equipment that is improperly used or maintained.

Typically occurs on the hands.

Very serious injury that needs immediate attention.

Falls

Electric shock can also cause indirect or secondary injuries.

Workers in elevated locations who experience a shock can fall, resulting in serious injury or death.

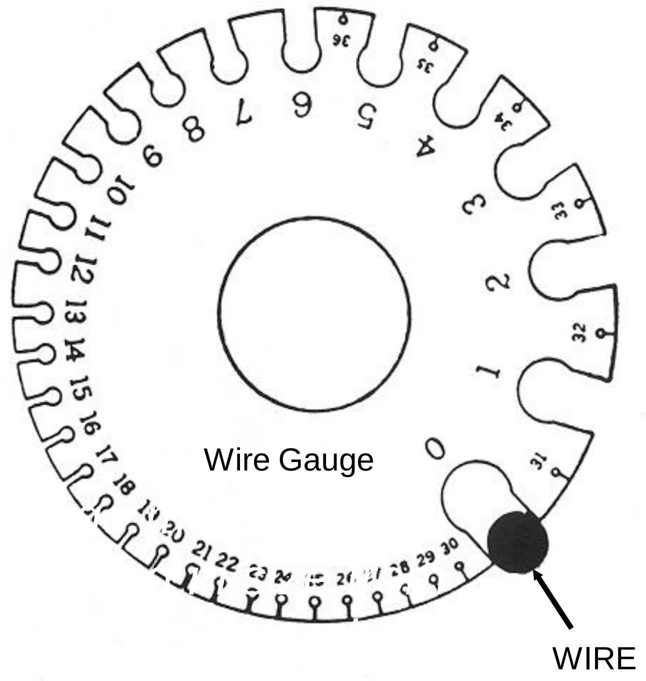
Inadequate Wiring Hazards

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.

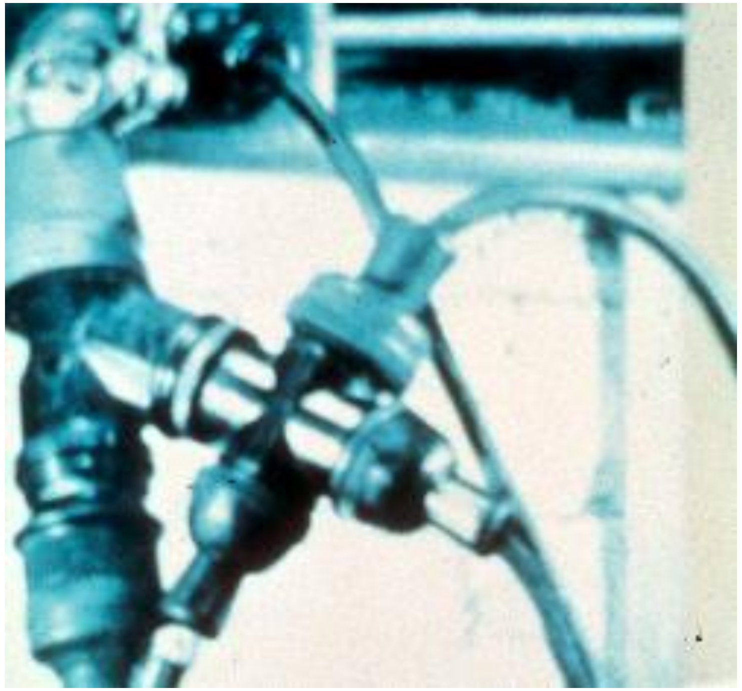
Note that wire-gauge size is inversely related to the diameter of the wire. For example, a No. 12 flexible cord has a larger diameter wire than a No. 14 flexible cord.



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.



If the circuit breakers or fuses are too big (high current rating) for the wires they are supposed to protect, an overload in the circuit will not be detected and the current will not be shut off.

A circuit with improper overcurrent protection devices – or one with no overcurrent protection devices at all – is a hazard.

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 (GFCI’s).

Fuses and circuit breakers are <u>overcurrent</u> devices

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

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

- In the case of a fuse, the fuse is destroyed before another part of the system is destroyed.
- In the case of a 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.
- However, the only electrical protective device whose sole purpose is to protect people is the ground-fault circuit-interrupter.

Ground-Fault Circuit Interrupter

- The GFCI continually matches the amount of current going to an electrical device against the amount of current returning from the device along the electrical path.
- Whenever the amount of current going differs from the amount returning by approximately 5 milliamperes, the GFCI interrupts the electric power within as little as 1/40 of a second, protecting you from a dangerous shock.
- GFCI’s are able to detect the loss of current resulting from leakage through a person who is beginning to be shocked. If this situation occurs, the GFCI switches off the current in the circuit.
- GFCI’s are different from circuit breakers and fuses because they detect leakage currents rather than overloads.

This device protects you from dangerous shock

Grounding Hazards

- Grounding is a physical connection to the earth, which is at zero volts.
- Current flows through a conductor if there is a difference in voltage (electrical force).
  - 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.

Two kinds of grounds are required by OSHA:

1. Service or system ground.
   - In this instance, one wire — called the neutral conductor or grounded conductor — is grounded.
   - In an ordinary low-voltage circuit, the white (or gray) wire is grounded at the generator or transformer and again at the service entrance of the building.
   - This type of ground is primarily designed to protect machines, tools, and insulation against damage.
2. For enhanced worker protection, an additional ground, called the equipment ground, must be furnished by providing another path from the tool or machine through which the current can flow to the ground.
   - This additional ground safeguards the electric equipment operator if a malfunction causes the metal frame of the tool to become energized.

Grounding Hazards

Some of the most frequently violated OSHA standards:

- 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.

Overhead Powerline Hazards

- Overhead power lines must be deenergized and grounded by the owner or operator of the lines, or other protective measures must be provided before work is started.
  - Protective measures (such as guarding or insulating the lines) must be designed to prevent contact with the lines.
- Minimum clearance distances for employees working in the vicinity of overhead power lines are given in 29 CFR 1910.333(c)(3).
- PPE may consist of rubber insulating gloves, hoods, sleeves, matting, blankets, line hose, and industrial protective helmets.

Overhead Powerline Hazards

Most people don't realize that overhead powerlines are usually not insulated.

Powerline workers need special training and personal protective equipment (PPE) to work safely.

Do not use metal ladders – instead, use fiberglass ladders.

Beware of powerlines when you work with ladders and scaffolding.

Some Examples of OSHA Electrical Requirements

Electrical accidents appear to be caused by a combination of three factors:

1. Unsafe equipment and/or installation,
2. Workplaces made unsafe by the environment, and
3. Unsafe work practices.

There are various ways of protecting people from the hazards caused by electricity. These include: insulation, guarding, grounding, electrical protective devices, and safe work practices.

Grounding Path
OSHA 29 CFR 1910.304(f)(4)

The path to ground from circuits, equipment, and enclosures must be permanent and continuous.

Violation shown here is an extension cord with a missing grounding prong.

Hand-Held Electric Tools
29 CFR 1910.304(f)(5)(v)(C)(*3*)

Hand-held electric tools pose a potential danger because they make continuous good contact with the hand.

To protect you from shock, burns, and electrocution, tools must:

- Have a three-wire cord with ground and be plugged into a grounded receptacle, or
- Be double insulated, or
- Be powered by a low-voltage isolation transformer

Hazards of Portable Electric Tools

- Currents as small as 10 mA can paralyze, or “freeze” muscles
  - Person cannot release tool
  - Tool is held even more tightly, resulting in longer exposure to shocking current
- Power drills use 30 times as much current as what will kill.
- Double-insulated equipment must be distinctly marked to indicate that the equipment utilizes an approved system of double insulation. The common marking is:

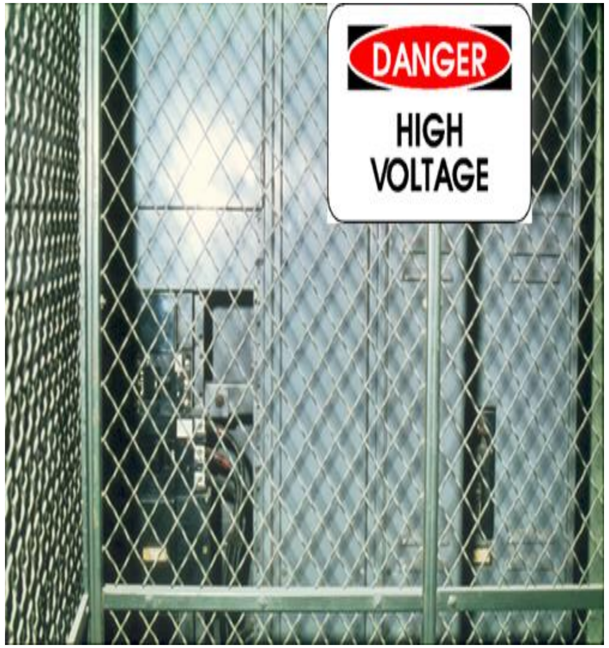
Guarding of Live Parts

OSHA 29 CFR 1910.303(g)(2)(i)
OSHA 29 CFR 1910.303(g)(2)(iii)

Must guard live parts of electric equipment operating at 50 volts or more against accidental contact by:

- Approved cabinets/enclosures, or
- Location or permanent partitions making them accessible only to qualified persons, or
- Elevation of 8 ft. or more above the floor or working surface

Mark entrances to guarded locations with conspicuous warning signs.



How to Avoid Power Tool Electrical Hazards?

1. Use ground-fault circuit interrupters (GFCI) on all 120-volt, single-phase, 15 and 20 amp receptacles.
2. Follow manufacturers' recommended testing procedure to ensure GFIC is working correctly.
3. Use double-insulated tools and equipment, distinctively marked, whenever possible.
4. Use tools and equipment according to the instructions included in their listing, labeling or certification.
5. Visually inspect all electrical equipment before use.
   - Remove from service any equipment with frayed cords, missing ground prongs, cracked tool casings, etc.
   - Apply a warning tag to any defective tool and do not use it until the problem has been corrected.
6. A 3-prong plug should never be installed on a double insulated power tool cord.

Guarding of Live Parts
29 CFR 1910.303(g)(2)(ii)

Must enclose or guard electric equipment in locations where it would be exposed to physical damage.

Violation shown here is physical damage to conduit.

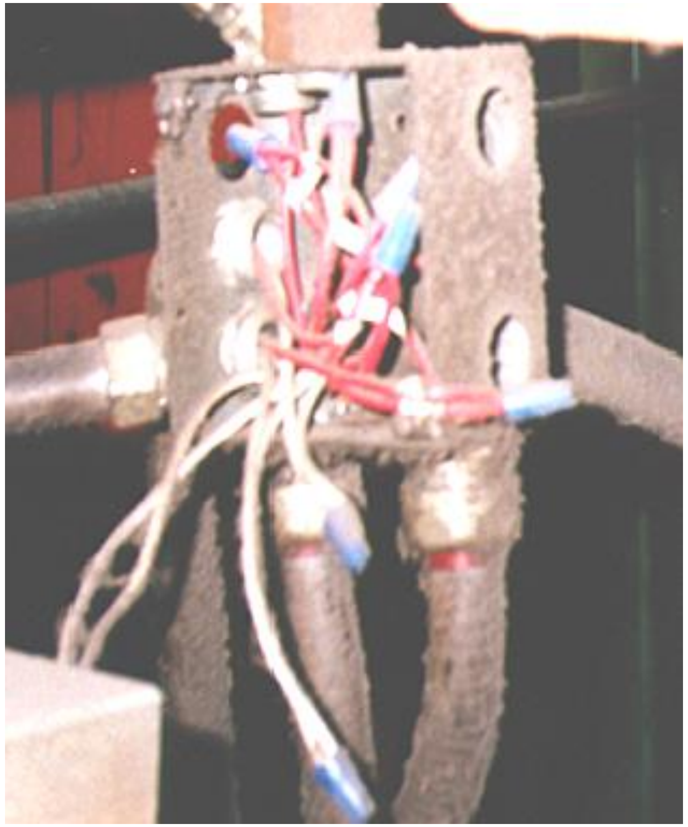
Cabinets, Boxes, and Fittings

OSHA 29 CFR 1910.305(b)(1) and (2)

Junction boxes, pull boxes and fittings must have approved covers

Unused openings in cabinets, boxes and fittings must be closed (no missing knockouts)

Photo shows violations of these two requirements



Circuit Breaker Panels

The National Electric Code (NEC) includes the minimum standards for installing a circuit breaker panel box. These standards set the minimum safety standards for panel boxes. Three of these standards concern the box location, clearance and space around the box, and box height.

- Height
  - The minimum height for a circuit breaker box is 4 feet, though the ideal height is between 5 feet and 6 feet. The maximum height allowed for the circuit breaker box is 6 feet.
- Location
  - A circuit breaker box cannot be installed in a bathroom. The box can be installed in a closet that is not located in bathrooms. The ideal place for a circuit breaker in a family house or a building is in the basement. In an apartment, the ideal location is near the main entrance.
- Accessibility
  - The circuit breaker box must be accessible without moving or lifting any objects.
  - A three-foot clearance should be maintained around the box.
  - The box door should be able to open to a 90 degree angle without obstacles. The height of the ceiling should be at least 6 feet.

Use of Flexible Cords
29 CFR 1910.305(g)

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:

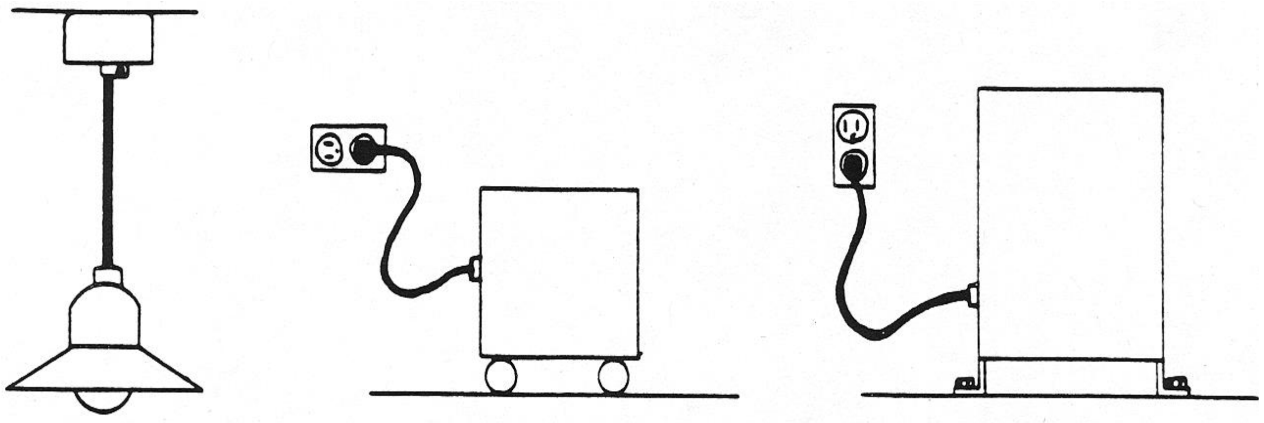
- Aging
- Door or window edges
- Staples or fastenings
- Abrasion from adjacent materials
- Activities in the area

Improper use of flexible cords can cause shocks, burns or fire.

Permissible Uses of Flexible Cords
29 CFR 1910.305(g)(1)(i)

Examples:

- Elevator cables
- Wiring of cranes and hoists
- Prevention of the transmission of noise or vibration
- Appliances where the fastening means and mechanical connections are designed to permit removal for maintenance and repair
- Data processing cables approved as part of the data processing system



Pendant, or Fixture Wiring

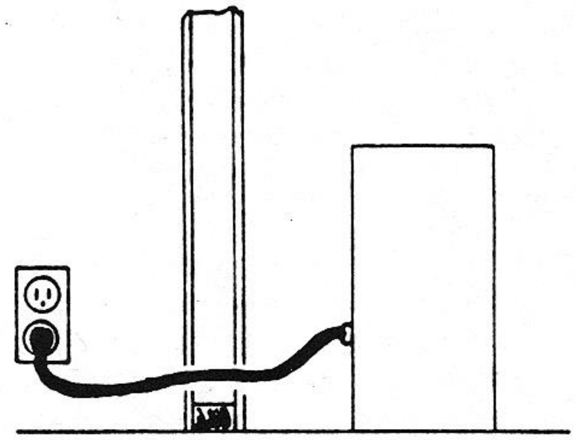
Portable lamps, tools or appliances

Stationary equipment

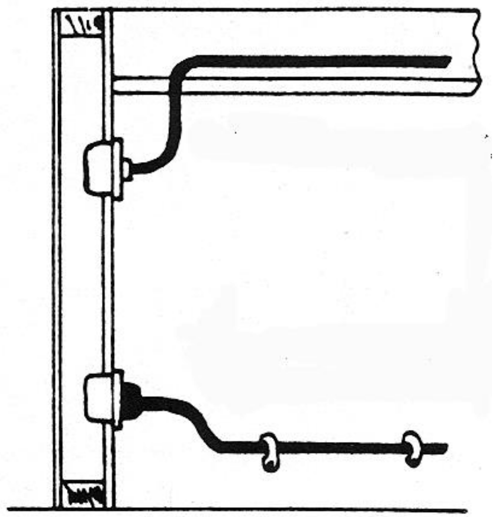
Prohibited Uses of Flexible Cords

OSHA 29 CFR 1910.305(g)(1)(iii)

Substitute for fixed wiring



Run through walls, ceilings, floors, doors, or windows



Concealed behind or attached to building surfaces

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.

Requirements

Deenergize electric equipment before inspecting or making repairs following Lockout/Tagout.

Use electric tools that are in good repair.

Use good judgment when working near energized lines.

Use appropriate protective equipment.

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 powerlines
- 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