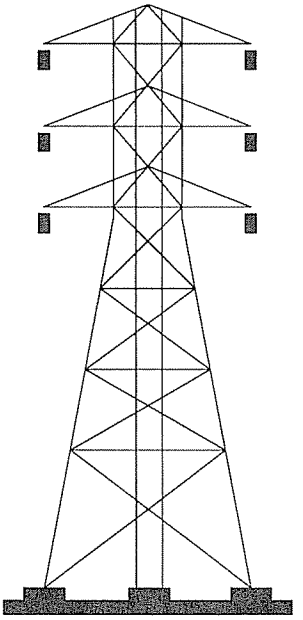
ELECTRICAL
SUBPART S



Electricity has become an essential of modern life, both at home and on the job. Some employees work with electricity directly, as is the case with engineers, electricians, or people who do wiring, such as overhead lines, cable harnesses, or circuit assemblies. Others, such as office workers and salespeople, work with it indirectly. As a source of power, electricity is accepted without much thought to the hazards encountered. Perhaps because it has become such a familiar part of our surroundings, it often is not treated with the respect it deserves.

For 1989, the Bureau of Labor Statistics[1] reported that 3,600 work-related deaths occurred in private sector workplaces employing 11 workers or more. Nine percent of the fatalities, or around 324 deaths, were the direct result of electrocutions at work. What makes these statistics more tragic is that, for the most part, these fatalities could have been easily avoided.

OSHA's electrical standards address the government's concern that electricity has long been recognized as a serious workplace hazard, exposing employees to such dangers as electric shock, electrocution, fires and explosions. The objective of the standards is to minimize such potential hazards by specifying *design* characteristics of safety in use of electrical equipment and systems.

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[1] U.S. Department of Labor, Bureau of Labor Statistics, **Occupational Injuries and Illnesses in the United States by Industry**, 1989, Bulletin 2379 (Washington, D.C.: Government Printing Office, April 1991)

OSHA's electrical standards were carefully developed to cover only those parts of any electrical system that an employee would normally use or contact. The exposed and/or operating elements of an electrical installation - lighting equipment, motors, machines, appliances, switches, controls, enclosures, etc. - must be so constructed and installed as to minimize electrical dangers to people in any workplace.

The OSHA electrical standards were based on the National Fire Protection Association's standard NFPA 70E, *Electrical Safety Requirements for Employee Workplaces*, and the NFPA 70 Committee derived Part I of their document from the 1978 edition of the *National Electrical Code* (NEC). The standards extracted from the NEC were those considered to most directly apply to employee safety and least likely to change with each new edition of the NEC. OSHA's electrical standards are performance oriented; therefore they contain few direct references to the NEC. However, the NEC contains specific information as to how the required performance can be obtained.

GENERAL REQUIREMENTS - 1910.303

Approval

The conductors and equipment required or permitted by this subpart shall be acceptable only if approved.

Examination, Installation and Use of Equipment

Examination

Electrical equipment shall be free from recognized hazards that are likely to cause death or serious physical harm to employees. Safety of equipment shall be determined using the following considerations:

- Suitability for installation and use in conformity with the provisions of this subpart. Suitability of equipment for an identified purpose may be evidenced by listing or labeling for that identified purpose.
- Mechanical strength and durability, including, for parts designed to enclose and protect other equipment, the adequacy of the protection thus provided.
- Electrical insulation.
- Heating effects under conditions of use.
- Arcing effects.
- Classification by type, size, voltage, current capacity, and specific use.
- Other factors which contribute to the practical safeguarding of employees using or likely to come in contact with the equipment.

Installation and Use

Listed or labeled equipment shall be used or installed in accordance with any instructions included in the listing or labeling.

Splices

Conductors shall be spliced or joined with splicing devices suitable for the use or by brazing, welding, or soldering with a fusible metal or alloy. Soldered splices shall be so spliced or joined as to be mechanically and electrically secure without solder and then soldered. All splices and joints and the free ends of conductors shall be covered with an insulation equivalent to that of the conductors or with an insulating device suitable for the purpose.

Arcing Parts

Parts of electric equipment which in ordinary operation produce arcs, sparks, flames, or molten metal shall be enclosed or separated and isolated from all combustible material.

Marking

Electrical equipment may not be used unless the manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the product may be identified is placed on the equipment. Other markings shall be provided giving voltage, current, wattage, or other ratings as necessary. The markings shall be of sufficient durability to withstand the environment involved.

Sometimes this section is confused with the section *Identification of disconnecting means*. The difference is that *Identification* (as used in OSHA standards) means marked to indicate the purpose of a disconnecting means, rather than its rating.

Marking is very important. If an item of equipment is connected to a voltage higher than its rating, the chances are that a violent failure will result. If it is connected to a voltage below its rating, it may attempt to perform its intended function, but may overheat badly and eventually fail. If A-C equipment is energized with the wrong frequency, or with direct current, it will probably fail violently. These occurrences can cause burns to employees, and may cause fires.

If equipment is connected to a circuit not adequate for the load, conductors may overheat and deteriorate. Overcurrent protective devices should prevent serious damage in such a case, but sometimes these devices have been tampered with and do not protect properly.

If the manufacturer's name is not marked on the nameplate, there will be difficulty in tracing the reasons for faulty performance and in preventing future failures. Sometimes it is necessary to know the manufacturer in order to determine if equipment is approved for a particular purpose. The manufacturer's name is also necessary in many cases so that the user can obtain information or replacement parts.

The marking described above is almost always provided on the name-plate of the equipment of reputable manufacturers. Violations usually appear when the nameplate is covered by some part of the installation, is removed, or is obliterated by painting or other abuse.

Identification of Disconnecting Means and Circuits

Each disconnecting means required by this subpart for motors and appliances shall be legibly marked to indicate its purpose, unless located and arranged so the purpose is evident. Each service, feeder, and branch circuit, at its disconnecting means or overcurrent device, shall be legibly marked to indicate its purpose, unless located and arranged so the purpose is evident. These

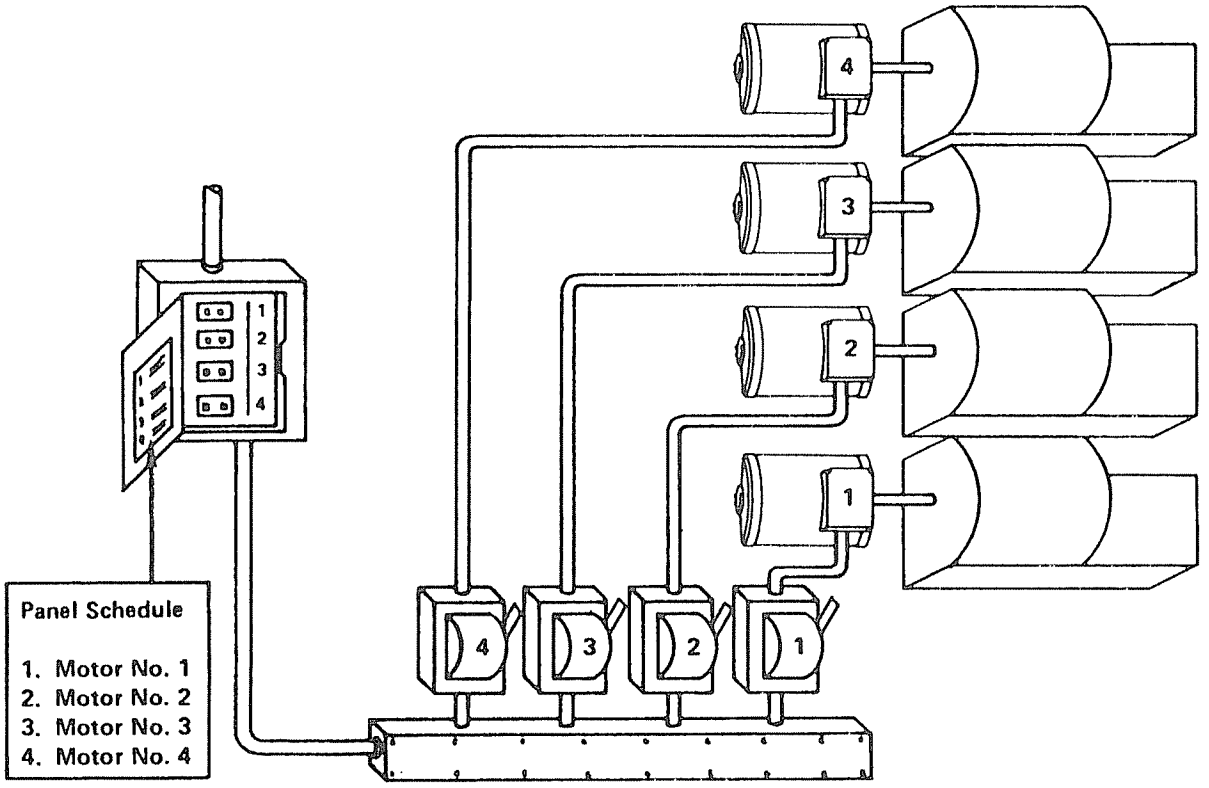
markings shall be of sufficient durability to withstand the environment involved.

A disconnecting means is a switch that is used to disconnect the conductors of a circuit from the source of electric current. Disconnect switches are important because they enable a circuit to be opened, stopping the flow of electricity, and thus can effectively protect workers and equipment.

Each disconnect switch or overcurrent device required for a service, feeder, or branch circuit must be clearly labeled to indicate the circuit's function, and the label or marking should be located at the point where the circuit originates. For example, on a panel that controls several motors or on a motor control center, each disconnect must be clearly marked to indicate the motor to which each circuit is connected. In the figure below, the Number 2 circuit breaker in the panel box supplies current only to disconnect Number 2, which in turn controls the current to motor Number 2. This current to motor Number 2 can be shut off by the Number 2 circuit breaker or the Number 2 disconnect.

If the purpose of the circuit is obvious, no identification of the disconnect is required.

All labels and markings must be durable enough to withstand weather, chemicals, heat, corrosion, or any other environment to which they may be exposed.



Motor No. 1 is Controlled by Disconnect No. 1 and Circuit Breaker No. 1

NOTE: As shown in the figure, the purposes of these disconnecting switches are clearly evident. In such cases, identification may be omitted. In the actual installation however, the motors may not be within sight of the disconnects or arranged in such a way that the purpose is not evident and identification would be required.

Each Disconnect and Circuit Requires Identification

600 Volts, Nominal, or Less

Working Space About Electric Equipment

Note that this particular section is concerned with the safety of a *person qualified to work on the equipment* (presumably an electrician). Obviously, the hazard must be treated in a different way if the person will remove guards and enclosures and actually work on the live parts. Sufficient access and working space shall be provided and maintained about all electric equipment to permit ready and safe operation and maintenance of such equipment.

Working Clearances

Except as required or permitted elsewhere in this subpart, the dimension of the working space in the direction of access to live parts operating at 600 volts or less and likely to require examination, adjustment, servicing, or maintenance while alive may not be less than indicated in Table S-1 of 1910.303(g)(1)(i). In addition, workspace may not be less than 30 inches wide in front of the electrical equipment. Distances shall be measured from the live parts if they are exposed, or from the enclosure front or opening if the live parts are enclosed. Concrete, brick, or tile walls are considered to be grounded. Working space is not required in back of assemblies such as dead-front switchboards or motor control centers where there are no renewable or adjustable parts such as fuses or switches on the back and where all connections are accessible from locations other than the back.

The remaining paragraphs of this section require that the working spaces shall not be used for storage, that access to the working space be maintained, and that reasonable illumination and headroom be maintained.

Guarding of Live Parts

It should be noted that the purpose of this requirement is to protect *any person* who may be in the vicinity of electrical equipment against accidental contact. These people are presumably not electricians working on the equipment, and are not qualified or trained to be in close proximity to live parts.

Except as required or permitted elsewhere in this subpart, live parts of electric equipment operating at 50 volts or more shall be guarded against accidental contact by approved cabinets or other forms of approved enclosures, or by any of the following means:

- By location in a room, vault, or similar enclosure that is accessible only to qualified persons.
- By suitable permanent, substantial partitions or screens so arranged that only qualified persons will have access to the space within reach of the live parts. Any openings in such partitions or screens shall be so sized and located that persons are not likely to come into accidental contact with the live parts or to bring conducting objects into contact with them.
- By location on a suitable balcony, gallery, or platform.
- By elevation of 8 feet or more above the floor or other working surface.

In locations where electric equipment would be exposed to physical damage, enclosures or guards shall be so arranged and of such strength as to prevent such damage.

Over 600 Volts, Nominal

Enclosure for Electrical Installations

Electrical installations in a vault, room, closet or in an area surrounded by a wall, screen, or fence, access to which is controlled by lock and key or other approved means, are considered accessible to qualified persons only. A wall, screen, or fence less than 8 feet in height is not considered to prevent access unless it has other features that provide a degree of isolation equivalent to an 8 foot fence. The entrances to all buildings, rooms, or enclosures containing exposed live parts or exposed conductors operating at over 600 volts, nominal, shall be kept locked or shall be under the observation of a qualified person at all times.

Workspace About Equipment

Electrical installations having exposed live parts shall be accessible to qualified persons only. Sufficient space shall be provided and maintained about electric equipment to permit ready and safe operation and maintenance of such equipment. Where energized parts are exposed, the minimum clear workspace may not be less than 6 feet 6 inches high (measured vertically from the floor or platform), or less than 3 feet wide (measured parallel to the equipment). The minimum depth of clear working space in front of electric equipment is given in Table S-2 of 1910.303(h)(3)(i).

Illumination

Adequate illumination shall be provided for all working spaces about electric equipment. The lighting outlets shall be so arranged that persons changing lamps or making repairs on the lighting system will not be endangered by live parts or other equipment. The points of control shall be so located that persons are not likely to come in contact with any live part or moving part of the equipment while turning on the lights.

Elevation of Unguarded Live Parts

Unguarded live parts above working space shall be maintained at elevations not less than specified in Table S-3 of 1910.303(h)(3)(iii).

Entrance and Access to Workspace

At least one entrance not less than 24 inches wide and 6 feet 6 inches high shall be provided to give access to the working space about electric equipment. On switchboard and control panels exceeding 48 inches in width, there shall be one entrance at each end of such board where practicable. Where bare energized parts at any voltage or insulated energized parts above 600 volts are located adjacent to such entrance, they shall be suitably guarded.

Permanent ladders or stairways shall be provided to give safe access to the working space around electric equipment installed on platforms, balconies, mezzanine floors, or in attic or roof rooms or spaces.

WIRING DESIGN AND PROTECTION - 1910.304

Use and Identification of Grounded and Grounding Conductors

Identification of Conductors

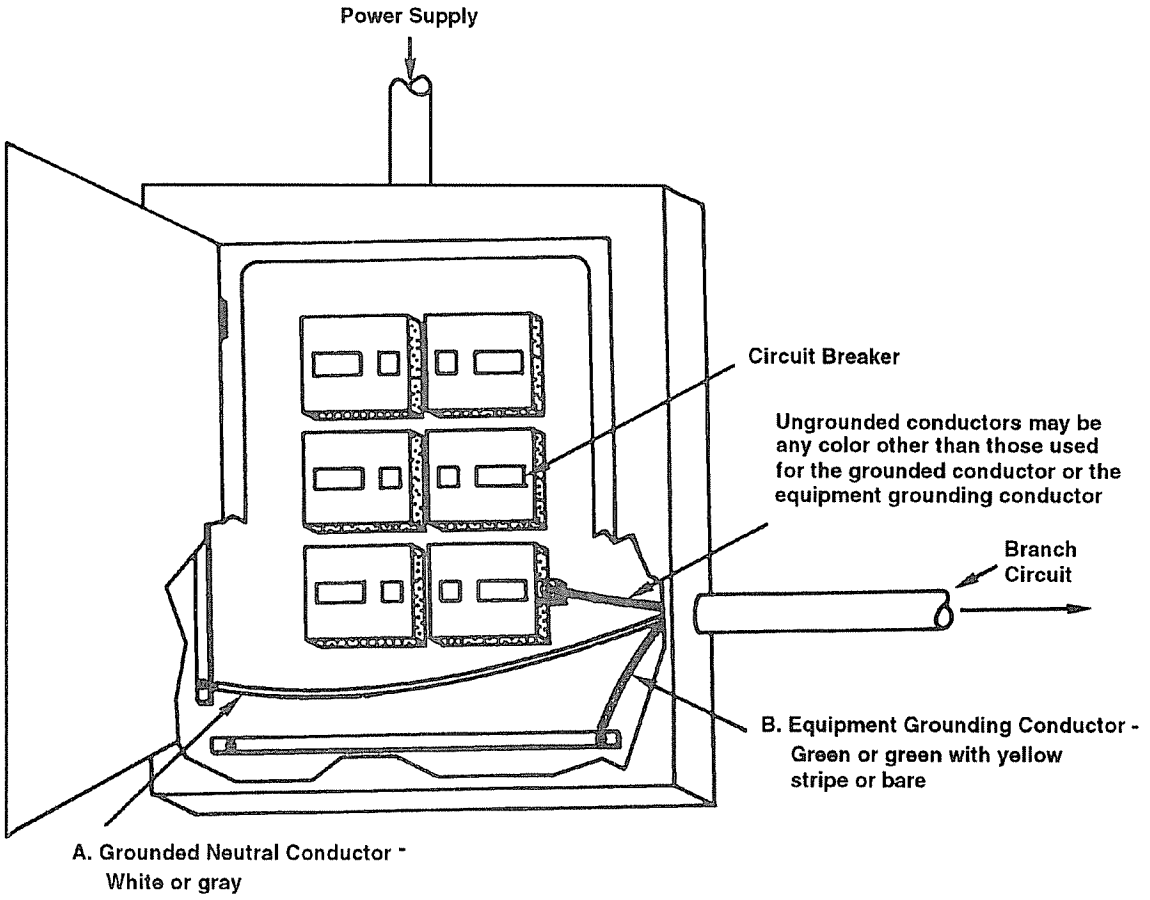
A conductor used as a grounded conductor shall be identifiable and distinguishable from all other conductors. A conductor used as an equipment grounding conductor shall be identifiable and distinguishable from all other conductors.

The grounded conductor is an energized circuit conductor that is connected to earth through the system ground. It is commonly referred to as the *neutral*. The equipment grounding conductor is not an energized conductor under normal conditions. The equipment grounding conductor acts as a safeguard against insulation failure or faults in the other circuit conductors. The equipment grounding conductor is energized *only* if there is a leak or fault in the normal current path, and it directs this current back to the source. Directing the fault current back to the source enables protective devices, such as circuit breakers or fuses, to operate thus preventing fires and reducing the hazard of electrical shocks.

The grounded and equipment grounding conductors of an electrical circuit 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.

The figure below illustrates a distribution panelboard. One means by which each conductor's use is identified and made distinguishable from the other circuit conductors is the use of color coding. Acceptable color coding includes the method required by the *National Electrical Code*, Section 210-5. The Code states: "The grounded conductor of a branch circuit shall be identified by a continuous white or natural gray color." Also, "The equipment grounding

conductor of a branch circuit shall be identified by a continuous green color or a continuous green color with one or more yellow stripes unless it is bare." Bare copper or aluminum wire is permitted for use as a grounding conductor.



A. The grounded conductor is identified and distinguished from other conductors by using white or gray color-coded insulated wires.

B. The equipment grounding conductor is identified and distinguished from other conductors by using green, or green with yellow stripe, color coding on wires, or run as a bare conductor.

DISTRIBUTION PANELBOARD

Polarity of Connections

No grounded conductor may be attached to any terminal or lead so as to reverse designated polarity.

Use of Grounding Terminals and Devices

A grounding terminal or grounding-type device on a receptacle, cord connector, or attachment plug may not be used for purposes other than grounding.

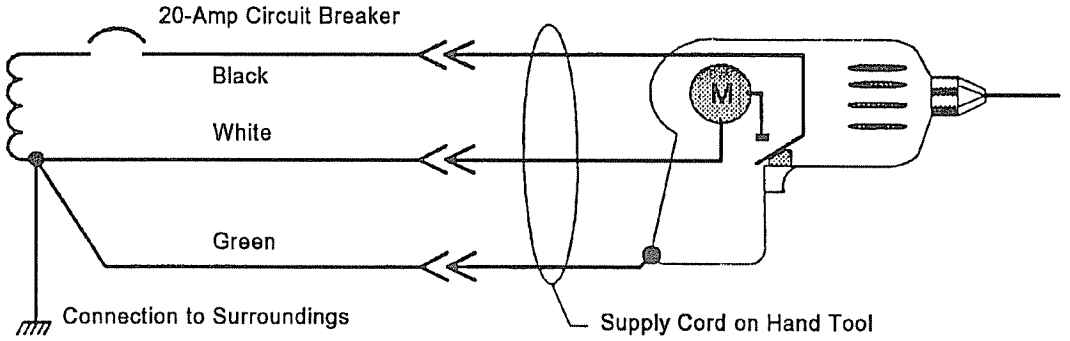
Reversed Polarity

The above two subparagraphs dealing with polarity of connections and use of grounding terminals and devices address one potentially dangerous aspect of alternating current: many pieces of equipment will operate properly even though the supply wires are not connected in the order designated by design or the manufacturer. Improper connection of these 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.

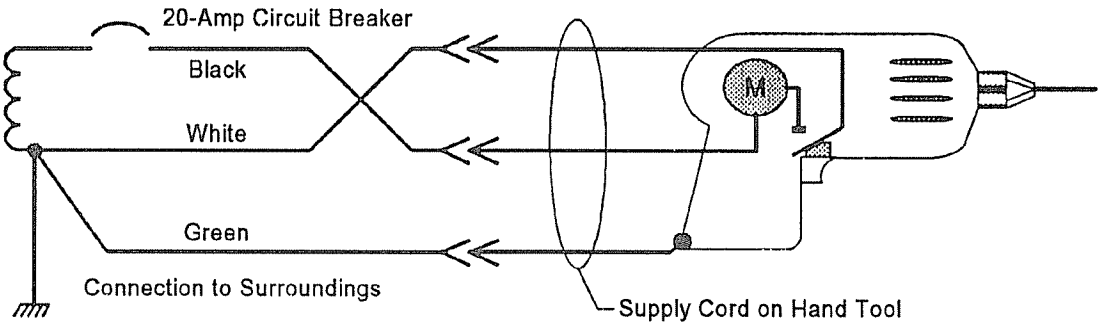
Reversed polarity is a condition when the identified circuit conductor (the grounded conductor or neutral) is incorrectly connected to the ungrounded or "hot" terminal of a plug, receptacle, or other type of connector.

The figure below shows the correct wiring for the common 120-volt outlet with a portable hand tool attached.



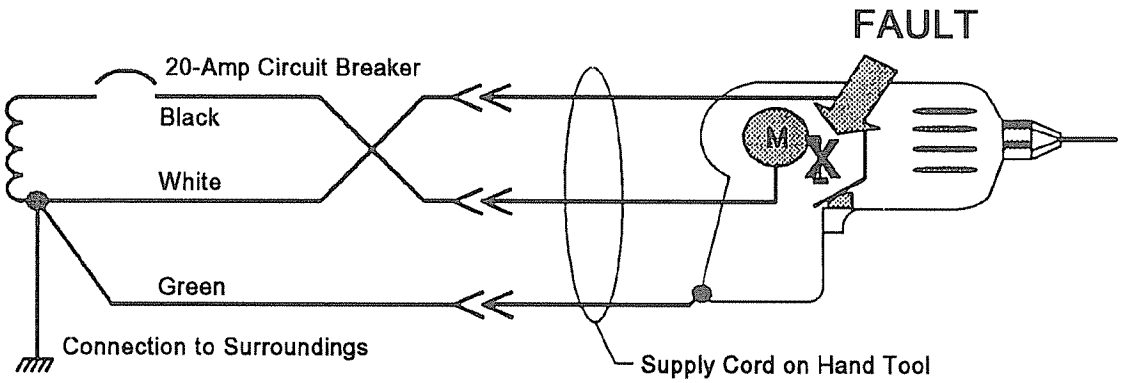
TYPICAL 120 VOLT BRANCH CIRCUIT WITH CORRECT WIRING

Suppose now that the black (ungrounded) and white (grounded) conductors are reversed as shown in the figure below. This is the traditional *reversed polarity*. Although a shock hazard may not exist, there are other mechanical hazards that can occur.



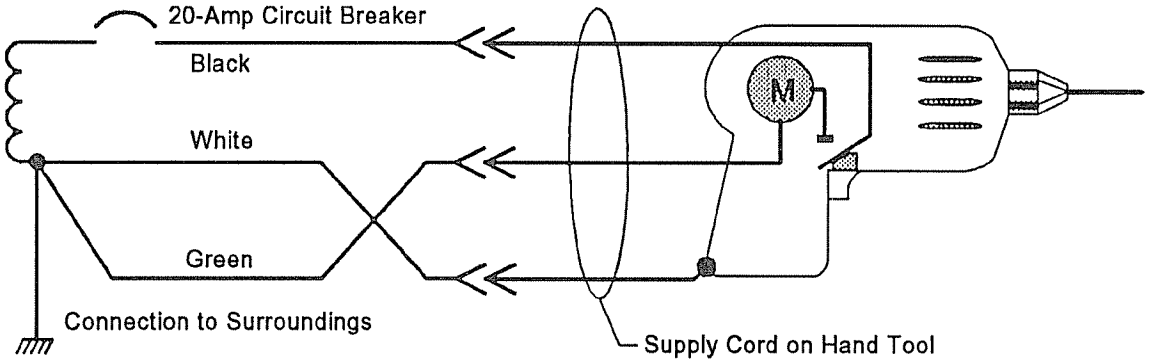
120 VOLT BRANCH CIRCUIT WITH BLACK AND WHITE WIRES REVERSED

For example, if an internal fault should occur in the wiring as shown in the figure below, the equipment would not stop when the switch is released or would start as soon as a person plugs the supply cord into the improperly wired outlet. This could result in serious injury.



120 VOLT BRANCH CIRCUIT WITH BLACK AND WHITE WIRES REVERSED
INTERNAL FAULT IN EQUIPMENT WIRING

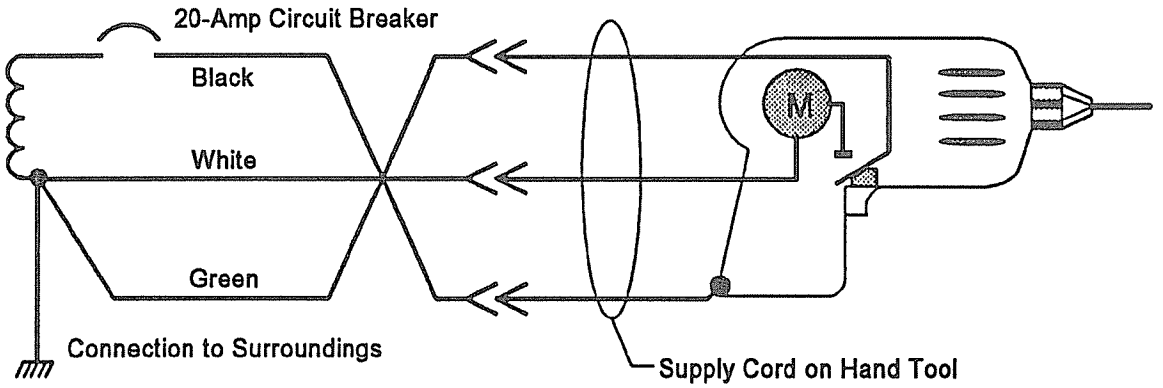
The figure below shows the white (grounded) and green (grounding) conductors reversed. Although it is not fitting, considering OSHA or code terminology, to call this *reversed polarity*, a hazard can still exist. In this case, due to the wiring error, the white wire is being used to provide equipment grounding. Under certain conditions, this could be dangerous.



WHITE AND GREEN WIRES REVERSED

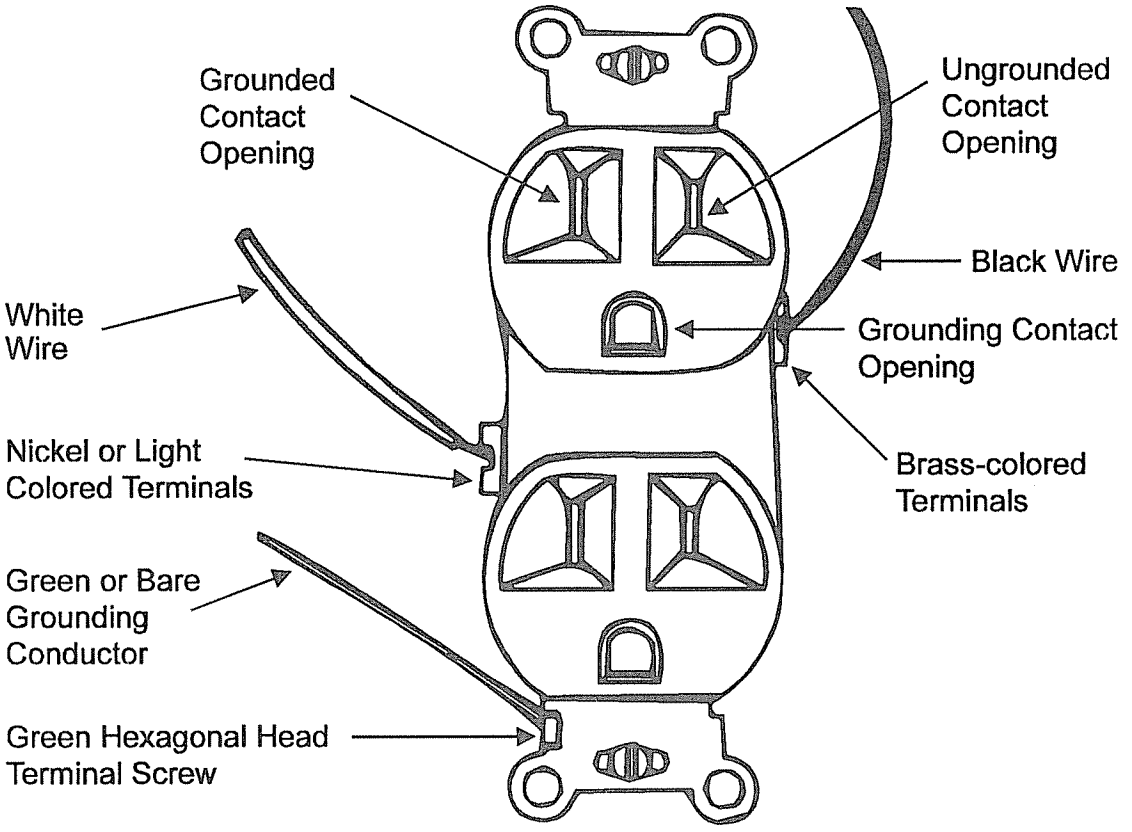
The figure below shows an *extremely* dangerous situation. In this example, the black (ungrounded) and green (grounding) conductors have been reversed. The metal case of the equipment is at 120 volts with reference to the surroundings. As soon as a person picks up the equipment and touches a conductive surface in their surrounding, they will receive a serious, or even deadly, shock.

Although the equipment will not work with this wiring error, it would not be unusual for a person to pick up the equipment before realizing this. The person may even attempt to troubleshoot the problem before unplugging the power cord.



BLACK AND GREEN WIRES REVERSED

Correct polarity is achieved when the grounded conductor is connected to the corresponding grounded terminal and the ungrounded conductor is connected to the corresponding ungrounded terminal. The reverse of the designated polarity is prohibited. The figure below illustrates a duplex receptacle correctly wired. Terminals are designated and identified to avoid confusion. An easy way to remember the correct polarity is "white to light" - the white (grounded) wire should be connected to the light or nickel-colored terminal; "black to brass" - the black or multi-colored (ungrounded) wire should be connected to the brass terminal; and "green to green" - the green or bare (grounding) wire should be connected to the green hexagonal head terminal screw.



DUPLEX RECEPTACLE CORRECTLY WIRED TO DESIGNATED TERMINALS

Services

Disconnecting Means

Means shall be provided to disconnect all conductors in a building or other structure from the service-entrance conductors. The disconnecting means shall plainly indicate whether it is in the open or closed position and shall be installed at a readily accessible location nearest the point of entrance of the service-entrance conductors.

A readily accessible means of disconnecting conductors is required to be located at a point near the service entrance. The service entrance is the location where the serving conductors enter a building. The disconnecting means can be a switch or circuit breaker, and must be capable of interrupting the circuit from the source of supply. This will disconnect the electrical equipment within the building from its source of supply in the event of an emergency or during normal servicing operations.

Services Over 600 Volts, Nominal

The following additional requirements apply to services over 600 volts, nominal:

- *Guarding*. Service-entrance conductors installed as open wires shall be guarded to make them accessible only to qualified persons.

- *Warning signs*. Signs warning of high voltage shall be posted where other than qualified employees might come in contact with live parts.

Overcurrent Protection

600 Volts, Nominal, or Less

The following requirements apply to overcurrent protection of circuits rated 600 volts, nominal, or less.

Protection of Conductors and Equipment

Conductors and equipment shall be protected from overcurrent in accordance with their ability to safely conduct current.

Electric current is the flow of electrons through a conductor. The size of the wire is the main determining factor as to how much current can safely flow through a conductor. The larger the wire, the more current can flow safely. If too much current flows through a conductor, excess heat is produced. If the circuit is not protected, the heat may continue to build and reach a temperature high enough to destroy insulation and cause a fire.

Fuses and circuit breakers are protective devices designed to disconnect a circuit from its source of supply when a maximum allowable heat level is reached. The basic idea of a protective 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 provide considerable protection against shock in most situations. It is important to ensure that overcurrent devices have adequate interrupting ratings in order to protect employees from shock.

The *National Electrical Code* specifies the allowable current flow permitted in certain-sized conductors. *Ampacity* is the term used to describe the current-carrying capacity of a conductor. The size of the fuse or circuit breaker

required to provide protection is determined by the ampacity of the conductor in the circuit to be protected and the type of load that is on the circuit.

Grounded Conductors

Except for motor running overload protection, overcurrent devices may not interrupt the continuity of the grounded conductor unless all conductors of the circuit are opened simultaneously. Unless excepted, overcurrent devices are always placed in the "hot" side of a circuit (usually a black wire) and in series with the load, so that all the current in the circuit must flow through them.

Disconnection of Fuses and Thermal Cutouts

Except for service fuses, all cartridge fuses which are accessible to other than qualified persons and all fuses and thermal cutouts on circuits over 150 volts to ground shall be provided with disconnecting means. This disconnecting means shall be installed so that the fuse or thermal cutout can be disconnected from its supply without disrupting service to equipment and circuits unrelated to those protected by the overcurrent device.

Location In or On Premises

Overcurrent devices shall be readily accessible to each employee or authorized building management personnel. These overcurrent devices may not be located where they will be exposed to physical damage nor in the vicinity of easily ignitible material.

The functions that overcurrent devices perform require proper operation and maintenance because of the tremendous amounts of energy likely to be handled during a fault. Also, when troubles occur, it may be necessary to reach these devices quickly.

Physical damage often results when overcurrent devices are located where they can be struck by lift trucks or other vehicles, by crane hooks, by materials being handled, etc.

It should be obvious that easily ignitible material should not be stored in the vicinity of the overcurrent devices. Most fuses and circuit breakers operate at elevated temperatures at least some of the time, and on occasion they may emit flashes or sparks.

Arcing or Suddenly Moving Parts
Fuses and circuit breakers shall be so located or shielded that employees will not be burned or otherwise injured by their operation.

Circuit Breakers
Circuit breakers shall clearly indicate whether they are in the open (off) or closed (on) position.

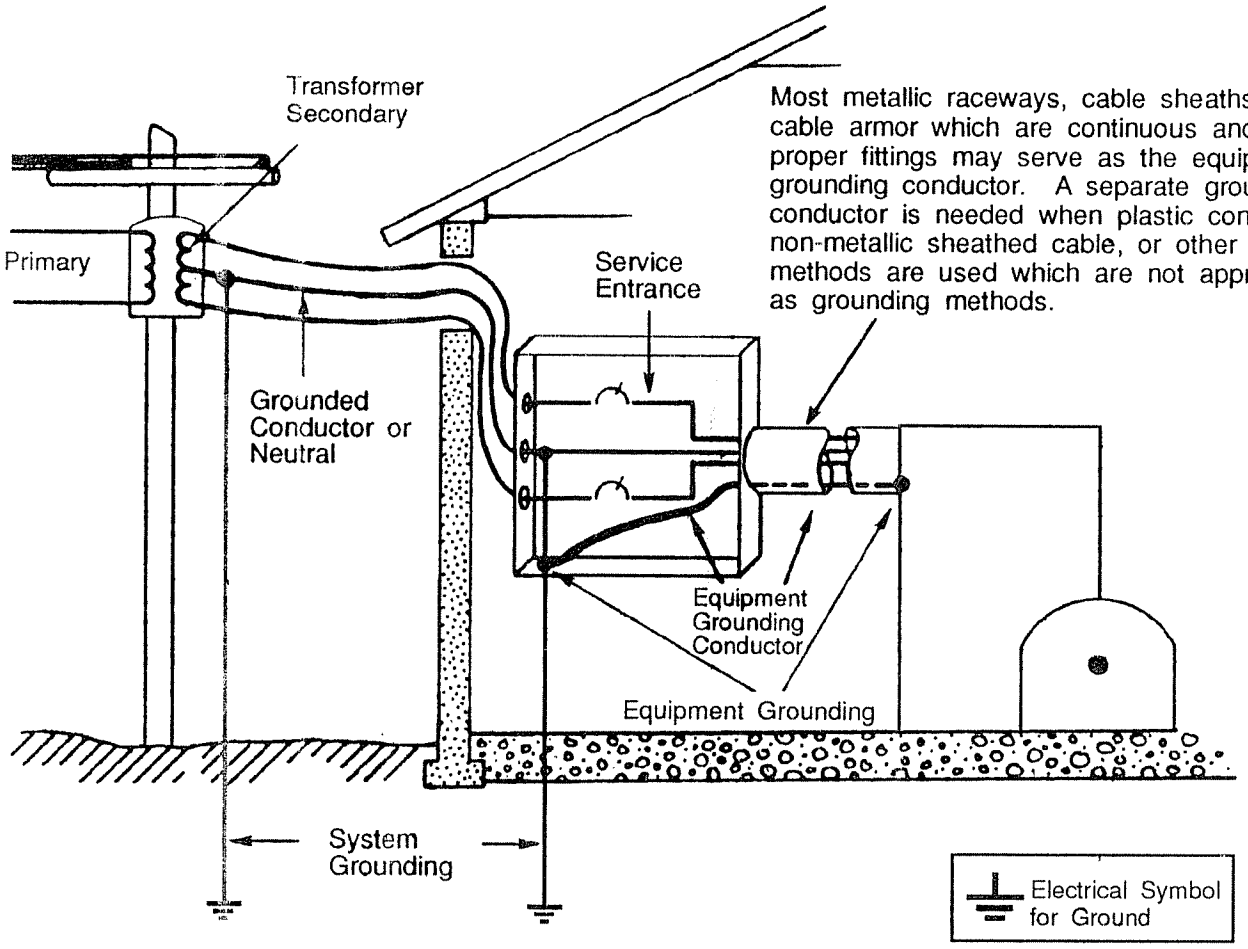
Where circuit breaker handles on switchboards are operated vertically rather than horizontally or rotationally, the up position of the handle shall be the closed (on) position.

If used as switches in 120-volt, fluorescent lighting circuits, circuit breakers shall be approved for the purpose and marked "SWD."

Over 600 Volts, Nominal
Feeders and branch circuits over 600 volts, nominal, shall have short-circuit protection.

Grounding

This section contains grounding requirements for systems, circuits, and equipment. Grounding electrical circuits and electrical equipment is required to protect employees against electrical shock, safeguard against fire, and protect against damage to electrical equipment. There are two kinds of grounding: (1) electrical circuit or system grounding, and (2) electrical equipment grounding. Electrical system grounding is accomplished when one conductor of the circuit is intentionally connected to earth. This is done to protect the circuit should lightning strike or other high voltage contact occur. Grounding a system also stabilizes the voltage in the system so "expected voltage levels" are not exceeded under normal conditions. The second kind of ground is equipment grounding. This 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 dangerous fault current to return to the system ground at the supply source of the circuit should an insulation failure take place. If installed properly, the equipment grounding conductor is the current path that enables protective devices, such as circuit breakers and fuses, to operate when a fault occurs. The figure below illustrates both types of grounding.



SYSTEM AND EQUIPMENT GROUNDING

Grounding Path

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

This requirement was extracted from NEC 250-51, *Effective Grounding Path,* which is more complete and fundamental to the understanding of electrical safety. It states that the path to ground:

1. "shall be permanent and continuous." (If the path is installed in such a way that damage, corrosion, loosening, etc. may impair the continuity during the life of the installation, then shock and burn hazards will develop.)

2. "shall have capacity to conduct safely any fault current likely to be imposed on it." (Fault currents may be many times normal currents, and such high currents may melt or burn metal at points of poor conductivity. These high temperatures may be a hazard in themselves, and they may destroy the continuity of the ground-fault path.)

3. "shall have sufficiently low impedance to limit the voltage to ground and to facilitate the operation of the circuit protective devices in the circuit." (If the ground-fault path has a high impedance, there will be hazardous voltages whenever fault currents attempt to flow. Also, if the impedance is high, the fault current will be limited to some value so low that the fuse or circuit breaker will not operate promptly, if at all.)

It is important to remember the following regarding safe grounding paths:

1. The fault current in A-C circuits will be limited by the sum of resistance and reactance, and the only low-reactance path is that which closely follows the circuit conductors.

2. If a metallic raceway system is used, make sure that the metallic system is continuous and permanent.

3. In cases where a metallic raceway system is not used, provide a green or bare equipment-grounding conductor close to the supply conductors to assure that all enclosures are bonded together and to the source.

Supports, Enclosures, and Equipment to be Grounded

Supports and Enclosures for Conductors

Metal cable trays, metal raceways, and metal enclosures for conductors shall be grounded, except that:

a. Metal enclosures such as sleeves that are used to protect cable assemblies from physical damage need not be grounded; or

b. Metal enclosures for conductors added to existing installations of open wire, knob-and-tube wiring, and non-metallic-sheathed cable need not be grounded if all of the following conditions are met:

- runs are less than 25 feet;
- enclosures are free from probable contact with ground, grounded metal, metal laths, or other conductive materials; and
- enclosures are guarded against employee contact.

Service Equipment Enclosures

Metal enclosures for service equipment shall be grounded.

Frames of Ranges and Clothes

Frames of electric ranges, wall-mounted ovens, counter-mounted cooking units, clothes dryers, and metal outlet or junction boxes which are part of the circuit for these appliances shall be grounded.

Fixed Equipment

Exposed non-current carrying metal parts of fixed equipment which may become energized shall be grounded under any of the following conditions:

a. If within 8 feet vertically or 5 feet horizontally of ground or grounded metal objects and subject to employee contact.

b. If located in a wet or damp location and not isolated.

c. If in electrical contact with metal.

d. If in a hazardous (classified) location.

e. If supplied by a metal-clad, metal-sheathed, or grounded metal raceway wiring method.

f. If equipment operates with any terminal at over 150 volts to ground; however, the following need not be grounded:

- Enclosures for switches or circuit breakers used for other than service equipment and accessible to qualified persons only;

- Metal frames of electrically heated appliances which are permanently and effectively insulated from ground; and

- The cases of distribution apparatus such as transformers and capacitors mounted on wooden poles at a height exceeding 8 feet above ground or grade level.

Equipment Connected by Cord and Plug

Under any of the conditions described below, exposed non-current-carrying metal parts of cord- and plug-connected equipment which may become energized shall be grounded.

a. If in a hazardous (classified) location.

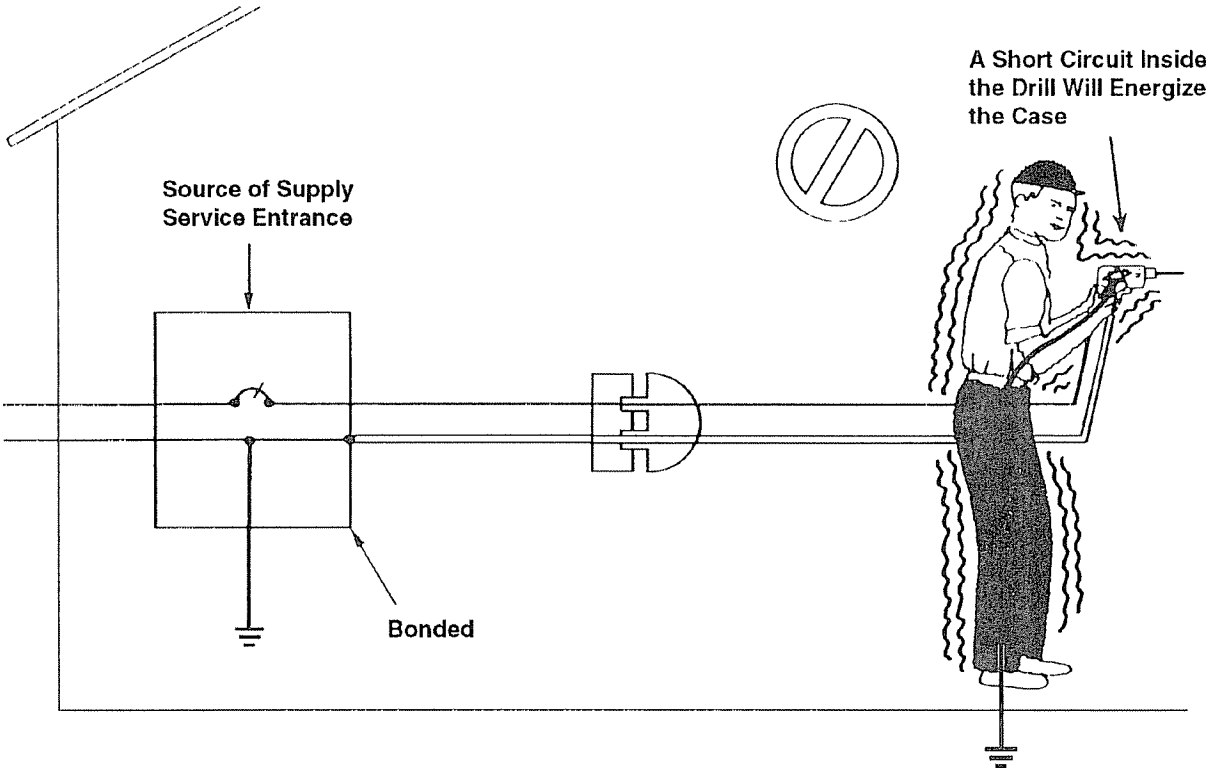
b. If operated at over 150 volts to ground, except for guarded motors and metal frames of electrically heated appliances if the appliance frames are permanently and effectively insulated from ground.

c. If the equipment is of the following types:

- Refrigerators, freezers, and air conditioners;
- Clothes-washing, clothes-drying and dishwashing machines, sump pumps, and electrical aquarium equipment;
- Hand-held motor-operated tools;
- Motor-operated appliances of the following types: hedge clippers, lawn mowers, snow blowers, and wet scrubbers;
- Cord- and plug-connected appliances used in damp or wet locations or by employees standing on the ground or on metal floors or working inside of metal tanks or boilers;
- Portable and mobile X-ray and associated equipment;
- Tools likely to be used in wet and conductive locations; and
- Portable hand lamps.

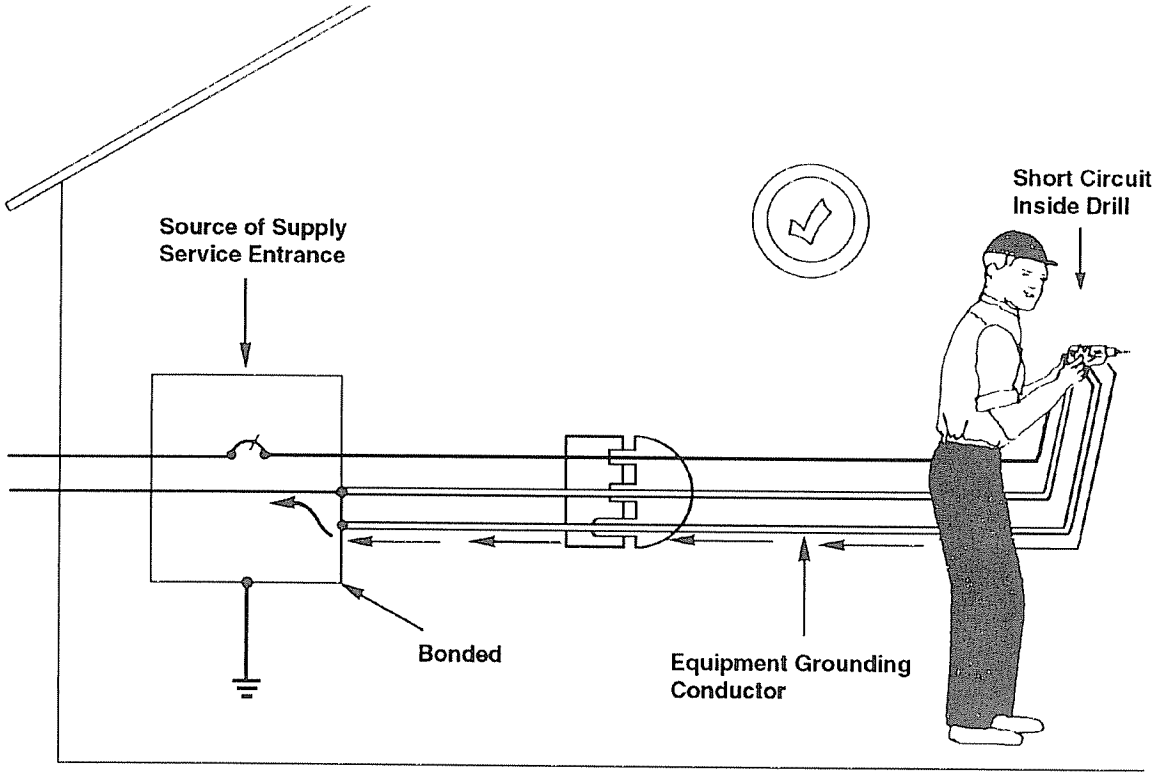
Under the conditions described above, exposed non-current-carrying metal parts of cord- and plug-connected equipment must be grounded. Grounding metal parts is not required where the equipment is supplied through an isolating transformer with an ungrounded secondary of not over 50 volts or if portable tools are protected by an approved system of double insulation. To ground cord- and plug-connected equipment, a third wire is commonly provided in the cord set and a third prong in the plug. The third wire serves as an equipment grounding conductor which is connected to the metal housing of a portable tool and a metal grounding bus inside the service entrance equipment. The service entrance equipment is located at the entrance point of the electric supply for a building or plant and contains, or serves other panelboards which contain, branch circuit protective devices such as fuses and circuit breakers. The third wire provides a path for fault current should an insulation failure occur. In this manner, dangerous fault current will be directed back to the source, the service entrance, and will enable circuit breakers or fuses to operate, thus opening the circuit and stopping the current flow.

The figure below illustrates the potential shock hazard that exists when no third wire, grounding conductor, is used. If a fault occurs, most of the current will follow the path of least resistance. If the worker provides a path to ground as shown, some portion of the current will flow away from the grounded white conductor (neutral) and return to ground through the worker. The severity of the shock received will depend on the amount of current that flows through the worker.



CORD- AND PLUG-CONNECTED EQUIPMENT
WITHOUT A GROUNDING CONDUCTOR

The figure below illustrates the advantage of a properly connected grounded conductor. It should be noted that properly bonded conduit and associated metal enclosures can also serve as a grounding conductor.



CORD- AND PLUG-CONNECTED EQUIPMENT
WITH A GROUNDING CONDUCTOR

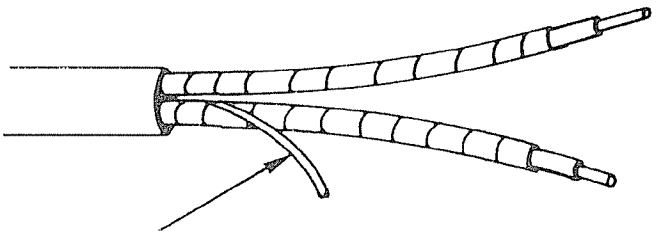
Tools likely to be used in wet and conductive locations need not be grounded if supplied through an isolating transformer with an ungrounded secondary of not over 50 volts. Listed or labeled portable tools and appliances protected by an approved system of double insulation, or its equivalent, need not be grounded. If such a system is employed, the equipment shall be distinctively marked to indicate that the tool or appliance utilizes an approved system of double insulation.

Non-Electrical Equipment

The metal parts of the following non-electrical equipment shall be grounded: frames and tracks of electrically operated cranes; frames of non-electrically driven elevator cars to which electric conductors are attached; hand operated metal shifting ropes or cables of electric elevators, and metal partitions, grill work, and similar metal enclosures around equipment of over 750 volts between conductors.

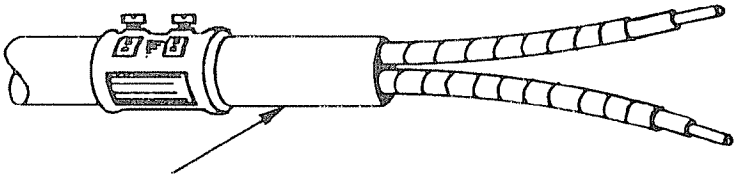
Methods of Grounding Fixed Equipment

Non-current-carrying metal parts of fixed equipment, if required to be grounded by this Subpart (Electrical), shall be grounded by an equipment grounding conductor which is contained within the same raceway, cable, or cord, or runs with or encloses the circuit conductors. For D-C circuits only, the equipment grounding conductor may be run separately from the circuit conductors. The figure below illustrates examples of how equipment grounding conductors may be run.



The equipment grounding conductor must run with the circuit conductors powering fixed equipment . . .

or:



The metal conduit that encloses the power conductors servicing fixed equipment may serve as the equipment grounding conductor for that equipment.

GROUNDING METHODS FOR FIXED EQUIPMENT

Grounding of Systems and Circuits of 1000 Volts and Over (High Voltage)

If high voltage systems are grounded, they shall comply with all applicable provisions previously discussed in this Subpart (Electrical) as well as additional requirements and modifications contained in this section.

WIRING METHODS, COMPONENTS, AND EQUIPMENT FOR GENERAL USE - 1910.305

Wiring Methods

The provisions of this section do not apply to the conductors that are an integral part of factory-assembled equipment.

General Requirements

Electrical Continuity of Metal Raceways and Enclosures

Metal raceways, cable armor, and other metal enclosures for conductors shall be metallically joined together into a continuous electric conductor and shall be so connected to all boxes, fittings, and cabinets as to provide effective electrical continuity.

Wiring in Ducts

No wiring systems of any type shall be installed in ducts used to transport dust, loose stock or flammable vapors. No wiring system of any type may be installed in any duct used for vapor removal or for ventilation of commercial-type cooking equipment, or in any shaft containing only such ducts.

Temporary Wiring

Temporary electrical power and lighting wiring methods may be of a class less than would be required for a permanent installation. Except as specifically modified in this paragraph, all other requirements of this Subpart (Electrical) for permanent wiring shall apply to temporary wiring installations.

Uses Permitted, 600 Volts, Nominal, or Less
Temporary electrical power and lighting installations 600 volts, nominal, or less may be used only:

- During and for remodeling, maintenance, repair, or demolition of buildings, structures, or equipment, and similar activities;
- For experimental or development work, and
- For a period not to exceed 90 days for Christmas decorative lighting, carnivals, and similar purposes.

Uses Permitted, Over 600 Volts, Nominal
Temporary wiring over 600 volts, nominal may be used only during periods of tests, experiments, or emergencies.

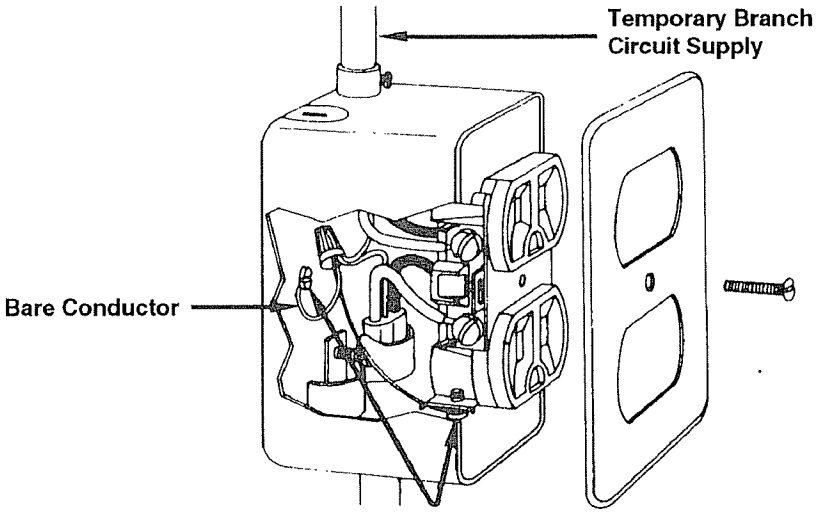
General Requirements for Temporary Wiring

a. Feeders shall originate in an approved distribution center. The conductors shall be run as multi-conductor cord or cable assemblies, or, where not subject to physical damage, they may be run as open conductors or insulators not more than 10 feet apart.

b. Branch circuits shall originate in an approved power outlet or panelboard. Conductors shall be multi-conductor cord or cable assemblies or open conductors. If run as open conductors, they shall be fastened at ceiling height every 10 feet. No branch-circuit conductor may be laid on the floor. Each branch circuit that supplies receptacles or fixed equipment shall contain a separate equipment grounding conductor if run as open conductors.

c. Receptacles used in temporary wiring circuits must provide a connection for an equipment grounding conductor. Unless the receptacle is supplied by a metallic raceway that provides a continuous grounding path back to the

source, a separate equipment grounding conductor must be placed in the branch circuit. There must be good electrical connection between the receptacle grounding terminal and the equipment grounding conductor. See figure below.



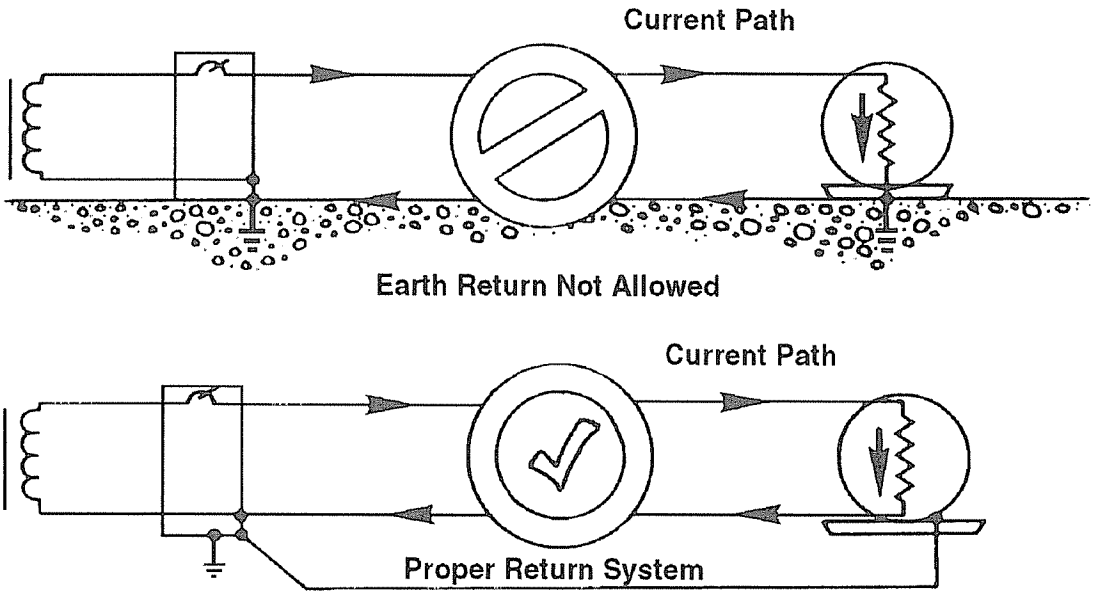
Each receptacle used for tempory wiring shall be connected to the grounding conductor.

A bonding jumper connected to terminal screws provides an electrical connection.

d. No bare conductors nor earth returns may be used for the wiring of any temporary circuit. Bare conductors are conductors that do not have any coverings whatsoever and may not be used for wiring temporary circuits.

Earth returns use the earth itself to provide a current path back to the supply source. This is done by implanting a grounding electrode at the

equipment being served and connecting the equipment to the ungrounded conductor and to the grounding electrode. Since one side of the supply source is also connected to ground through a grounding electrode, a return path exists; however, its effectiveness is dependent on varying soil conditions. Earth returns must not be used for wiring temporary circuits because they are not always effective and may present a serious hazard on temporary work sites. The figure below shows an earth return, which is not allowed, in contrast to a proper return system.



In addition, a separate equipment grounding conductor must be used to provide a low-impedance path to the source. This path will allow sufficient current to flow to operate the circuit breaker when a fault occurs.

EARTH RETURNS

e. Suitable disconnecting switches or plug connectors shall be installed to permit the disconnection of all ungrounded conductors of each temporary circuit.

f. Lamps for general illumination shall be protected from accidental contact or breakage. Protection shall be provided by elevation of at least 7 feet from normal working surface or by a suitable fixture or lampholder with a guard.

g. Flexible cords and cables shall be protected from accidental damage. Sharp corners and projections shall be avoided. Where passing through doorways or other pinch points, flexible cords and cables shall be provided with protection to avoid damage.

Cabinets, Boxes, and Fittings

Conductors Entering Boxes, Cabinets, or Fittings

Since conductors can be damaged if they rub against the sharp edges of cabinets, boxes, or fittings, they must be protected from damage where they enter. To protect the conductors, some type of clamp or rubber grommet must be used. The device used must close the hole through which the conductor passes as well as provide protection from abrasion. If the conductor is in a conduit and the conduit fits tightly in the opening, additional sealing is not required.

The knockouts in cabinets, boxes, and fittings should be removed only if conductors are to be run through them. However, if a knockout is missing or if there is another hole in the box, the hole or opening must be closed.

Covers and Canopies

All pull boxes, junction boxes, and fittings shall be provided with covers approved for the purpose. If metal covers are used, they shall be grounded. In

completed installations, each outlet box shall have a cover, faceplate, or fixture canopy. Covers of outlet boxes having holes through which flexible cord pendants pass shall be provided with bushings designed for the purpose or shall have smooth, well-rounded surfaces on which the cords may bear.

Pull and Junction Boxes for Systems over 600 Volts, Nominal

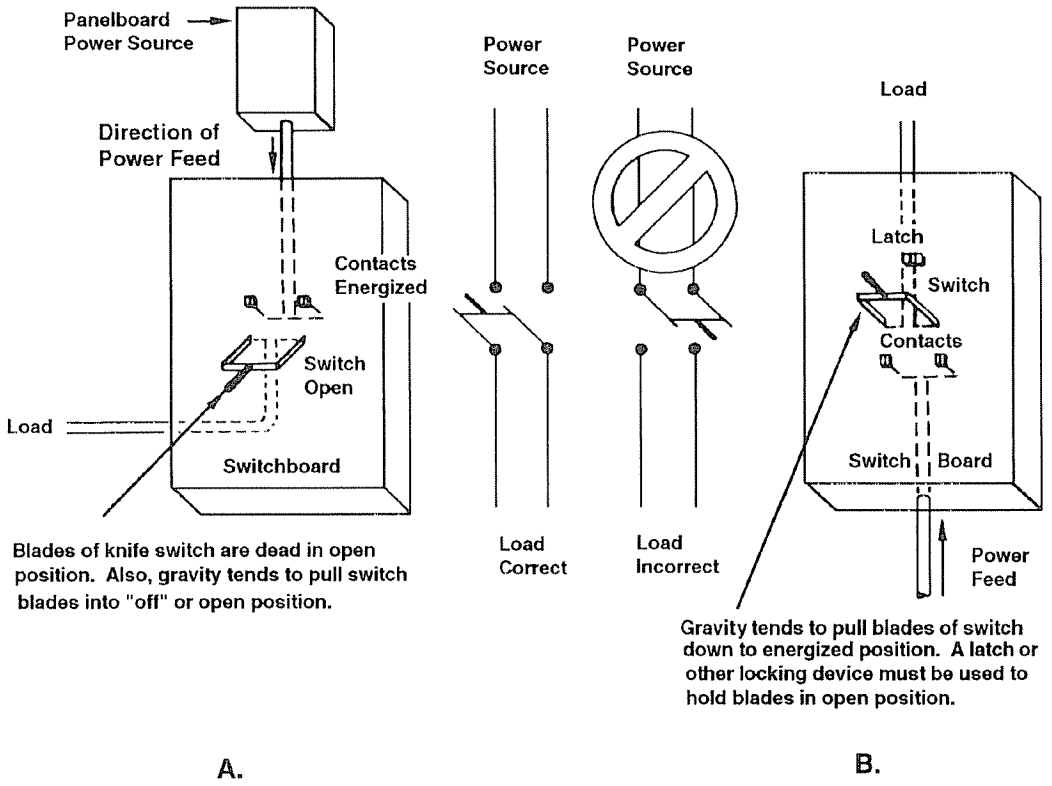
Boxes shall provide a complete enclosure for the contained conductors or cables.

Boxes shall be closed by suitable covers securely fastened in place. Underground box covers that weigh over 100 pounds meet this requirement. Covers for boxes shall be permanently marked "HIGH VOLTAGE." The marking shall be on the outside of the box cover and shall be readily visible and legible.

Switches

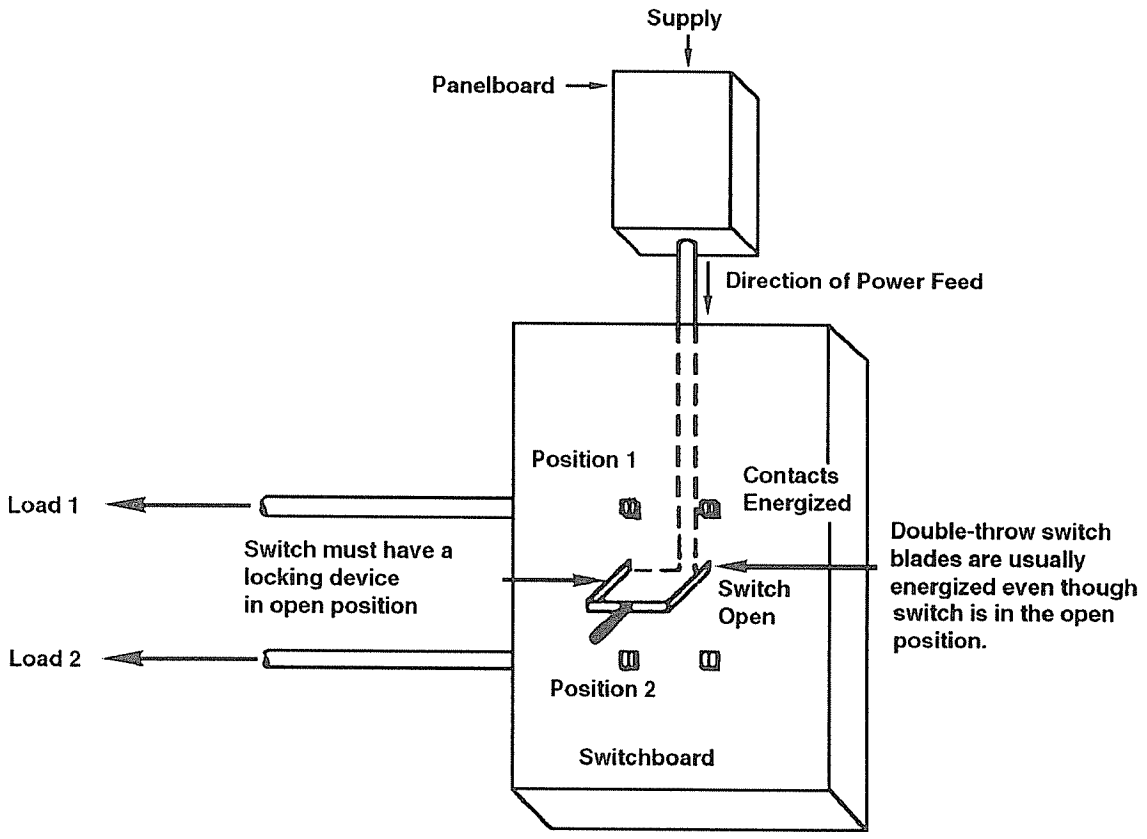
Knife Switches

Single-throw knife switches have one energized (closed or "ON") position and one open (dead or "OFF") position. The switch must be designed so that when it is in the open position, the blades are not energized (i.e., the blades must be connected to the load side, not the supply side of the circuit). The switches must also be installed so that if the switch falls downward, it will not fall into its energized position. However, some single-throw knife switches are designed to be installed so that they open upward. To be approved for this type of installation, they must have a latch or other locking device (such as a spring-loaded device) used to secure the switch in the open position. In the figure below, illustration A shows a single-throw knife switch connected so that the blades are dead when the switch is open. Additionally, illustration B shows a latch arrangement that holds the blade in the open position and will prevent gravity from pulling the switch closed.



SINGLE-THROW KNIFE SWITCHES

Double-throw knife switches are knife switches that have two energized (closed or "ON") positions and one open (dead or "OFF") position. These switches can be mounted vertically so that they are moved up and down, or horizontally so that they are moved back and forth. If switches are mounted vertically, they must have a locking device (such as a spring-loaded device) that will hold the switch blades in the open position. See figure below.



DOUBLE-THROW KNIFE SWITCHES WITH LOCKING DEVICE

Flush snap switches that are mounted in ungrounded metal boxes and located within reach of conducting floors or other conducting surfaces shall be provided with faceplates of non-conducting, non-combustible material.

Switchboards and Panelboards

A switchboard that has exposed live parts must be located in an area that is not subject to wetness or dampness. One purpose of this regulation is to lessen the chance of severe shock if a worker accidentally comes into contact with the live parts. Additionally, only qualified persons may have access to switchboards with exposed live parts. To limit access, the switchboard should be located in a locked room or within a locked cage or fenced area. Keys to the locks should be controlled to ensure that only properly trained personnel are allowed to enter the area.

Enclosures for Damp or Wet Locations

Cabinets, cutout boxes, fittings, boxes, and panelboard enclosures in damp or wet locations shall be installed so as to prevent moisture or water from entering and accumulating within the enclosures. In wet locations, the enclosures shall be weatherproof.

Switches, circuit breakers, and switchboards installed in wet locations shall be enclosed in weatherproof enclosures.

Conductors for General Wiring

To provide adequate protection against shock and fire hazards, conductors must be insulated with approved materials. Insulating material should be the appropriate composition and thickness for the voltage and current the conductor will carry, for the temperature extremes and other environmental factors to which it will be subjected, and for the location in which it is to be placed.

Insulated conductors must also be easily identifiable, and color coding is most often used. Neutral, or grounded, conductors should be white or natural gray.

Grounding conductors such as equipment grounding conductors should be green or green with yellow stripes. Grounding conductors are permitted to be bare wires. Other types of circuit wires may be any colors except these.

Flexible Cords and Cables

This standard for safe use of flexible cords is one of the most frequently violated electrical standards, particularly in smaller plants. There is a definite need and place for cords, but there is also a temptation to misuse them because they seem to offer a quick and easy way to carry electricity to where it is needed. The basic problem is that flexible cords in general are more vulnerable than the fixed wiring of the building. Therefore, cords should not be used if one of the recognized wiring methods could be used instead.

Use of Flexible Cords and Cables

Flexible cords and cables shall be approved and suitable for conditions of use and location. The standard lists specific situations in which flexible cords may be used. Flexible cords and cables shall be used only for:

a. Pendants (a lampholder or cord-connector body suspended by a length of cord properly secured and terminated directly above the suspended device);

b. Wiring of fixtures;

c. Connection of portable lamps or appliances;

d. Elevator cables;

e. Wiring of cranes and hoists (where flexibility is necessary);

f. Connection of stationary equipment to facilitate their frequent interchange (equipment which is not normally moved from place to place, but might be on occasion);

g. Prevention of the transmission of noise or vibration. (In some cases vibration might fatigue fixed wiring and result in a situation more hazardous than flexible cord.)

h. Appliances where the fastening means and mechanical connections are designed to permit removal for maintenance and repair (e.g. water coolers, exhaust fans);

i. Data processing cables approved as a part of the data processing system.

Note that all of the above situations involve conditions where flexibility is necessary. Unless specifically permitted by one of these situations, flexible cords and cables may not be used:

a. As a substitute for the fixed wiring of the structure;

b. Where run through holes in walls, ceilings, or floors;

c. Where run through doorways, windows, or similar openings;

d. Where attached to building surfaces; or

e. Where concealed behind building walls, ceilings, or floors.

There is usually not much question about use of the short length of cord which is furnished as part of an approved appliance or tool; there is usually no question about an extension cord used temporarily to permit use of the appliance or tool in its intended manner at some distance from a fixed outlet;

but there are questions when the usage is not obviously temporary, and when the cord is extended to some distant outlet in order to avoid providing a fixed outlet where needed.

Flexible cord used in violation of this standard is likely to be damaged by activities in the area; by door or window edges; by staples or fastenings; by abrasion from adjacent materials; or simply by aging. If the conductors become partially exposed over a period of time, there will be danger of shocks, burns, or fire.

Identification, Splices and Terminations

Flexible cords shall be used only in continuous lengths without splice or tap. Hard service flexible cords, No. 12 or larger, may be repaired if spliced so that the splice retains the insulation, outer sheath properties, and usage characteristics of the cord being spliced.

Flexible cords shall be connected to devices and fittings so that strain relief is provided which will prevent pull from being directly transmitted to joints or terminal screws.

Portable Cables Over 600 Volts, Nominal

Multi-conductor portable cable for use in supplying power to portable or mobile equipment at over 600 volts, nominal, shall consist of No. 8 or larger conductors employing flexible stranding. Cables operated at over 2000 volts shall be shielded for the purpose of confining the voltage stresses to the insulation. Grounding conductors shall be provided. Connectors for these cables shall be of a locking type with provisions to prevent their opening or closing while energized. Strain relief shall be provided at connections and terminations. Portable cables may not be operated with splices unless the splices are of the permanent molded, vulcanized, or other approved type. Termination enclosures

shall be suitably marked with a high voltage hazard warning, and terminations shall be accessible only to authorized and qualified personnel.

Equipment for General Use

Lighting Fixtures, Lampholders, Lamps, and Receptacles

Fixtures, lampholders, lamps, rosettes, and receptacles may have no live parts normally exposed to employee contact. However, rosettes and cleat-type lampholders and receptacles located at least 8 feet above the floor may have exposed parts.

Portable type handlamps supplied through flexible cords shall be equipped with a handle of molded composition or other material approved for the purpose, and a substantial guard shall be attached to the lampholder or the handle.

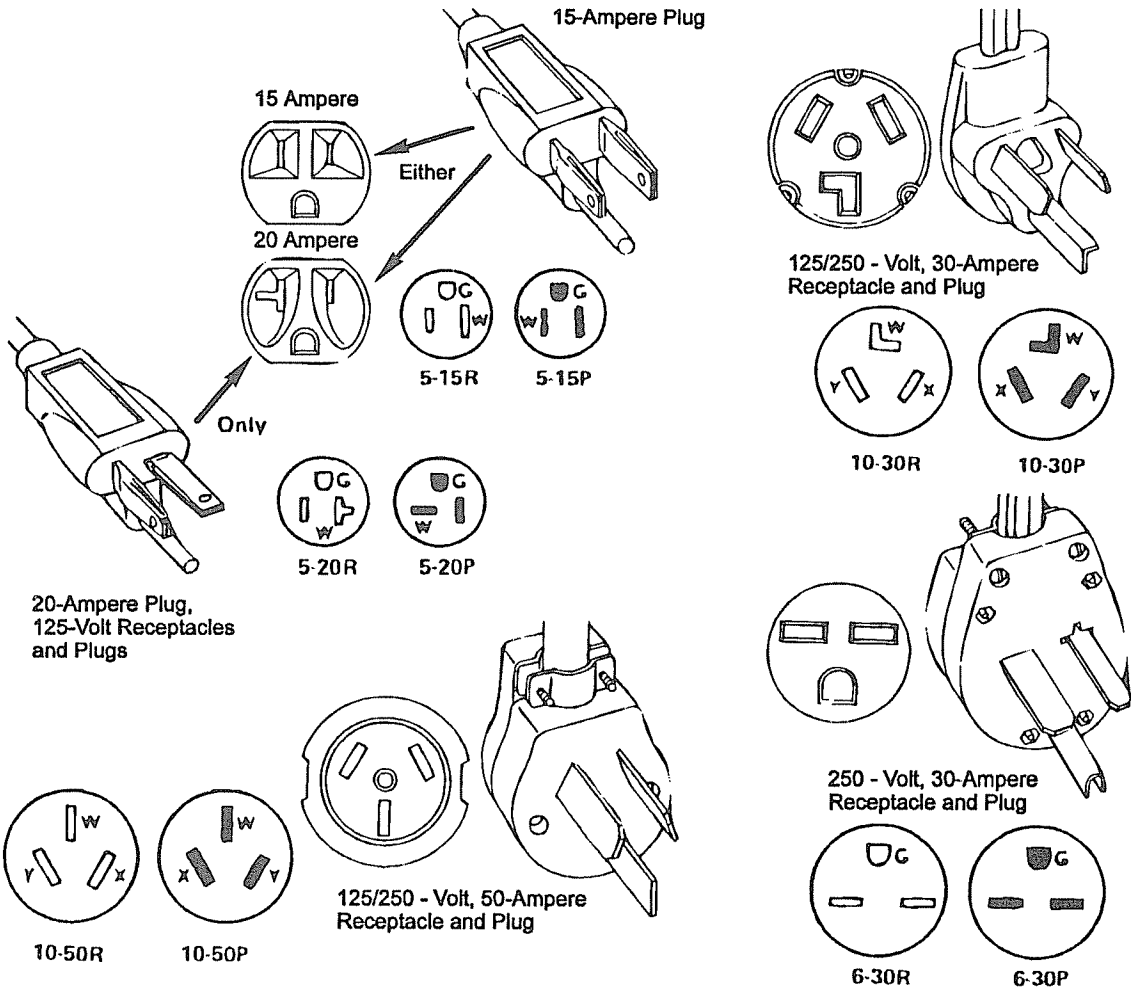
Screw-shell type lampholders shall be installed for use as lampholders only and must not be used with screw-base socket adapters. These adapters screw into the existing lamp socket and convert lampholders into receptacles. These adapters are not permitted because equipment grounding connections cannot be made through the two-blade adapters and because the fixture has been designed only for lighting. Only weatherproof lampholders may be installed in wet or damp areas. Unprotected lampholders might allow moisture to enter the lampholder socket, creating an electrical shock hazard.

Receptacles, Cord Connectors, and Attachment Plugs (Caps)

Cord connectors are devices that join two sections of electrical cord together. Attachment plugs are devices that are fastened onto the end of a cord so that electrical contact can be made between the conductors in the cord and the conductors in a receptacle. Connectors, plugs, and receptacles are uniquely designed for different voltages and currents, so that only matching plugs will fit into the correct receptacle or cord connector. In this way, a piece of

equipment rated for one voltage-current combination cannot be plugged into a power system that is of a different voltage or current capacity.

The only exceptions to this are 125-volt and 250-volt, 20-ampere, T-slot receptacles. One of these is illustrated in the figure below.



RECEPTACLES AND PLUGS WITH NEMA CONFIGURATIONS

A 125-volt and a 250-volt, 15-ampere plug will fit into a 20-ampere T-slot receptacle or connector of the same voltage rating as well as in a 120-volt, 15-ampere grounding type receptacle or connector of the same voltage rating. An electrical appliance that is rated for 15 amperes will not overload a 20-ampere circuit, and the 20-ampere breaker will still provide overcurrent protection for 15-ampere equipment. Note that the opposite is not necessarily true and that a 20-ampere plug will not fit into a 15-ampere receptacle or cord connector.

The National Electrical Manufacturer's Association (NEMA) has standard plug and receptacle connector blade configurations. Each has been developed to standardize the use of plugs and receptacles for different voltages, amperages, and phases from 115 volts through 600, from 15 amperes through 60, and for single- and three-phase systems.

A receptacle installed in a wet or damp location shall be suitable for the location.

Appliances

Electrical appliances such as portable air conditioning units, coffee-makers, and fans must not have any exposed live wires or electrical parts that might create an electrical shock hazard.

Exceptions to this are appliances such as heaters or toasters that must have exposed current-carrying parts that operate at high temperatures to transfer heat (e.g., a space heater). The heat generated by these parts minimizes the possibility of direct contact and resultant electric shock.

A disconnecting means is a switch or plug that can open an electric circuit under load and safely stop the flow of current. All appliances must have a disconnecting means.

Each appliance shall be marked with its rating in volts and amperes or volts and watts.

Motors

Disconnecting Means

a. A disconnecting means shall be located in sight from the controller (i.e., visible from and located within 50 feet of the controller). However, a single disconnecting means may be located adjacent to a group of coordinated controllers mounted adjacent to each other on a multi-motor continuous process machine. The controller disconnecting means for motor branch circuits over 600 volts, nominal, may be out of sight of the controller, if the controller is marked with a warning label giving the location and identification of the disconnecting means which is to be locked in the open position.

b. The disconnecting means shall disconnect the motor and the controller from all ungrounded supply conductors and shall be so designed that no pole can be operated independently.

c. If a motor and the driven machinery are not in sight from the controller location, the installation shall comply with one of the following conditions:

    1. The controller disconnecting means shall be capable of being locked in the open position.

    2. A manually operable switch that will disconnect the motor from its source of supply shall be placed in sight from the motor location.

d. The disconnecting means shall plainly indicate whether it is in the open (off) or closed (on) position.

e. The disconnecting means shall be readily accessible. If more than one

disconnect is provided for the same equipment, only one need be readily accessible.

f. An individual disconnecting means shall be provided for each motor, but a single disconnecting means may be used for a group of motors under any one of the following conditions:

1. If a number of motors drive special parts of a single machine or piece of apparatus, such as a metal or woodworking machine, crane, or hoist;

2. If a group of motors is under the protection of one set of branch-circuit protective devices; or

3. If a group of motors is in a single room in sight from the location of the disconnecting means.

Motor Overload, Short-Circuit, and Ground Fault Protection

Motors, motor-control apparatus, and motor branch-circuit conductors shall be protected against overheating due to motor overloads or failure to start, and against short-circuits or ground faults. These provisions shall not require overload protection that will stop a motor where a shutdown is likely to introduce additional or increased hazards, as in the case of fire pumps, or where continued operation of a motor is necessary for a safe shutdown of equipment or process and motor overload sensing devices are connected to a supervised alarm.

Protection of Live Parts - All Voltages

Stationary motors having commutators, collectors, and brush rigging located inside of motor end brackets and not conductively connected to supply circuits operating at more than 150 volts to ground need not have such parts guarded.

Exposed live parts of motors and controllers operating at 50 volts or more between terminals shall be guarded against accidental contact by any of the following:

1. By installation in a room or enclosure that is accessible only to qualified persons;

2. By installation on a suitable balcony, gallery, or platform, so elevated and arranged as to exclude unqualified persons; or

3. By elevation 8 feet or more above the floor.

Where live parts of motors or controllers operating at over 150 volts to ground are guarded against accidental contact only by location, and where adjustment or other attendance may be necessary during the operation of the apparatus, suitable insulating mats or platforms shall be provided so that the attendant cannot readily touch live parts unless standing on the mats or platforms.

Transformers

These requirements for transformers apply to most transformers, with some exceptions noted in the standard.

a. The operating voltage of exposed live parts of transformer installations shall be indicated by warning signs or visible markings on the equipment or structure.

b. Dry-type, high fire point liquid-insulated, and askarel-insulated transformers installed indoors and rated over 35kV shall be in a vault.

c. If they present a fire hazard to employees, oil-insulated transformers installed indoors shall be in a vault.

d. Combustible material, combustible buildings and parts of buildings, fire escapes, and door and window openings shall be safeguarded from fires which may originate in oil-insulated transformers attached to or adjacent to a building or combustible material.

e. Transformer vaults shall be constructed so as to contain fire and combustible liquids within the vault and to prevent unauthorized access. Locks and latches shall be so arranged that a vault door can be readily opened from the inside.

f. Any pipe or duct system foreign to the vault installation may not enter or pass through a transformer vault.

g. Materials may not be stored in transformer vaults.

Capacitors

Capacitors store electrical charge and can be a source of severe shock unless that charge is drained when the capacitors are disconnected from the power source. Unless some type of automatic discharge is designed into a system, devices such as resistors must be permanently attached across the terminals of the capacitors to drain the charge when the circuit is open (de-energized). Most capacitors are manufactured with this type of discharge resistor already built in. Surge capacitors, which act like lightning rods, do not require an automatic means for draining the charge.

Storage Batteries

Storage batteries, which are usually lead-acid or alkali, produce explosive gases, including hydrogen, if they are overcharged. These explosive gases must not accumulate in quantities that may form an explosive mixture with air. A spark or open flame could ignite the mixture and cause an explosion. Good ventilation must be provided to prevent this accumulation.

HAZARDOUS (CLASSIFIED) LOCATIONS - 1910.307

Hazardous (classified) locations are those areas where a potential for explosion and fire exist because of flammable gases, vapors or finely pulverized dusts in the atmosphere, or because of the presence of easily ignitable fibers or flyings. Hazardous locations may result from the normal processing of certain volatile chemicals, gases, grains, etc., or it may result from accidental failure of storage systems for these materials. It is also possible that a hazardous location may be created when volatile solvents or fluids, used in a normal maintenance routine, vaporize to form an explosive atmosphere.

Hazardous (classified) locations may be found in occupancies such as aircraft hangars, gasoline dispensing and service stations, bulk storage plants for gasoline or other volatile flammable liquids, paint-finishing process plants, health care facilities, agricultural or other facilities where excessive combustible dusts may be present, marinas, boat yards, and petroleum and chemical processing plants. Each room, section or area shall be considered individually in determining its classification.

Regardless of the cause of a hazardous location, it is necessary that every precaution be taken to guard against ignition of the atmosphere. Certainly no open flames would be permitted in these locations, but there are other potential sources of ignition, including electrical equipment. The normal operation of switches, circuit breakers, motor starters, contactors and plugs and receptacles release this energy in the form of arcs and sparks as contacts open and close; making and breaking circuits.

Electrical equipment such as lighting fixtures and motors are classified as "heat producing" and they will become a source of ignition if they reach a surface temperature which exceeds the ignition temperature of the particular gas, vapor or dust in the atmosphere.

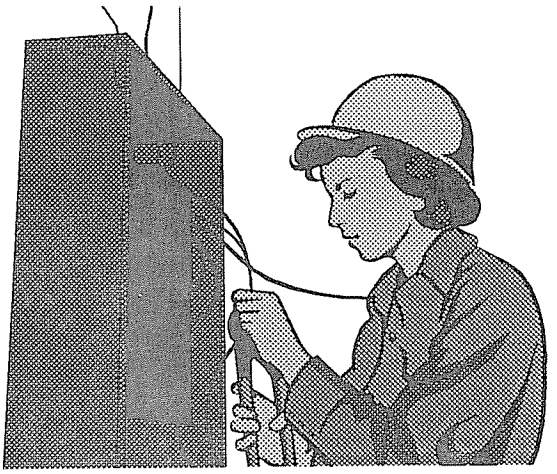
It is also possible that an abnormality or failure in an electrical system could provide a source of ignition. The failure of insulation from cuts, nicks or aging can also act as an ignition source again from sparking, arcing and heat.

There are several OSHA standards that require the installation of electrical wiring and equipment in hazardous (classified) locations according to the requirements of Subpart S, Electrical. Most of these standards are contained in Subpart H, Hazardous Materials. Some examples include Acetylene, Flammable and Combustible Liquids, Spray Finishing Using Flammable and Combustible Liquids, and Dip Tanks Containing Flammable or Combustible Materials.

The basis for OSHA standard 1910.307 is the *National Electrical Code* (NEC), NFPA 70. A general overview of the guidelines contained in the NEC for installation of electrical wiring and equipment in hazardous (classified) locations can be found in this document under the section entitled "Hazardous Materials."

Electrical Safety Related Work Practices

OSHA's Safety-Related Work Practice standards for general industry, §§1910.331-.399, are performance-oriented regulations that complement the existing electrical installation standards. These work-practice standards include requirements for work performed on or near exposed energized and de-energized parts of electric equipment; use of electrical protective equipment; and the safe use of electric equipment.



These rules are intended to protect employees from the electrical hazards that they may be exposed to even though equipment may be in compliance with the installation requirements in Subpart S (Electrical). When employees are working with electric equipment, they must use safe work practices. Such safety-related work practices include keeping a prescribed distance from exposed energized lines, avoiding the use of electric equipment when the employee or the equipment is wet, and locking-out and tagging equipment which is de-energized for maintenance.

Another important safety practice involves the use of electrical protective devices, such as rubber gloves and rubber mats for the purpose of insulation against live parts, or live-line tools for purposes of both insulation and manipulation of energized parts from a distance. However, to assure the protection of the employee, this equipment must be properly manufactured and maintained.

It is important to understand the distinction between these standards and OSHA Standard §1910.147, *Control of Hazardous Energy (Lockout/Tagout)*. The lockout/tagout standard helps safeguard employees from hazardous energy while they are performing servicing or maintenance on machines and equipment. The standard covers electrical energy sources, but it specifically excludes "exposure to electrical hazards from work on, near, or with conductors or equipment in electrical utilization installations," which is covered by Subpart S (Electrical). Thus, the lockout/tagout standard does not cover electrical hazards associated with conductors and equipment but only covers that electrical equipment which relates to machinery and equipment that is covered by the lockout standard.

SCOPE - 1910.331

Covered Work by Both Qualified and Unqualified Persons

The provisions of these standards cover electrical safety-related work practices for both qualified persons (those who have training in avoiding the electrical hazards of working on or near exposed energized parts) and unqualified persons (those with little or no such training) working on, near, or with the following installations:

- *Premises Wiring.* Installations of electric conductors and equipment within or on buildings or other structures, and on other premises such as yards, carnival, parking, and other lots, and industrial substations;

- *Wiring for Connections to Supply.* Installations of conductors that connect to the supply of electricity; and

- *Other Wiring.* Installations of other outside conductors on the premises.

- *Optical Fiber Cable.* Installations of optical fiber cable where such installations are made along with electric conductors.

Other Covered Work by Unqualified Persons

The provisions of these standards also cover work performed by unqualified persons on, near, or with the following installations:

- *Generation, transmission, and distribution installations.* Installations for the generation, control, transformation, transmission, and distribution of electric energy (including communication and metering) located in buildings used for such purposes or located outdoors.

- *Communications installations.* Installations of communications equipment to the extent that the work is covered under OSHA standard §1910.268.

- *Installations in vehicles.* Installations in ships, watercraft, railway rolling stock, aircraft, or automotive vehicles other than mobile homes and recreational vehicles.

- *Railway installations.* Installations of railways for generation, transformation, transmission, or distribution of power used exclusively for operation of rolling stock or installations of railways used exclusively for signaling and communication purposes.

Excluded Work by Qualified Persons

The provisions of these standards do not apply to work performed by qualified persons on or directly associated with the four types of installations described above.

TRAINING - 1910.332

Scope

The training requirements contained in this section apply to employees who face a risk of electric shock that is not reduced to a safe level by the electrical installation requirements of §§1910.303-.308. Employees in occupations listed below face such a risk and are required to be trained:

- Blue collar supervisors
- Electrical and electronic engineers
- Electrical and electronic equipment engineers
- Electrical and electronic technicians
- Electricians
- Industrial machine operators
- Material handling equipment operators
- Mechanics and repairers
- Painters
- Riggers and roustabouts
- Stationary engineers
- Welders

With the exception of electricians and welders, workers in the above groups do not need to be trained if their work or the work of those they supervise does not bring them or the employees they supervise close enough to exposed parts of electric circuits operating at 50 volts or more to ground for a hazard to exist.

Other employees who also may reasonably be expected to face a comparable risk of injury due to electric shock or other electrical hazards must also be trained.

Content of Training

Employees shall be trained in and familiar with the safety-related work practices required by §§1910.331-.355 that pertain to their respective job assignments.

Employees who are covered by the scope of this standard but who are not qualified persons shall also be trained in and familiar with any electrically related safety practices not specifically addressed by §§1910.331-.335 but which are necessary for their safety.

Qualified persons (i.e., those permitted to work on or near exposed energized parts) shall, at a minimum, be trained in and familiar with the following:

- The skills and techniques necessary to distinguish exposed live parts from other parts of electric equipment,
- The skills and techniques necessary to determine the nominal voltage of exposed live parts, and
- The clearance distances specified in this standard and the corresponding voltages to which the qualified person will be exposed.

Type of Training

The training required by this section shall be of the classroom or on-the-job type. The degree of training provided shall be determined by the risk to the employee.

SELECTION AND USE OF WORK PRACTICES - 1910.333

General

Safety-related work practices shall be employed to prevent electric shock or other injuries resulting from either direct or indirect electrical contacts, when work is performed near or on equipment or circuits which are or may be energized. The specific safety-related work practices shall be consistent with the nature and extent of the associated electrical hazards.

De-energized Parts

Live parts to which an employee may be exposed shall be de-energized before the employee works on or near them, unless the employer can demonstrate that de-energizing introduces additional or increased hazards or is infeasible due to equipment design or operational limitations. Live parts that operate at less than 50 volts to ground need not be de-energized if there will not be increased exposure to electrical burns or to explosion due to electric arcs.

Energized Parts

If the exposed live parts are not de-energized, (i.e., for reasons of increased or additional hazards or infeasibility), other safety-related work practices shall be used to protect employees who may be exposed to the electrical hazards involved. Such work practices shall protect employees against contact with energized circuit parts directly with any part of their body or indirectly through some other conductive object.

Working On or Near Exposed De-energized Parts

Application

This paragraph applies to work on exposed de-energized parts or near enough to them to expose the employee to any electrical hazard they present.

Conductors and parts of electric equipment that have been de-energized but have not been locked out or tagged shall be treated as *energized* parts.

Lockout and Tagging

While any employee is exposed to contact with parts of fixed electric equipment or circuits which have been de-energized, the circuits energizing the parts shall be locked out or tagged or both in accordance with the requirements of this paragraph in the following order:

1. Procedures shall be in place before equipment may be de-energized.

2. Circuits and equipment to be worked on shall be disconnected from all electrical energy sources.

3. Stored electrical energy which poses a hazard to workers shall be released.

4. Stored non-electrical energy in devices that could re-energize electric circuit parts shall be blocked or relieved to the extent that the circuit parts could not be accidentally energized by the device.

5. A lock and a tag shall be placed on each disconnecting means used to de-energize circuits and equipment on which work is to be performed, except as provided below.

6. Each tag shall contain a statement prohibiting unauthorized operation of the disconnecting means and removal of the tag.

7. If a lock cannot be applied, or if the employer can demonstrate that tagging procedures will provide a level of safety equivalent to that obtained by the use of a lock, a tag may be used without a lock.

8. A tag used without a lock as permitted above, shall be supplemented by at

least one additional safety measure that provides a level of safety equivalent to that obtained by the use of a lock. Examples include the removal of an isolating circuit element, blocking of a controlling switch, or opening of an extra disconnecting device.

9. A lock may be placed without a tag only under the following conditions:

    a. Only one circuit or piece of equipment is de-energized, and

    b. The lockout period does not extend beyond the work shift, and

    c. Employees exposed to the hazards associated with re-energizing the circuit or equipment are familiar with this procedure.

10. Before any circuits or equipment can be considered and worked as de-energized:

    a. A qualified person shall operate the equipment operating controls or otherwise verify that the equipment cannot be restarted.

    b. A qualified person shall use test equipment to test the circuit elements and electrical parts of equipment to which employees will be exposed and shall verify that the circuit elements and equipment parts are de-energized.

11. Before circuits and equipment are re-energized, even temporarily, the following requirements shall be met, in the order given:

    a. A qualified person shall conduct tests and visual inspections, as necessary, to verify that all tools, electrical jumpers, shorts, grounds, and other such devices have been removed, so that the circuits and equipment can be safely energized.

b. Employees exposed to the hazards associated with re-energizing the circuit or equipment shall be warned to stay clear of circuits and equipment.

c. Each lock and tag shall be removed by the employee who applied it or under his or her direct supervision. However, if this employee is absent from the workplace, then the lock or tag may be removed by a qualified person designated to perform this task provided that the employer ensures that the employee who applied the lock or tag is not available at the workplace and is aware that the lock or tag has been removed before he or she resumes work at that workplace.

d. There shall be a visual determination that all employees are clear of the circuits and equipment.

Working On or Near Exposed Energized Parts

Application

This paragraph applies to work performed on exposed live parts (involving either direct contact or contact by means of tools or materials) or near enough to them for employees to be exposed to any hazard they present.

Work on Energized Equipment

Only qualified persons may work on electric circuit parts or equipment that have not been de-energized under the procedures of these standards. Such persons shall be capable of working safely on energized circuits and shall be familiar with the proper use of special precautionary techniques, personal protective equipment, insulating and shielding materials, and insulated tools.

Overhead Lines

If work is to be performed near overhead lines, the lines shall be de-energized and grounded, or other protective measures shall be provided before work is started. If the lines are to be de-energized, arrangements shall be made with the operator or controller of the electric circuits involved to de-energize and ground them. If protective measures are provided such as guarding, isolating, or insulating, these precautions shall prevent employees from contacting such lines directly with any part of their body or indirectly through conductive materials, tools, or equipment.

Unqualified Persons

When an unqualified person is working in an elevated position near overhead lines, the location shall be such that the person and the longest conductive object he or she may contact cannot come closer to any unguarded, energized overhead line than the following distances:

- For voltages to ground 50kV or below - 10 feet
- For voltages to ground over 50kV - 10 feet plus 4 inches for every 10kV over 50kV.

When an unqualified person is working on the ground in the vicinity of overhead lines, the person may not bring any conductive object closer to unguarded, energized overhead lines than the distances given above.

Qualified Persons

When a qualified person is working in the vicinity of overhead lines, whether in an elevated position or on the ground, the person may not approach or take any conductive object without an approved insulating handle closer to exposed energized parts than shown in Table S-5 of §1910.333(c)(3)(ii) unless certain insulation requirements are met.

Vehicular and Mechanical Equipment

Any vehicle or mechanical equipment capable of having parts of its structure elevated near energized overhead lines shall be operated so that a clearance of 10 feet is maintained. If the voltage is higher than 50kV, the clearance shall be increased 4 inches for every 10kV over that voltage. The standard outlines several conditions under which this clearance may be reduced.

Illumination

Employees may not enter spaces containing exposed energized parts, unless illumination is provided that enables the employees to perform the work safely.

Where lack of illumination or an obstruction precludes observation of the work to be performed, employees may not perform tasks near exposed energized parts. Employees may not reach blindly into areas which may contain energized parts.

Confined or Enclosed Work Spaces

When an employee works in a confined or enclosed space (such as a manhole or vault) that contains exposed energized parts, the employer shall provide, and the employee shall use, protective shields, protective barriers, or insulating materials as necessary to avoid inadvertent contact with these parts. Doors, hinged panels, and the like shall be secured to prevent their swinging into an employee and causing the employee to contact exposed energized parts.

Conductive Materials and Equipment

Conductive materials and equipment that are in contact with any part of an employee's body shall be handled in a manner that will prevent them from contacting exposed energized conductors or circuit parts. If an employee must handle long dimensional conductive objects (such as ducts and pipes) in areas with exposed live parts, the employer shall institute work practices (such as the use of insulation, guarding, and material handling techniques) which will minimize the hazard.

Portable Ladders

Portable ladders shall have non-conductive siderails if they are used where the employee or the ladder could contact exposed energized parts.

Conductive Apparel

Conductive articles of jewelry and clothing may not be worn if they might contact exposed energized parts, unless they are rendered non-conductive by covering, wrapping, or other insulating means.

Housekeeping Duties

Where live parts present an electrical contact hazard, employees may not perform housekeeping duties at such close distances to the parts that there is a possibility of contact, unless adequate safeguards (such as insulating equipment or barriers) are provided.

Electrically conductive cleaning materials may not be used in proximity to energized parts unless procedures are followed which will prevent electrical contact.

Interlocks

Only a qualified person following the requirements of this section may defeat an electrical safety interlock, and then only temporarily while he or she is working on the equipment. The interlock system shall be returned to its operable condition when this work is completed.

USE OF EQUIPMENT - 1910.334

Portable Electric Equipment

This paragraph applies to the use of cord- and plug-connected equipment, including flexible cord sets (extension cords).

Handling

Portable equipment shall be handled in a manner which will not cause damage. Flexible electric cords connected to equipment may not be used for raising or lowering the equipment. Flexible cords may not be fastened with staples or otherwise hung in such a fashion as could damage the outer jacket or insulation.

Visual Inspection

Portable cord- and plug-connected equipment and flexible cord sets (extension cords) shall be visually inspected before use on any shift for external defects and for evidence of possible internal damage. Cord- and plug-connected equipment and extension cords which remain connected once they are put in place and are not exposed to damage need not be visually inspected until they are relocated. Defective or damaged items shall be removed from service until repaired.

Grounding-Type Equipment

A flexible cord used with grounding-type equipment shall contain an equipment grounding conductor.

Attachment plugs and receptacles may not be connected or altered in a manner which would prevent proper continuity of the equipment grounding conductor at the point where plugs are attached to receptacles. Additionally, these devices may not be altered to allow the grounding pole of a plug to be inserted into slots intended for connection to the current-carrying conductors.

Adapters which interrupt the continuity of the equipment grounding connection may not be used.

Conductive Work Locations

Portable electric equipment and flexible cords used in highly conductive work locations (such as those inundated with water or other conductive liquids), or in job locations where employees are likely to contact water or conductive liquids, shall be approved for those locations.

Connecting Attachment Plugs

Employees' hands may not be wet when plugging and unplugging flexible cords and cord- and plug-connected equipment, if energized equipment is involved.

Energized plug and receptacle connections may be handled only with insulating protective equipment if the condition of the connection could provide a conducting path to the employee's hand.

Locking-type connectors shall be properly secured after connection.

Electric Power and Lighting Circuits

Routine Opening and Closing of Circuits

Load rated switches, circuit breakers, or other devices specifically designed as disconnecting means shall be used for the opening, reversing, or closing of circuits under load conditions. Cable connectors not of the load-break type, fuses, terminal lugs, and cable splice connections may not be used for such purposes, except in an emergency.

Re-closing Circuits After Protective Device Operation

After a circuit is de-energized by a circuit protective device, the circuit may not be manually re-energized until it has been determined that the equipment and

circuit can be safely energized. The repetitive manual re-closing of circuit breakers or re-energizing circuits through replaced fuses is prohibited.

Overcurrent Protection Modification

Overcurrent protection of circuits and conductors may not be modified, even on a temporary basis, beyond that allowed in §1910.304(e), the installation safety requirements for overcurrent protection.

Test Instruments and Equipment

Use

Only qualified persons may perform testing work on electric circuits or equipment.

Visual Inspection

Test instruments and equipment and all associated test leads, cables, power cords, probes, and connectors shall be visually inspected for external defects and damage before the equipment is used. If there is a defect or evidence of damage that might expose an employee to injury, the defective or damaged item shall be removed from service, and no employee may use it until necessary repairs and tests to render the equipment safe have been made.

Rating of Equipment

Test instruments and equipment and their accessories shall be rated for the circuits and equipment to which they will be connected and shall be designed for the environment in which they will be used.

Occasional Use of Flammable or Ignitable Materials

Where flammable materials are present only occasionally, electric equipment capable of igniting them shall not be used, unless measures are taken to prevent hazardous conditions from developing.

SAFEGUARDS FOR PERSONNEL PROTECTION - 1910.335

Use of Protective Equipment

Personal Protective Equipment

Employees working in areas where there are potential electrical hazards shall be provided with, and shall use, electrical protective equipment that is appropriate for the specific parts of the body to be protected and for the work to be performed.

Protective equipment shall be maintained in a safe, reliable condition and shall be periodically inspected or tested, as required by §1910.137.

If the insulating capability of protective equipment may be subject to damage during use, the insulating material shall be protected. (For example, an outer covering of leather is sometimes used for the protection of rubber insulating material.)

Employees shall wear non-conductive head protection wherever there is a danger of head injury from electric shock or burns due to contact with exposed energized parts.

Employees shall wear protective equipment for the eyes or face wherever there is danger of injury to the eyes or face from electric arcs or flashes or from flying objects resulting from electrical explosion.

General Protective Equipment and Tools

When working near exposed energized conductors or circuit parts, each employee shall use insulated tools or handling equipment if the tools or handling equipment might make contact with such conductors or parts. If the insulating capability of insulated tools or handling equipment is subject to damage, the insulating material shall be protected.

Fuse handling equipment, insulated for the circuit voltage, shall be used to remove or install fuses when the fuse terminals are energized.

Ropes and handlines used near exposed energized parts shall be non-conductive.

Protective shields, protective barriers, or insulating materials shall be used to protect each employee from shock, burns, or other electrically-related injuries while that employee is working near exposed energized parts which might be accidentally contacted or where dangerous electric heating or arcing might occur. When normally enclosed live parts are exposed for maintenance or repair, they shall be guarded to protect unqualified persons from contact with the live parts.

Alerting Techniques

The following alerting techniques shall be used to warn and protect employees from hazards which could cause injury due to electric shock, burns, or failure of electric equipment parts:

1. *Safety signs and tags.* Safety signs, safety symbols, or accident prevention tags shall be used where necessary to warn employees about electrical hazards which may endanger them, as required by §1910.145.

2. *Barricades.* Barricades shall be used in conjunction with safety signs where it is necessary to prevent or limit employee access to work areas exposing employees to uninsulated energized conductors or circuit parts. Conductive barricades may not be used where they might cause an electrical contact hazard.

3. *Attendants.* If signs and barricades do not provide sufficient warning and protection from electrical hazards, an attendant shall be stationed to warn and protect employees.