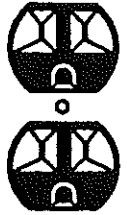


**Section E. Electrical Safety**



*Electrical safety is an important component of a construction safety program. To minimize personal injury from contact with energized sources, construction workers shall be trained in the fundamentals of electrical safety; and all electrical hazards found on the construction site must be recorded and corrected immediately.*

*The following section covers safety requirements for users of electricity (general site workers and tradespeople) and electrical workers (electricians). Additional installation requirements, interpretations, and definitions may be found in 29 Code of Federal Regulations (CFR) 1926.400–449 and the National Electric Code (National Fire Protection Association [NFPA 70]); other national, state, and local codes; and manufacturer's instructions attached to equipment. All appropriate requirements shall be followed.*

**1. Requirements for All Site Workers**

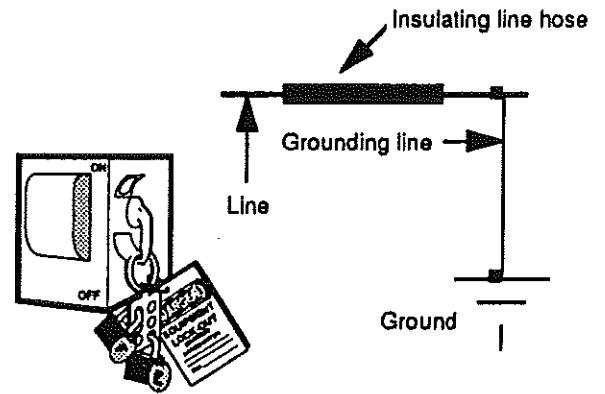
a. Before work begins it shall be determined by inquiry, direct observation, or by instrument that the electric power circuit, exposed or concealed, is so located that work may bring a worker, tools, or machine into physical or electrical contact with the circuit. Where such a circuit exists, warning signs shall be posted and maintained, and workers shall be advised of such circuit locations, the hazard involved, and the protective means to be taken.

29 CFR 1926.416(a)(3)



b. Workers shall not be permitted to work near any part of an electrical power circuit where there could be contact with the circuit in the course of their work unless the worker is protected against shock by guarding or de-energizing and grounding the circuit.

29 CFR 1926.416(a)(1)



**De-energizing, Guarding, and Grounding Methods**

c. Entrances to rooms and other guarded locations of exposed live parts shall be posted with warnings forbidding entry of unqualified persons. Workers shall obey all warning signs and tags.

29 CFR 1926.403(i)(2)(iii)



**Obey Warnings**

d. Workspaces, walkways, and similar locations shall be clear of electric cords and tools, so that workers can pass freely.

29 CFR 1926.416(b)(2)

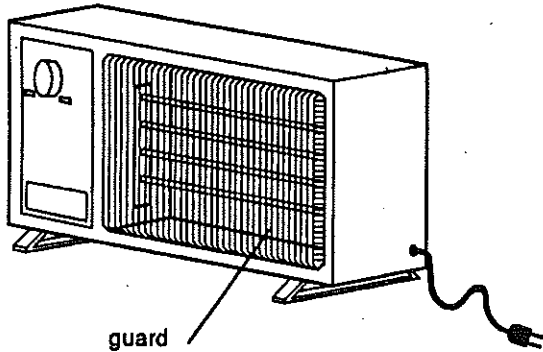


e. Workers shall not store material in or around electrical cabinets or equipment, if the material blocks the service space.

29 CFR 1926.403(i)(1)(i,ii)

f. Appliances shall have no live parts exposed to worker contact. Guards which prevent worker exposure to live parts shall not be removed or altered.

29 CFR 1926.405(j)(3)(i)



Guarded Appliance

g. Workers using electrically powered equipment shall confirm that such equipment is free of recognized hazards.

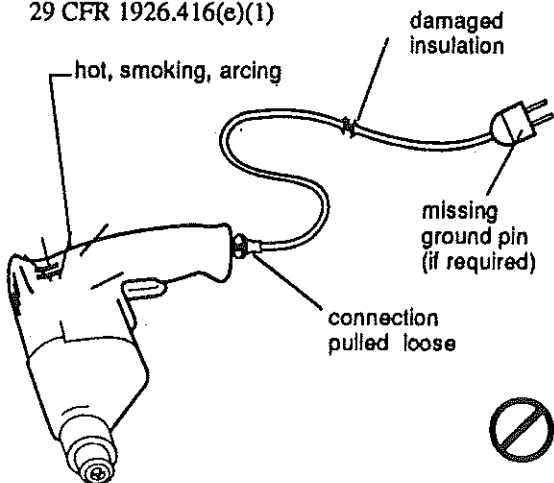
29 CFR 1926.300(a); .403(b)

h. Workers shall inspect electric power tools and equipment (including extension cords and plugs) for the following hazards:

- missing ground pins on plugs (except double insulated);
- insulation pulled free from plugs or support connections;
- damaged insulation (breaks, cuts, or cracks);
- exposed wires; and
- evidence of arcing, sparking, or smoking.

i. If the hazards in paragraph h. above are evident in electric power tools or equipment, the tool or equipment shall be removed from the construction site until repaired.

29 CFR 1926.416(e)(1)

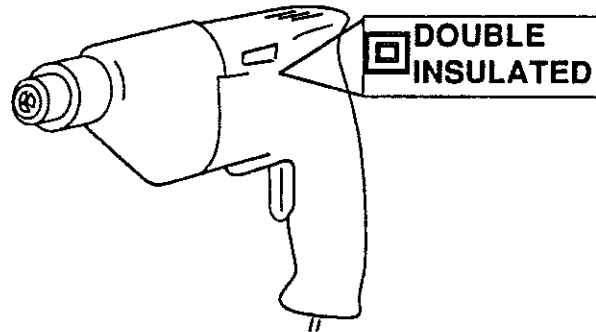


j. Electrically powered equipment shall be connected only to approved outlets or sources that meet the requirements.

29 CFR 1926, subpart K

k. Electric power tools shall be grounded or double insulated. If double insulated, they shall be permanently labeled "DOUBLE INSULATED."

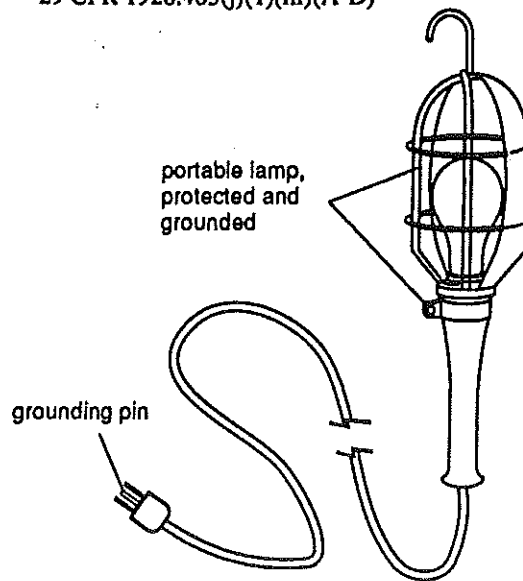
29 CFR 1926.302(a)(1); .404(f)(7)(iv)(C)(6); .951(f)(2)(i-ii)



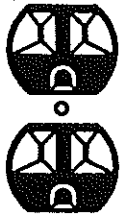
*Note: The use of double-insulated electrical hand tools does not alter the requirements for a ground-fault circuit interrupter (GFCI) system or an assured equipment grounding program for a worksite-supplied electric power system as required in 29 CFR 1926.404(b)(1)(i).*

l. Portable lampholders used by workers shall be wired with flexible cord and a polarized or grounding-type attachment plug; they shall be equipped with an insulated, molded-composition handle. A substantial guard (if metal, it shall be grounded by a conductor run inside the power cord) shall be attached to the handle or lampholder.

29 CFR 1926.405(j)(1)(iii)(A-D)



## Section E. Electrical Safety



*Electrical safety is an important component of a construction safety program. To minimize personal injury from contact with energized sources, construction workers shall be trained in the fundamentals of electrical safety; and all electrical hazards found on the construction site must be recorded and corrected immediately.*

*The following section covers safety requirements for users of electricity (general site workers and tradespeople) and electrical workers (electricians). Additional installation requirements, interpretations, and definitions may be found in 29 Code of Federal Regulations (CFR) 1926.400–449 and the National Electric Code (National Fire Protection Association [NFPA 70]); other national, state, and local codes; and manufacturer's instructions attached to equipment. All appropriate requirements shall be followed.*

### 1. Requirements for All Site Workers

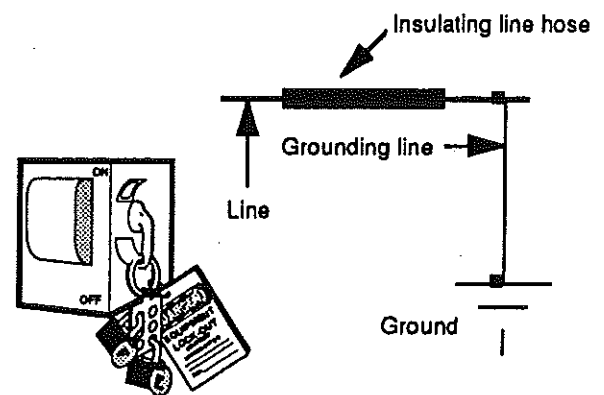
a. Before work begins it shall be determined by inquiry, direct observation, or by instrument that the electric power circuit, exposed or concealed, is so located that work may bring a worker, tools, or machine into physical or electrical contact with the circuit. Where such a circuit exists, warning signs shall be posted and maintained, and workers shall be advised of such circuit locations, the hazard involved, and the protective means to be taken.

29 CFR 1926.416(a)(3)



b. Workers shall not be permitted to work near any part of an electrical power circuit where there could be contact with the circuit in the course of their work unless the worker is protected against shock by guarding or de-energizing and grounding the circuit.

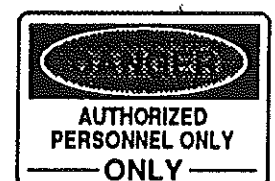
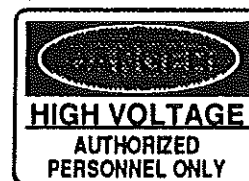
29 CFR 1926.416(a)(1)



De-energizing, Guarding, and Grounding Methods

c. Entrances to rooms and other guarded locations of exposed live parts shall be posted with warnings forbidding entry of unqualified persons. Workers shall obey all warning signs and tags.

29 CFR 1926.403(i)(2)(iii)



Obey Warnings

d. Workspaces, walkways, and similar locations shall be clear of electric cords and tools, so that workers can pass freely.

29 CFR 1926.416(b)(2)

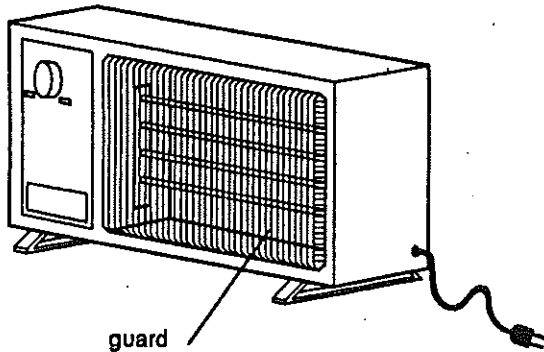


e. Workers shall not store material in or around electrical cabinets or equipment, if the material blocks the service space.

29 CFR 1926.403(i)(1)(i,ii)

f. Appliances shall have no live parts exposed to worker contact. Guards which prevent worker exposure to live parts shall not be removed or altered.

29 CFR 1926.405(j)(3)(i)



Guarded Appliance

g. Workers using electrically powered equipment shall confirm that such equipment is free of recognized hazards.

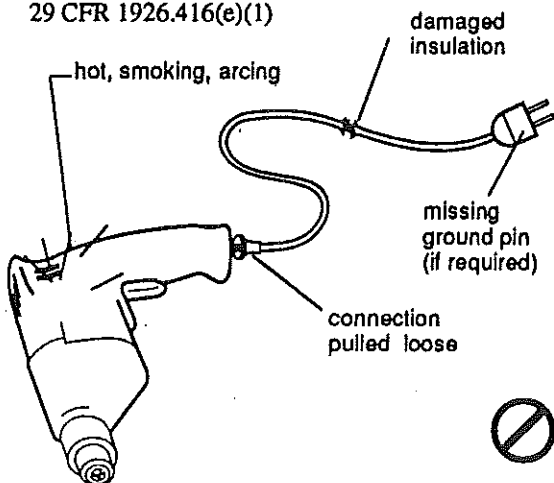
29 CFR 1926.300(a); 403(b)

h. Workers shall inspect electric power tools and equipment (including extension cords and plugs) for the following hazards:

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- damaged insulation (breaks, cuts, or cracks);
- exposed wires; and
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i. If the hazards in paragraph h. above are evident in electric power tools or equipment, the tool or equipment shall be removed from the construction site until repaired.

29 CFR 1926.416(e)(1)

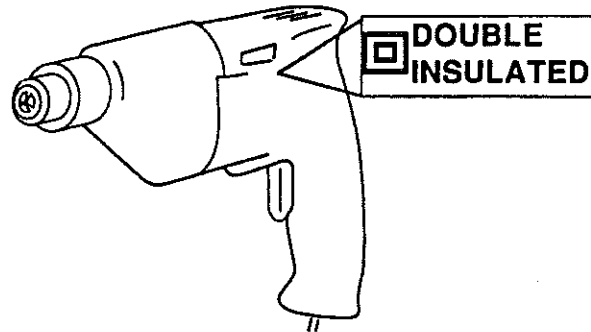


j. Electrically powered equipment shall be connected only to approved outlets or sources that meet the requirements.

29 CFR 1926, subpart K

k. Electric power tools shall be grounded or double insulated. If double insulated, they shall be permanently labeled "DOUBLE INSULATED."

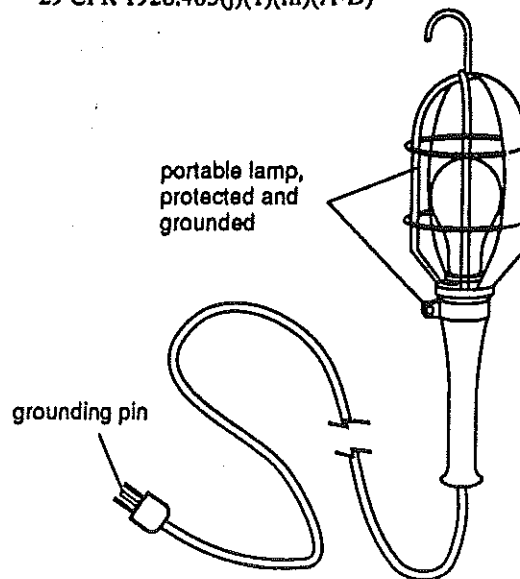
29 CFR 1926.302(a)(1); .404(f)(7)(iv)(C)(6); .951(f)(2)(i-ii)



*Note: The use of double-insulated electrical hand tools does not alter the requirements for a ground-fault circuit interrupter (GFCI) system or an assured equipment grounding program for a worksite-supplied electric power system as required in 29 CFR 1926.404(b)(1)(i).*

l. Portable lampholders used by workers shall be wired with flexible cord and a polarized or grounding-type attachment plug; they shall be equipped with an insulated, molded-composition handle. A substantial guard (if metal, it shall be grounded by a conductor run inside the power cord) shall be attached to the handle or lampholder.

29 CFR 1926.405(j)(1)(iii)(A-D)



m. Where the exact location of underground electric power lines is unknown, workers who break ground with jack hammers, metal bars, or similar tools shall use specially insulated gloves to prevent injury. Prior to breaking unmarked ground, the employer shall ascertain by inquiry, observation, or instrument whether there is an underground power source.

29 CFR 1926.416(a)(2,3)

n. The following requirements for flexible cords and extension cords shall be followed:

(1) Flexible cords and cables shall be suitable for the condition and location in which they are used and shall only be used for pendants, fixture wiring, portable lamps and appliances, elevator cables, cranes and hoists, applications to prevent the transmission of vibration or noise, and stationary equipment that requires frequent interchange or removal for maintenance or repair.

29 CFR 1926.405(g)(1)(i)

(2) Three-wire extension cords shall be used with portable electric tools and appliances and shall be designed for hard or extra-hard use. Flexible cords used with temporary or portable lights shall be designed for hard or extra-hard use.

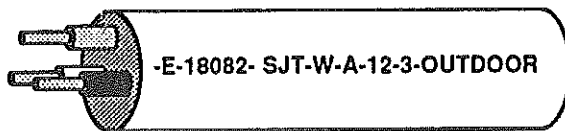
29 CFR 1926.405(a)(2)(ii)(J)



Three-Wire Hard-Use Cord

(3) Only type SJ, SJO, SJT, SJTO, S, SO, ST, and STO extension and flexible cords shall be used on the construction site. Each cord shall have the type, size, and number of conductors durably marked on its surface.

29 CFR 1926.405(g)(2)(ii)



Common Wire Marking

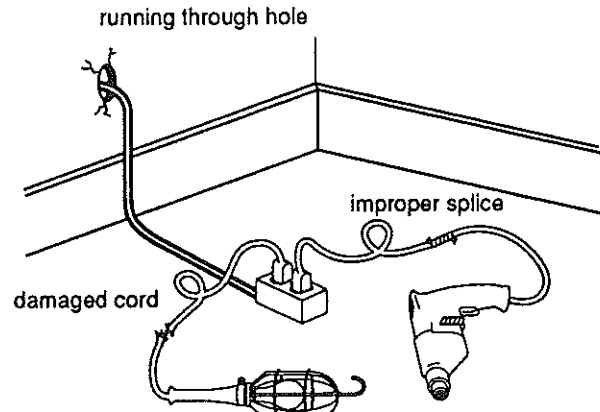
(4) Flexible and extension cords shall be used only in continuous lengths, without splices or taps. Hard-service flexible cords No. 12 or larger may be repaired, if the insulation and outer sheath properties remain the same and the usage characteristics of the original cord are retained.

29 CFR 1926.405(g)(2)(iii)

(5) Unless otherwise permitted, flexible cords and cables shall not be used for the following: as substitutes for fixed wiring; run through holes in walls, ceilings, or floors; run through doorways, windows, or similar openings except as

indicated in (6) below; as attachments to buildings or structures; or in concealed areas behind building walls, ceilings, or floors.

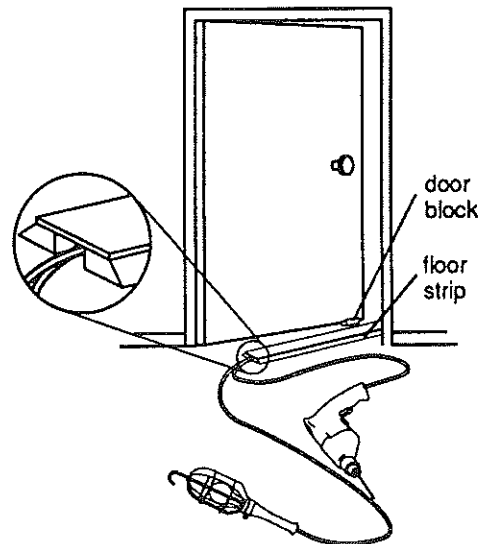
29 CFR 1926.405(g)(1)(iii)(A-E)



Unsafe Portable Cord Methods

(6) Flexible cords and cables may pass through doorways and other pinch points, if protection is provided to prevent damage.

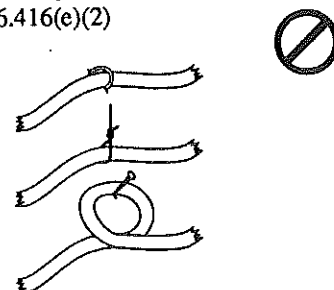
29 CFR 1926.405(a)(2)(ii)(I)



Cord Protection

(7) Extension cords shall not be fastened with staples, hung with nails, or suspended on wires.

29 CFR 1926.416(e)(2)





### 2. Requirements for Electrical Workers

a. Workers shall be trained in the safety-related work practices, safety procedures, and other safety requirements that pertain to their respective job assignments and shall not be permitted to work in an area likely to encounter electrical hazards unless they have been trained to recognize and avoid the hazards to which they will be exposed.

NFPA 70E II,1,A **T**

b. Only qualified workers may work on electric circuit parts or equipment that has not been de-energized. Such workers 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 insulating tools.

29 CFR 1910.333(c)(2)

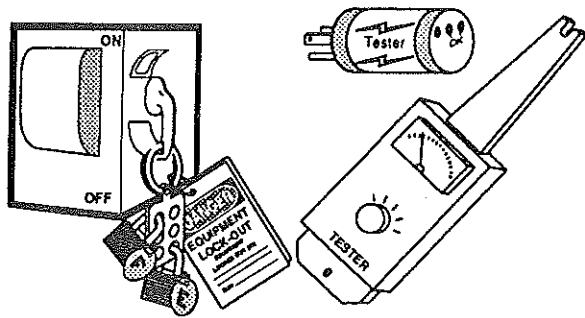
c. Only qualified workers trained to use test instruments shall test circuits or equipment.

29 CFR 1910.334(c)(1) **T**

d. Test equipment shall be visually inspected for external defects or damage before it is used; and, if there is evidence of a defect or damage, the equipment shall not be used. Test equipment shall be kept dry and damage-free.

29 CFR 1910.334(c)(2)

e. Electrical workers should test or observe electrical equipment or circuits to be worked on, to confirm if they are energized or de-energized.



f. Workers shall lockout and tagout any circuit or equipment that is being worked on to prevent the circuit or equipment from being energized accidentally. Workers shall verify that the equipment is de-energized.

29 CFR 1926.417(a-c)

g. Electrical workers shall not wear conductive apparel, such as metal watch bands, bracelets, rings, necklaces, or head gear.

NFPA 70E II,1,B,(2)(c)

h. Rubber personal protective equipment (PPE), such as gloves, blankets, hoods, line hoses, sleeves, and mats shall be used as prescribed for protection from energized sources. The PPE shall be inspected before use and kept dry and damage-free. Care must be taken to ensure that the correct class of rubber protective equipment is used, in accordance with the rated voltage and application. The manufacturer's recommendations should be followed for care, testing, and use.

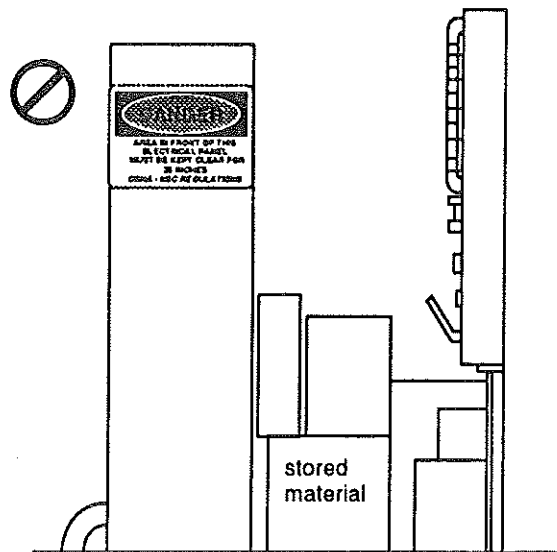
29 CFR 1926.951(a)(1)(i-iii)

i. Portable metal ladders or ladders with longitudinal metallic reinforcement shall not be used on or near exposed energized parts, circuits, or equipment.

NFPA 70E II,1,B,(2),(g)

j. There shall be sufficient space maintained in front of electrical equipment, and materials shall not be stored in this space. Space shall be maintained in accordance with Table E-1 for 600 volts, nominal, or less and Table E-2 for more than 600 volts, nominal.

29 CFR 1926.403(i)(1)(i),(j)(3)(i)



Improper Storage

**Table E-1. Clearance for Energized Parts, Workspace < 600 Volts**

Nominal Voltage	Minimum Clear Distance		
	(a)*	(b)	(c)*
0-150	3 ft	3 ft	3 ft
151-600	3 ft	3.5 ft	4 ft

**Table E-2. Minimum Depth of Clear Working Space in Front of Electrical Equipment, > 600 Volts**

Nominal Voltage to Ground	Conditions		
	(a)*	(b)*	(c)*
601-2,500	3 ft	4 ft	5 ft
2,500-9,000	4 ft	5 ft	6 ft
9,001-25,000	5 ft	6 ft	9 ft
25,001-75 kV	6 ft	8 ft	10 ft
Above 75 kV	8 ft	10 ft	12 ft

\*Conditions: Tables E-1 and E-2

\*(a) Exposed live parts on one side and no live or grounded parts on the other side of the working space, or exposed live parts on both sides effectively guarded by insulating materials. Insulated wire or insulated busbars operating at not more than 300 volts are not considered live parts.

\*(b) Exposed live parts on one side and grounded parts on the other side. Walls of concrete, block, or tile are considered grounded surfaces.

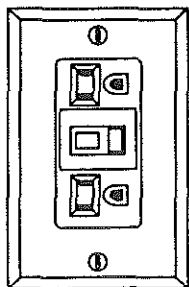
\*(c) Exposed live parts on both sides of the workspace [not guarded as specified in (a) above] with the operator between.

k. Special voltage-rated tools or fuse pullers shall be used to remove or install fuses in energized terminals.

29 CFR 1926.416(d); NFPA 70E II 1, B (2)(e)(i)

**3. On-Site Electrical Safety Requirements**

a. To protect workers from electric shock, the construction site shall be protected by ground-fault circuit interrupters, and/or an assured equipment-grounding conductor program.



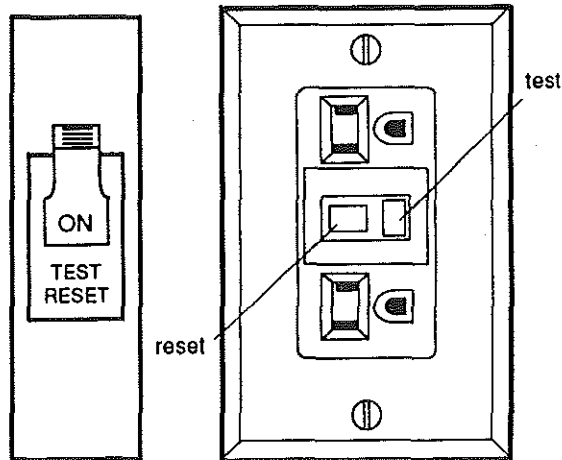
GFCI Outlet

*The DOE-recommended method for worker protection from electric shock is the use of ground-fault circuit interrupters because of their greater effectiveness and ease in implementation and verification. If, however, an assured equipment grounding program is selected, refer to 29 CFR 1926.404(b)(1)(iii).*

29 CFR 1926.404(b)(1)(i)

b. Single-phase, 120-volt, 15- and 20-ampere receptacle outlets that are not part of the permanent wiring of a building or structure shall have approved ground-fault circuit interrupters for workers' protection from electrical shock.

Note: A ground-fault circuit interrupter may be installed in the feeder to protect all branch circuits connected to that feeder.



Ground-Fault Circuit Interrupter

29 CFR 1926.404(b)(1)(ii)

c. Receptacles on a 2-wire, single-phase portable or vehicle-mounted generator rated at 5 kilowatt or below, in which the circuit conductors are insulated from the generator frame and all other grounded surfaces, need not be protected with a ground-fault circuit interrupter.

29 CFR 1926.404(b)(1)(ii)



d. When two or more receptacles are served by a branch circuit, the ampere rating shall meet the specifications in Table E-3.

Table E-3. Receptacle Ratings for Various Size Circuits

Circuit Rating Amperes	Receptacle Rating Amperes
15	Not over 15
20	15 or 20
30	30
40	40 to 50
50	50

29 CFR 1926.404(b)(2)(ii)

e. All electrical conductors and equipment shall be approved and free of hazards that may cause death or serious physical harm.

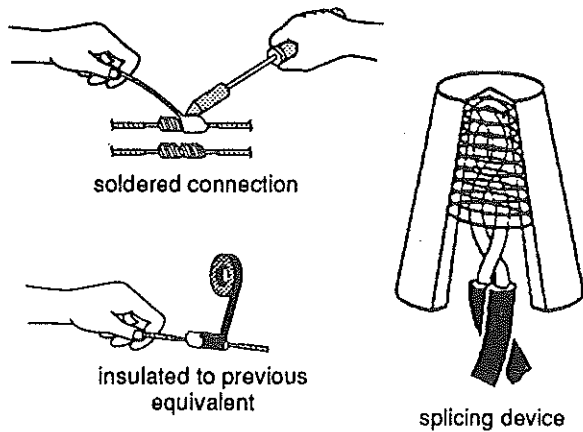
29 CFR 1926.403(a,b)

f. Circuit breakers, fuses, and other equipment intended to interrupt circuits shall have an interrupting rating sufficient for the current to be interrupted.

29 CFR 1926.403(c); NFPA 70,110-9

g. Conductors shall be spliced using approved splicing methods (welding, soldering, braising, or splicing devices).

29 CFR 1926.403(e)



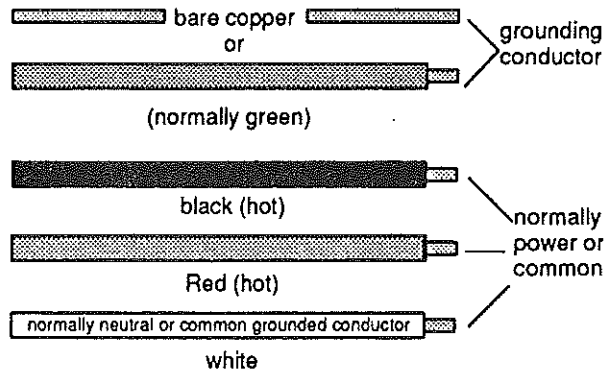
Approved Splicing Methods

h. All conductors used for general wiring shall be insulated for the voltage carried, unless otherwise specified.

29 CFR 1926.405(f)

i. Insulated grounded conductors, ungrounded conductors, and equipment-grounding conductors shall be distinguishable from each other by their colors.

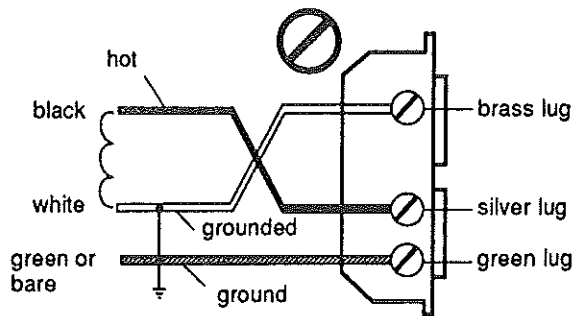
29 CFR 1926.405(f)



Distinguishable Colored Wire

j. No conductor shall be connected to a lead so as to reverse the designated polarity. Grounding terminals or grounding-type devices shall not be used for purposes other than grounding.

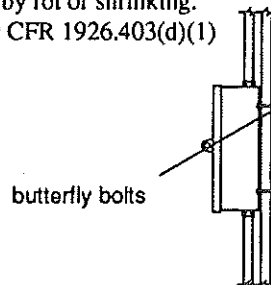
29 CFR 1926.404(a)(2,3)



Reverse Polarity Wiring

k. Equipment shall be firmly secured to its mounting surface. Equipment mounted on masonry, concrete, plaster, or similar material shall not be secured by wooden plugs because wooden plugs tend to loose anchoring ability by rot or shrinking.

29 CFR 1926.403(d)(1)

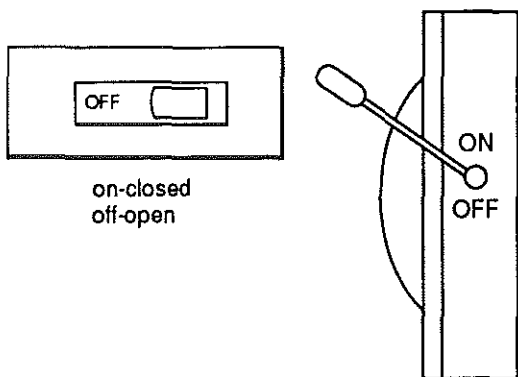


Wall-Mounted Enclosure Method



l. The disconnecting means shall indicate the open (off) or closed (on) position and shall simultaneously disconnect all ungrounded conductors. The "up" position will be the closed (on) position for circuit breaker handles that are operated vertically.

29 CFR 1926.404(e)(1)(vi)(A,B)



Disconnects

m. Circuit protection, including circuit breakers and fuses, shall not be bypassed or replaced with higher rated protective devices that would allow currents in excess of the load rating of the circuit wiring.

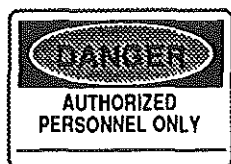
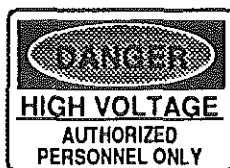
29 CFR 1926.416(c)

n. Overcurrent devices shall be kept readily accessible. They shall be located away from ignitable material and not exposed to damage by chemicals, equipment, or by other operations that can cause physical damage.

29 CFR 1926.404(e)(1)(iv)

o. Any room, vault, or other guarded location containing exposed live parts shall be posted with warning signs forbidding unqualified or unauthorized persons to enter. Installations of more than 600 volts, nominal, shall be kept locked or under the observation of a qualified person at all times.

29 CFR 1926.403(i)(2)(iii); 403(j)(2)



Warning Signs

p. When enclosed live parts are exposed for inspection or service and the workspace is in a passageway or open space, the space shall be guarded, and there shall be at least one unobstructed entrance to the area.

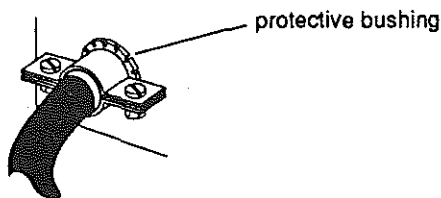
29 CFR 1926.403(i)(1)(ii,iii)

q. Live electrical equipment operating at 50 volts or more shall be guarded from accidental contact. Approved means of such guarding include cabinets or other enclosures; screens or partitions; placing the equipment in a room or vault; or locating the equipment on a balcony, gallery, or elevated platform (8 feet or more) and so arranged as to exclude unauthorized persons.

29 CFR 1926.403(i)(2)(i)(A-D)

r. Flexible cords shall be connected to devices and fittings so that, if strained, they will not pull on joints or terminal screws. Flexible cords shall be protected by bushings if they pass through holes in enclosures.

29 CFR 1926.405(g)(2)(iv,v)



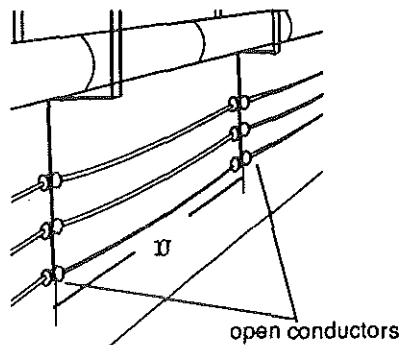
Enclosure Cord and Bushing

s. All requirements for permanent wiring shall apply to temporary wiring installations unless specifically modified according to paragraphs (1) through (9) below. Temporary wiring shall be removed as soon as the job for which the wiring was installed is completed.

29 CFR 1926.405(a)(2)(i)

(1) Feeders shall originate in a distribution center, and conductors shall be run as multiconductor cords or cable assemblies or within raceways. If conductors are not subject to damage or accidental contact, they may be run as open conductors on insulators spaced not more than 10 feet apart.

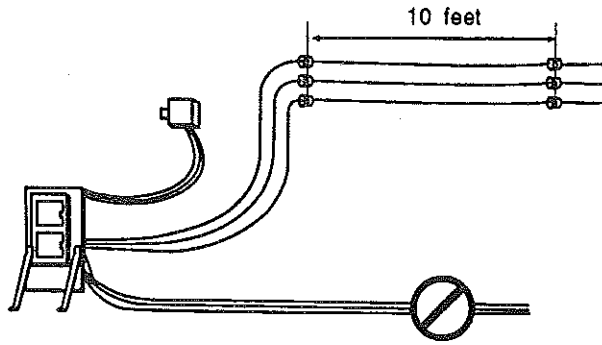
29 CFR 1926.405(a)(2)(ii)(A)





(2) Branch circuits shall originate in a power outlet or panel board. All conductors shall be protected by overcurrent devices at their ampacity; no branch-circuit conductors shall be laid on the floor.

29 CFR 1926.405(a)(2)(ii)(B)



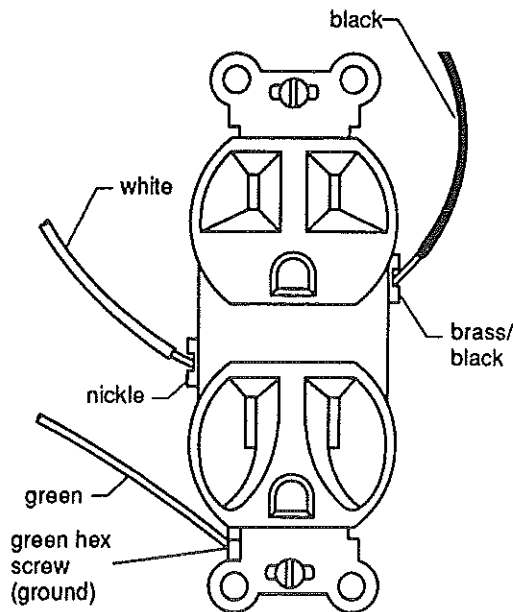
Branch Circuit on Ground

(3) Each branch circuit that supplies receptacles or fixed equipment and is run as an open conductor shall contain a separate equipment grounding conductor.

29 CFR 1926.405(a)(2)(ii)(B)

(4) All receptacles shall be a grounding type. Unless they are installed in a complete metallic conductive raceway providing a continuous path to ground, each branch circuit shall contain a separate equipment grounding conductor, and all receptacles shall be electrically connected to the grounding conductor.

29 CFR 1926.405(a)(2)(ii)(C)



Approved Receptacle

(5) Receptacles used for other than temporary lighting shall not be installed on branch circuits that supply temporary lighting. Receptacles shall not be connected to the same ungrounded conductor of multiwire circuits that supply temporary lighting.

29 CFR 1926.405(a)(2)(ii)(C)

(6) Disconnecting switches or plug connectors shall be installed to permit the ungrounded conductors of each temporary circuit to be disconnected.

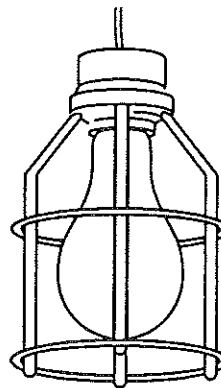
29 CFR 1926.405(a)(2)(ii)(D)

(7) Lamps for general illumination shall be protected from accidental contact or breakage. Metal-cased lamp sockets shall be grounded.

29 CFR 1926.405(a)(2)(ii)(E)

(8) Lampholders installed in wet or damp locations shall be of the waterproof type.

29 CFR 1926.405(j)(1)(iv)



Protected Lamp

(9) Temporary lights shall not be suspended by their electric cords, unless designed for such suspension.

29 CFR 1926.405(a)(2)(ii)(F)

(10) Portable electric lights used in wet and other conductive locations shall be operated at 12 volts or less. If they are protected by ground-fault circuit interrupters, 120-volt lights may be used.

29 CFR 1926.405(a)(2)(ii)(G)

t. Care must be taken to protect electric circuits from construction dust and fines, which could cause electrical explosion when power is switched on.

u. Equipment shall be installed according to listing, labeling, or certification found in instructions.

29 CFR 1926.403(b)(2); NFPA 70-110,3(g)

**4. General Wiring Design and Protection**

*The requirements in this section do not apply to conductors that are integral parts of factory-assembled equipment such as motors and controllers.*  
 29 CFR 1926.405(a)

a. Metal raceways, cable armor, and other metal enclosures for conductors shall be electrically continuous and shall be connected to all boxes, fittings, and cabinets.

29 CFR 1926.405(a)(1)(i)

b. Wiring systems of any type shall not be installed in ducts or shafts used to transport dust, loose stock, or flammable vapors.

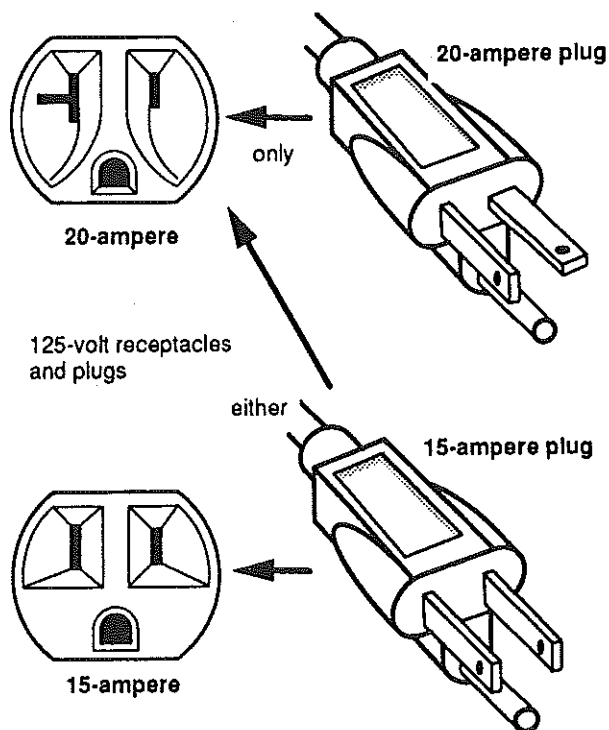
29 CFR 1926.405(a)(1)(ii)

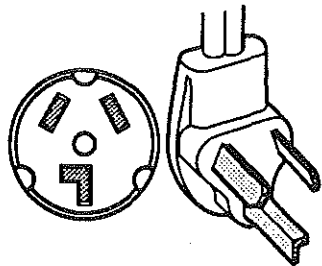
c. A receptacle installed in a wet or damp location shall be designed for the location.

29 CFR 1926.405(j)(2)(ii)

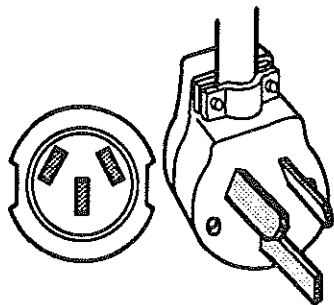
d. Receptacles connected to circuits having different voltages, frequencies, or types of current (DC or AC) on the same premises shall be designed so that the attachment plugs used on the circuits may not be interchanged.

29 CFR 1926.405(j)(2)(i)

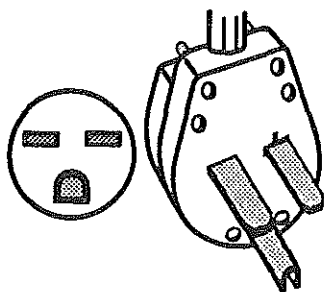




Plug and Cord Connectors



120/240-Volt, 50-Ampere Receptacle and Plug



240-Volt, 30-Ampere Receptacle and Plug

e. Control equipment and busways that are approved only for dry locations shall be protected during construction. All electrical equipment and accessories shall be suitable for the environment in which they are to be used.

29 CFR 1926.432(a)(2),(b)

f. Fixture wires shall be suitable for the voltage, temperature, and location of use and may be used for

- installation in lighting, fixtures, and similar equipment where enclosed or protected and not subject to bending or twisting and
- connecting light fixtures to the branch-circuit conductors.

29 CFR 1926.405(i)(1),(2)(i,ii)

g. Fixture wires may not be used as branch-circuit conductors except as permitted for Class 1 power-limited circuits.

29 CFR 1926.405(i)(3)

h. A means shall be provided for disconnecting appliances. Each appliance shall be marked with its rating in volts and amperes or volts and watts.

29 CFR 1926.405(j)(3)(ii)

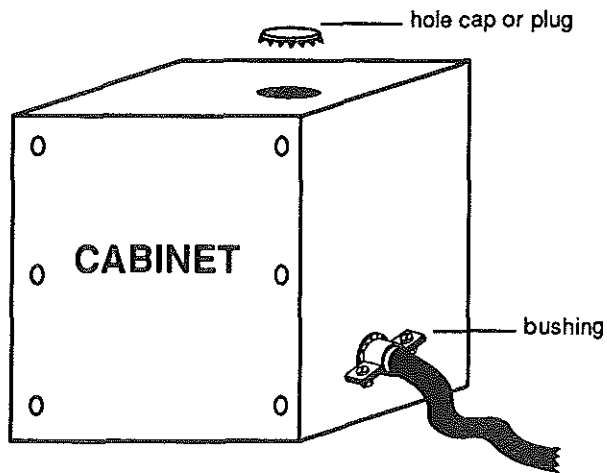
i. The grounding conductor of any cable or cord shall be distinguishable from all other conductors.

29 CFR 1926.405(g)(2)(i)

### 5. Cabinets, Boxes, and Switchboards

a. Conductors that enter boxes, cabinets, or fittings shall be protected from abrasion by bushings or fittings. Unused holes in the boxes shall be closed or plugged.

29 CFR 1926.405(b)(1)



Protected Cords/Covered Holes

b. Pull boxes, junction boxes, cabinets, or fittings shall have covers; if metal covers are used, they shall be grounded. In energized installations, each outlet box shall have a cover, faceplate, or fixture canopy.

29 CFR 1926.405(b)(2)

c. Covers for outlet boxes with holes through which flexible cord pendants pass shall have specially designed bushings or smooth, well-rounded surfaces on which the cord may rest to avoid insulation damage.

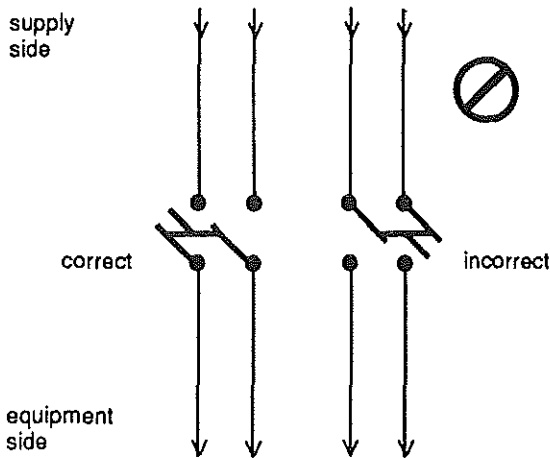
29 CFR 1926.405(b)(2)

d. For systems with more than 600 volts, nominal, pull and junction boxes shall have securely fastened covers and shall completely enclose conductors or cables. The covers shall be permanently marked, "High Voltage."

29 CFR 1926.405(b)(3)(i,ii)

e. Single-throw knife switches shall be connected so that the blades are dead when the switch is in the open position and placed so that gravity will not tend to close them. Single-throw knife switches approved for use in the inverted position shall be provided with a locking device to ensure that the blades remain in the open position when so set.

29 CFR 1926.405(c)



Connect knife switches properly.

f. Double-throw knife switches shall be mounted so that the throw will be either vertical or horizontal. If the throw is vertical, a locking device shall be provided to ensure that the blades remain in the open position when so set.

29 CFR 1926.405(c)

g. Switchboards with exposed live parts shall be installed in permanently dry locations and accessible only to qualified persons. Panel boards shall be mounted in cabinets, cutout boxes, or enclosures designed for the purpose and shall be dead front. Panel boards that are not dead front and are externally operated are permitted where accessible to qualified persons only.

29 CFR 1926.405(d)

h. Cabinets, cutout boxes, fittings, boxes, and panel board enclosures located in damp areas shall be installed so that moisture or water cannot enter or accumulate inside them. In wet locations, the enclosure shall be waterproof.

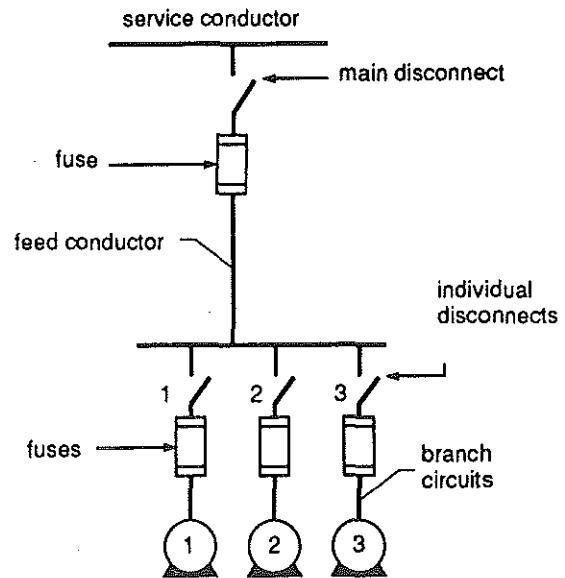
29 CFR 1926.405(e)(1)

i. A means to disconnect all conductors in a building from the service-entrance conductors shall be installed near the point where the service-entrance conductors enter the building.

29 CFR 1926.404(d)(1)(i)

j. Except for current-limiting devices on the supply side of the service disconnect means, all fuses and thermal cutouts on circuits over 150 volts to ground and all cartridge fuses accessible to other than qualified persons shall be provided with a disconnect means. The disconnect 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.

29 CFR 1926.404(e)(1)(iii)



Disconnects for overcurrent devices

k. Open wire service-entrance conductors over 600 volts, nominal, shall be guarded and accessible only to qualified persons. Warning signs shall be posted in areas where unauthorized workers might contact live parts.

29 CFR 1926.404(d)(2)(i,ii)

l. Outside open conductors run as a branch circuit, feeder, or service conductors operating at 600 volts, nominal, or less shall have clearance requirements specified in Table E-4.

29 CFR 1926.404(c)(1)



Table E-4. Service Feeder Clearance, 600 Volts, Nominal, or Less

Activity and Location	Minimum Clearance
Horizontal Clearance for Pole Climbing	
Open power below communications conductors	30 in.
Open power alone or above communications conductors	
300 volts or less	24 in.
More than 300 volts	30 in.
Communications below open power conductors	
300 volts or less	24 in.
More than 300 volts	30 in.
<b>Clearance Between Grounded Surface and Open Conductors</b>	
Above grade sidewalks or platforms	10 ft
Over vehicles traffic	12 ft
Over truck traffic	15 ft
Over public streets, roads, alleys, and driveways	18 ft
<b>Clearance from Buildings in Which Workers are Exposed</b>	
Open conductor from windows, doors, fire escapes, or similar locations	3 ft
Over roofs (highest point of roof)	
Insulated conductor vertical clearance	8 ft
Covered conductor vertical or diagonal	10 ft
Bare conductor	15 ft
<b>Other</b>	
Open conductor - roof with vehicular traffic (vertical)	18 ft
Insulated conductor - roof not normally open to workers	3 ft
Roof slope not less than 4 inches in 12 inches with voltage between conductors	
300 volts or less	3 ft
300 volts or less between conductors that do not pass over more than 4 feet of a roof overhang, terminates in a through-the-roof raceway or support.	18 in.
29 CFR 1926.404(c)(1)(i-iv)	

## 6. Motors and Pendants

a. A disconnecting means shall be located in sight of the controller location. The controller means of disconnect for motor branch circuits of more than 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.

29 CFR 1926.405(j)(4)(ii)(A)

*Note: If specified that one piece of motorized equipment shall be "in sight of" another piece of control equipment, one shall be visible from and not more than 50 feet from the other.*

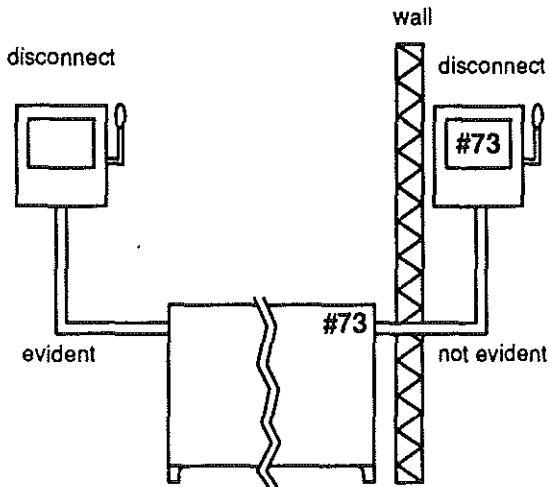
29 CFR 1926.405(j)(4)(i)

b. The disconnect means shall cut off the motor and controller from all ungrounded supply conductors; it shall be designed so that none of the poles can be operated independently.

29 CFR 1926.405(j)(4)(ii)(B)

c. Unless the disconnect is located so that the purpose or feed service is evident, each disconnect means shall be legibly marked to indicate its purpose or identify the equipment it feeds.

NOTE: To avoid any mistake, it is best to identify all disconnects to equipment.



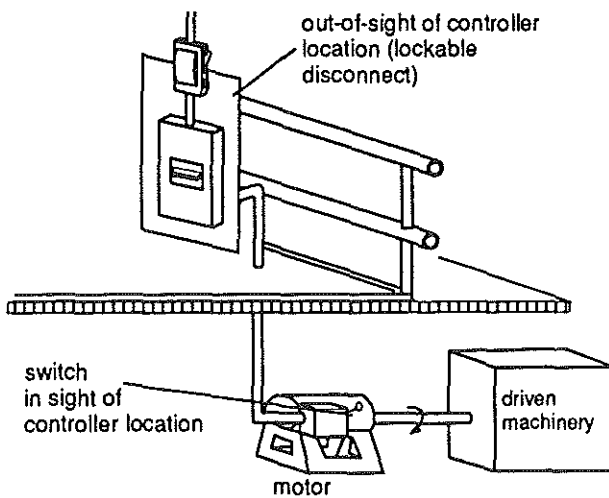
Equipment Disconnect Evident or Identified

29 CFR 1910.303(f)

d. If a motor and the machinery it drives are not visible from the controller's location, the installation shall

- be capable of being locked open or
- have a manually operated switch that will disconnect the motor from its supply source in sight of the motor location.

29 CFR 1926.405(j)(4)(ii)(C)(1,2)



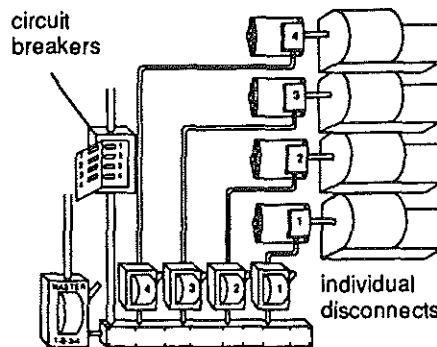
Out-of-Sight Disconnect to Motor

e. The means of disconnect shall be readily accessible. If more than one means of disconnect is provided for the same equipment, only one need be readily accessible.

29 CFR 1926.405(j)(4)(ii)(E)

f. Each motor shall be equipped with a means of disconnect; however, a single means of disconnect may be used for a group of motors, if they drive special parts of a single piece of equipment or are protected by one set of branch-circuit protection devices, or if they are in a single room in sight of the disconnect.

29 CFR 1926.405(j)(4)(ii)(F)(1-3)



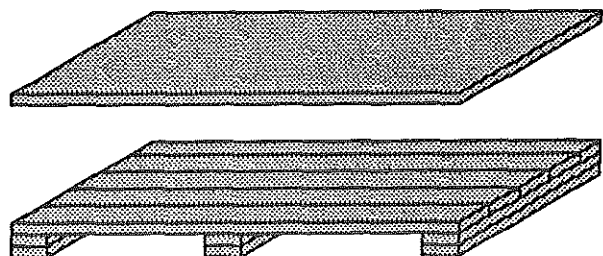
Various Means of Disconnect

g. To prevent accidental worker contact, exposed live parts of motors or controllers operating at 50 volts or more between terminals shall be installed in a room or enclosure that is accessible only to qualified persons; on a balcony, gallery, or platform elevated and arranged to exclude unqualified persons; or at an elevation of 8 feet or more above the floor.

29 CFR 1926.405(j)(4)(iv)(A)(1-3)

h. When live parts of motors or controllers operating at more than 150 volts to ground are protected as in paragraph g. above, and where adjustment or attendance may be necessary during the operation of the apparatus, insulating mats or a platform shall be provided so that a worker cannot touch live parts unless he or she is standing on the mats or platform.

29 CFR 1926.405(j)(4)(iv)(B)



Insulated Mat or Platform



- i. The rating of an attachment plug or receptacle used for connecting a motor, by cord or plug, to a branch circuit shall not exceed 15 amperes at 125 volts or 10 amperes at 250 volts, if individual overload protection is not provided.  
29 CFR 1926.404(b)(2)(iii)

### 7. Transformers

- a. This section covers all transformers except current transformers; dry-type transformers installed as a component part of other apparatus; transformers that are an integral part of an x-ray, high-frequency, or electrostatic-coating apparatus; transformers used with Class 2 and Class 3 circuits; sign and outline lighting; and power-limited fire-protective signaling circuits.  
29 CFR 1926.405(j)(5)(i)(A-D)

- b. The operating voltage of exposed live parts of transformers shall be indicated by warning signs on the equipment or structure.  
29 CFR 1926.405(j)(5)(ii)

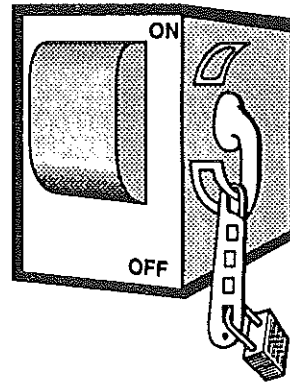
- c. Transformer vaults shall be constructed so that fire and combustible liquids are contained within the vault and unauthorized access is prevented. Locks and latches shall be installed so that the door can be easily opened from the inside.  
29 CFR 1926.405(j)(5)(vi)

- d. Material shall not be stored in transformer vaults.  
29 CFR 1926.405(j)(5)(viii)

### 8. Specific Purpose Equipment and Installations

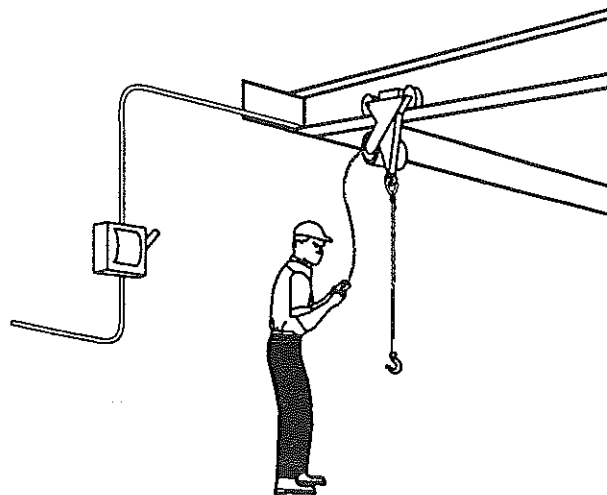
#### a. Cranes and Hoists

- (1) There shall be a switch, which can be locked open, to disconnect the power supply of any crane or monorail hoist.  
29 CFR 1926.406(a)(1)(i,ii)



Power Supply Switch

- (2) The switch to disconnect the runway conductor from its power supply shall be easy to find and operate.  
29 CFR 1926.406(a)(1)(i)



Readily Accessible Disconnect Switch

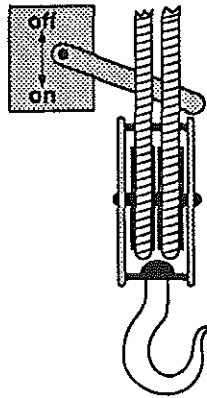
- (3) If the disconnecting switch is not in the crane or monorail operating station, it shall be possible to open the power circuits to all crane or monorail hoist motors from the operating station.  
29 CFR 1926.406(a)(1)(ii)(A)





(4) There shall be a limit switch to stop the load block from going higher than what is considered safe for each crane or a hoist.

29 CFR 1926.406(a)(2)



**Block Limit Switch**

*For additional crane information see Section H.1.i. and j of this guide.*

#### b. Elevators, Escalators, and Moving Walks

(1) There shall be one switch to disconnect all ungrounded main power supply conductors for each elevator, escalator, or moving walk.

29 CFR 1926.406(b)(1)

(2) If control panels are not in the same space as the drive machine, they shall be in cabinets with doors that can be locked closed.

29 CFR 1926.406(b)(2)

#### c. Electric Welding Equipment

(1) The supply circuit shall have a switch that disconnects each arc-welding unit, unless there is a disconnect switch on the unit itself.

29 CFR 1926.406(c)(1)

(2) There shall be a switch or circuit breaker to cut off each resistance welder from the supply circuit. The ampere rating of the switch or circuit breaker shall not be less than the current capacity of the supply conductor.

29 CFR 1926.406(c)(2)

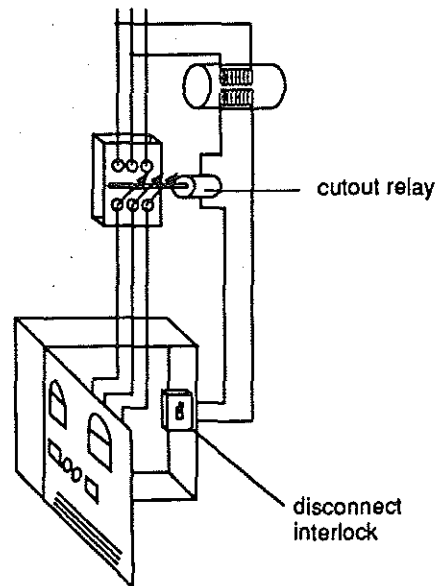
#### d. X-ray and Radiographic Equipment

(1) There shall be a switch accessible from an x-ray control to disconnect the supply circuit.

29 CFR 1926.406(d)(1)(i)

(2) To prevent workers from contacting live current-carrying parts, radiographic and fluoroscopic equipment shall always be enclosed or have interlocks that de-energize the equipment automatically.

29 CFR 1926.406(d)(2)



**Radiographic and Fluoroscopic Equipment Interlock**

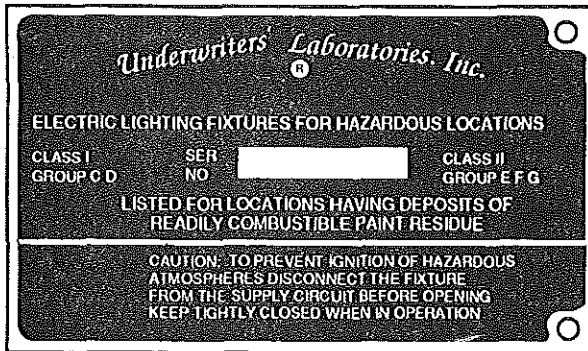
(3) If more than one piece of x-ray equipment is operated from the same high-voltage circuit, each piece of equipment or equipment group shall be provided with a high-voltage switch.

29 CFR 1926.406(d)(1)(ii)



### 9. Hazardous Locations

a. Electrical equipment and wiring installed in hazardous locations shall be classified according to the kinds of flammable vapors, liquids, gases, or combustible dust or fibers present. Each room, section, or area shall be classified individually. See Table E-5 for basic hazard locations classifications. For detailed information refer to NFPA 70, Chapter 5, or 29 CFR 1926.449.  
29 CFR 1926.407(a)



Underwriters' Label

b. Equipment and its associated wiring approved as intrinsically safe are permitted in the hazardous (classified) locations included in its listing or labeling.  
29 CFR 1926.407(b)(1)

c. Equipment shall be approved both for class of location and type of ignitable or combustible gas, vapor, dust, or fiber that will be present.  
29 CFR 1926.407(b)(2)(i)

d. Equipment shall not be used in a hazardous location unless it is marked to show the class, group, and operating temperature or temperature range.  
29 CFR 1926.407(b)(2)(ii)

e. All conduits shall be threaded and shall be made wrench-tight. When it is impractical to make a threaded joint tight, a bonding jumper shall be used.  
29 CFR 1926.407(c)

Table E-5. Basic Hazardous Location Classification

Classes	Division 1	Division 2	Groups
I. Flammable gases, vapors, or liquids.	Ignitable concentrations may exist under normal operating conditions or in the event of equipment failure or faulty operations.	Areas adjacent to Class I, Div. 1 areas; areas where flammable liquids or gas are present in closed containers but could be released in an accident, or areas where concentrations are controlled by mechanical ventilation the failure of which could result in ignitable concentrations.	A-Acetylene B-Hydrogen C-Ether, etc. D-Hydrocarbons
II. Combustible, ignitable or conductive dusts.	Ignitable or explosive concentrations may be in suspension under normal operating conditions or in the event equipment failure or faulty operations.	Not normally enough dust suspended to ignite but may infrequently exist in ignitable quantities due to malfunction of handling or processing equipment. Includes areas adjacent to Class II, Div. 1 locations and areas where accumulations of ignitable dust are on equipment or other surfaces.	E-Metal dust* F-Carbon black*, coke* or charcoal* G-Flour, grain, starch, combustible plastic, or chemical dust**
III. Ignitable fibers or flyings.	Areas where handled, used, or manufactured.	Areas where stored or handled (except in process of manufacturing).	Cotton, rayon, hemp, cocoa, other textiles

\* Could have conductive qualities and be explosive with mixture and ignition source.  
\*\* Could be explosive with mixture and ignition source.

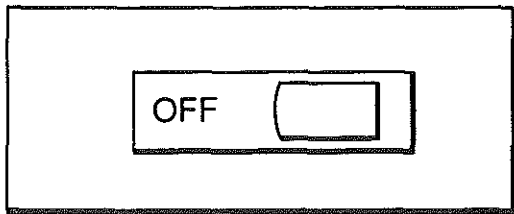
For further information see definitions in 29 CFR 1926.449 and NFPA Art. 500.

**10. Special Systems**

**a. Systems, Cables, and Installations of More than 600 Volts, Nominal**

(1) Indoor circuit breakers shall be cell-mounted, metal-enclosed, or fire-resistant units. In areas where only qualified personnel are allowed, circuit breakers need not be enclosed. The open and closed positions of circuit breakers shall be clearly marked.

29 CFR 1926.408(a)(2)(i)



**Marked Circuit Breaker**

(2) Fused cutouts installed in buildings or transformer vaults shall be of a type identified by the manufacturer as suitable for this purpose. Fuse cutouts shall be designed to allow fuses to easily be changed.

29 CFR 1926.408(a)(2)(ii)

(3) A means shall be provided to completely isolate equipment for inspection or repair. If the isolating means are not designed to interrupt the load current of the circuit, they shall be interlocked with a circuit interrupter or be posted with a sign warning against opening under load.

29 CFR 1926.408(a)(2)(iii)

(4) Cable connectors that are connected to power cables on a mobile machine shall be enclosed in metal. The enclosure shall include a solid connection for the ground-wire terminal so that the machine frame is safely grounded. The enclosure shall be provided with a lock so that only authorized or qualified personnel may open the enclosure, and a sign warning of energized parts shall be posted.

29 CFR 1926.408(a)(3)(i)

(5) All energized switching and control equipment for mobile and portable equipment shall be enclosed in locked, grounded metal cabinets or enclosures. The means to operate circuit breakers and protective equipment shall project through the cabinets or enclosures so they can be reset without opening the locked doors. Enclosures shall be provided with a lock, so that only authorized or qualified personnel may open the enclosure; and signs shall be posted warning workers of energized parts.

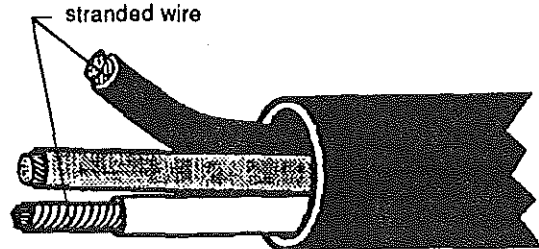
29 CFR 1926.408(a)(3)(ii)

(6) Collector ring assemblies on revolving-type machines, such as shovels and drag lines, shall be guarded.

29 CFR 1926.408(a)(3)(ii)

(7) Multiconductor portable cable used for supplying power to portable or mobile equipment at more than 600 volts, nominal, shall consist of No. 8 or larger flexible, stranded wire.

29 CFR 1926.405(h)



**Multiconductor Portable Cable**

(8) Portable cables operated at more than 2,000 volts shall be shielded so that voltage stress is confined to the insulation.

29 CFR 1926.405(h)

(9) Grounding conductors and locking-type connectors that cannot open or close while energized shall be used for portable cables of more than 600 volts, nominal. Strain relief shall be provided at the connections and terminations of these cables.

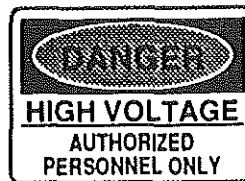
29 CFR 1926.405(h)

(10) Portable cables that have been spliced shall not be used unless the splices are permanently molded, vulcanized, or treated in an equivalent way.

29 CFR 1926.405(h)

(11) Termination enclosures for portable cables over 600 volts shall be marked with a high voltage hazard warning, and shall be accessible only to authorized and qualified workers.

29 CFR 1926.405(h)





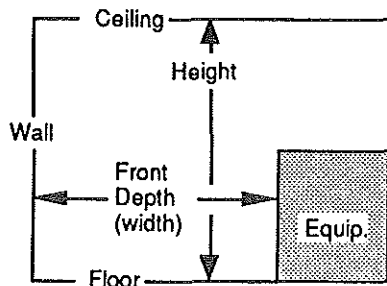
*Conductors and equipment used on circuits exceeding 600 volts, nominal, shall be used in accordance with requirements in the following paragraphs. The requirements do not apply to equipment on the supply side of the service conductors.*

(12) Electrical installations open to unqualified persons shall be enclosed in metal, vaults, or other enclosure with access limited by a lock; appropriate caution signs shall be posted.

29 CFR 1926.403(j)(2)(ii)

(13) The minimum clear workspace around exposed energized parts shall be at least 6 1/2 feet high and 3 feet wide. For higher voltage work depth (width) requirements, see Table E-2 of this section.

29 CFR 1926.403(j)(3)



Live Equipment Work Clearance

(14) When rear access is required to work on de-energized parts on the back of enclosed equipment, a minimum workspace of 30 inches horizontal shall be provided.

29 CFR 1926.403(j)(3)(i)

(15) Workspaces in which energized parts of electrical equipment may be exposed shall be barricaded or other means provided to ensure that these spaces are not used as passageways.

29 CFR 1926.416(b)(1)

(16) Lighting outlets and controls shall be located so that workers changing lights or repairing the lighting system will not be exposed to live parts or equipment.

29 CFR 1926.403(j)(3)(ii)

(17) Unguarded live parts of more than 600 volts, nominal, above a work surface shall be maintained at heights not less than 8' 6" for 601 to 7,500 volts, 9' 0" for 7,501 to 35,000 volts; 9' 0" plus 0.37 inches per 1,000 volts for more than 35,000 volts.

29 CFR 1926.403(j)(3)(iii)

*Capacitors rated more than 600 volts, nominal, shall comply with the following:*

(18) To prevent workers from switching load current, isolating or disconnecting switches that have no interrupting rating shall be interlocked with a load-interrupting device; or caution signs shall be prominently displayed.

29 CFR 1926.405(j)(6)(ii)(A)

(19) For series capacitors, at least one of the following shall be used to ensure proper switching: (1) mechanically sequenced isolating and by-pass switches, (2) interlocks, or (3) a switching procedure that is prominently displayed at the switching location.

29 CFR 1926.405(j)(6)(ii)(B)

b. Installations Inside Tunnels

(1) This section refers to installing and using portable and/or mobile, high-voltage power distribution equipment inside tunnels. Such equipment includes substations, trailers, cars, mobile shovels, drag lines, hoists, drills, dredges, compressors, pumps, conveyors, and underground excavators.

29 CFR 1926.408(a)(4)(i)

(2) Conductors inside tunnels shall be installed in metal conduit or raceways or in type MC cables or other suitable multiconductor cables and shall be placed in a safe location or guarded.

29 CFR 1926.408(a)(4)(ii)

(3) Nonenergized metal parts of electrical equipment, metal raceways, and cable sheaths shall be grounded and bonded to all metal pipes and rails at the entrance to the tunnel and at intervals of 1,000 feet or less.

29 CFR 1926.408(a)(4)(v)

(4) Bare terminals in transformers, switches, motor controllers, and other equipment shall be enclosed to prevent accidental worker contact with energized parts. Enclosures that are used in tunnels shall be drip-proof, weatherproof, or submersible, according to the environmental conditions in the tunnel.

29 CFR 1926.408(a)(4)(iii)

(5) There shall be a disconnecting means to simultaneously open all ungrounded conductors at each transformer and motor.

29 CFR 1926.408(a)(4)(iv)

c. Communication Systems

(1) Communication systems include central-station- and noncentral-station-connected telephone circuits, radio receivers and transmitters, outside wiring for fire and burglar alarms, and similar equipment.

29 CFR 1926.408(c)(1)

(2) Each communication system has specific wiring and installation requirements. NFPA 70-800 lists requirements for specific types of equipment.

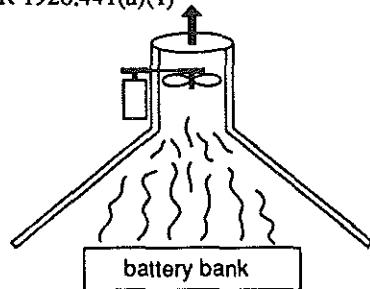
(3) Workers shall be protected from static discharge from outdoor radio transmission antenna lead-in conductors by an antenna discharge unit or other means that will drain static charges from the antenna system. For further information, see NFPA 70-800.

29 CFR 1926.408(c)(2)(ii)

**d. Battery Servicing**

(1) Unsealed batteries shall be located in enclosures with outside vents or in well-ventilated rooms. Batteries shall be arranged in such a way that fumes, gases, or electrolyte spray do not escape into the work area.

29 CFR 1926.441(a)(1)



**Forced Ventilation for Battery Charging**

(2) To prevent an explosion, ventilation shall be provided to diffuse the gases and fumes from batteries.

29 CFR 1926.441(a)(2)

(3) Battery racks and trays shall be substantial and treated to resist electrolytes.

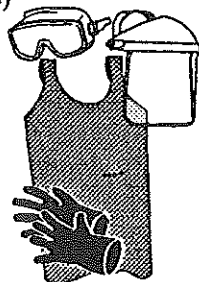
29 CFR 1926.441(a)(3)

(4) Floors shall be constructed of an acid-resistant material or coating unless they are protected from acid build-up.

29 CFR 1926.441(a)(4)

(5) Protective equipment such as aprons, rubber gloves, safety-approved glasses, and/or face shields shall be used by workers handling batteries or acids. See Section A of this guide for more details on personal protective equipment (PPE).

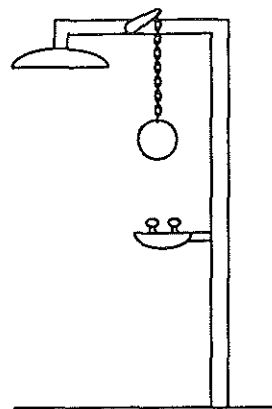
29 CFR 1926.441(a)(5)



**Use personal protective equipment (PPE).**

(6) Facilities for drenching the eyes and body shall be provided within 25 feet of an area in which batteries are handled or serviced.

29 CFR 1926.441(a)(6)



**Eye-Wash/Safety Shower**

(7) Facilities and supplies shall be provided for flushing and neutralizing spilled electrolyte and for fire protection.

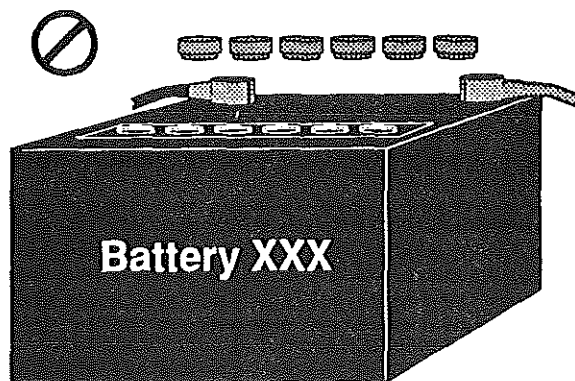
29 CFR 1926.441(a)(7)

(8) Batteries shall be charged in areas designed for this purpose, and the charging apparatus shall be protected from moving vehicles and equipment.

29 CFR 1926.441(b)(1,2)

(9) Battery caps shall be kept in place when batteries are charged; the caps shall be kept in good condition.

29 CFR 1926.441(b)(3)



**Do not remove battery caps during charging.**



### 11. Grounding

#### a. General Requirements

(1) AC and DC wiring systems shall be appropriately grounded.

29 CFR 1926.404(f)

(2) AC systems between 50 and 1,000 volts shall be grounded under any of the following conditions, unless exempted under paragraph (3) below:

- if the system can be grounded so that the maximum voltage to ground on the ungrounded conductors does not exceed 150 volts;
- if the system is nominally rated 480Y/277-volt, 3-phase, 4-wire in which the neutral is used as a circuit conductor;
- if the system is nominally rated 240/120-volt, 3-phase, 4-wire in which the midpoint of one phase is used as a circuit conductor; or
- if a service conductor is not insulated.

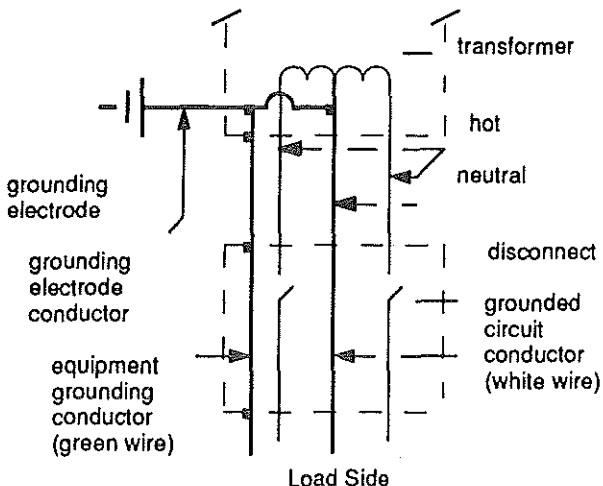
29 CFR 1926.404(f)(1)(iv)(A-D)

(3) AC systems between 50 and 1,000 volts do not require grounding if the system is separately derived, is supplied by a transformer that has a primary voltage rating of less than 1,000 volts, and meets the following requirements:

- The system is used exclusively for control circuits.
- Only qualified workers service the system.
- Continuity of control power to the control circuits is required.
- Ground detectors are installed on the control system.

29 CFR 1926.404(f)(1)(v)(A-D)

(4) For a grounded system, a grounding-electrode conductor shall be used to connect both the equipment-grounding conductor and the grounded-circuit conductor to the grounding electrode. Both the equipment-grounding conductor and the grounding-electrode conductor shall be



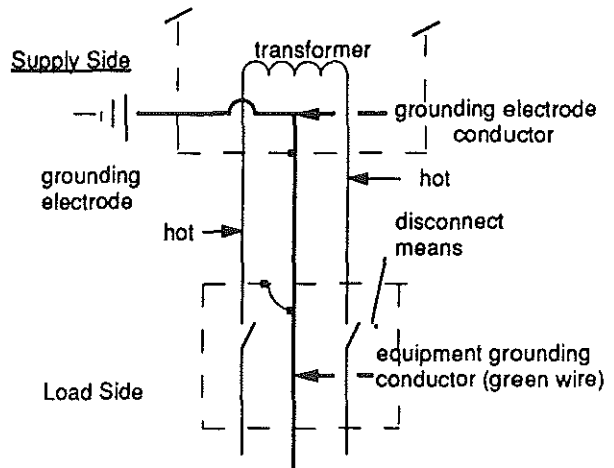
Grounded System - Service Supplied

connected to the grounded-circuit conductor on the supply side of the service disconnect, or on the supply side of the system disconnect or overcurrent device if the system is separately derived.

29 CFR 1926.404(f)(5)(i)

(5) In ungrounded, service-supplied systems, the equipment-grounding conductor shall be connected to the grounding-electrode conductor at the service equipment.

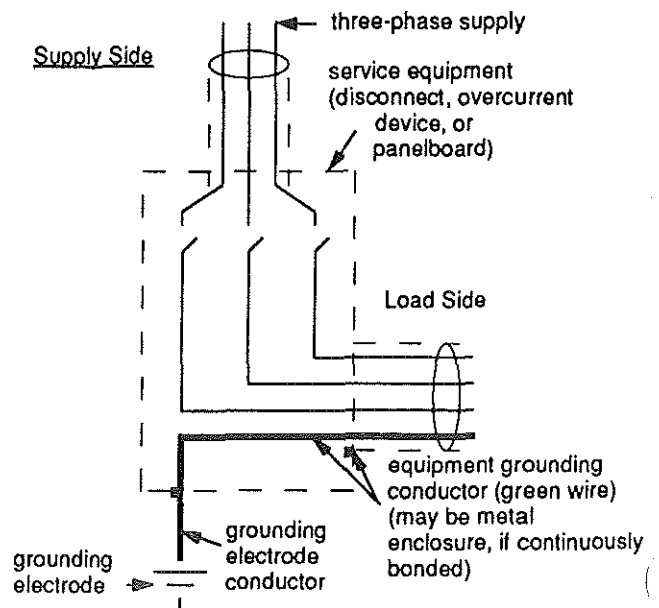
29 CFR 1926.404(f)(5)(ii)



Ungrounded System - Separately Derived

(6) In ungrounded, separately derived systems, the equipment-grounding conductor shall be connected to the grounding-electrode conductor at or ahead of the system disconnecting means or overcurrent devices.

29 CFR 1926.404(f)(5)(ii)



Ungrounded Service - Supplied System



(7) All grounds shall be permanent and continuous.  
29 CFR 1926.404(f)(6)

**b. Requirements for Portable and Vehicle-Mounted Generators**

(1) The frame of portable or vehicle-mounted generators need not be grounded if the following conditions are met:

- the generator supplies only equipment powered by and mounted on the generator including cord- and/or plug-connected equipment connected to receptacles mounted on the generator, and
- the noncurrent-carrying parts of equipment and receptacles are bonded to the generator frame.

29 CFR 1926.404(f)(3)(i)(A-B)

(2) The vehicle frame may serve as the ground for a system supplied by a generator and located on the vehicle, if the generator and vehicle frames are bonded together and meet the conditions of paragraph (1) above.

29 CFR 1926.404(f)(3)(ii)(A-B)

**c. Grounding of Supports, Enclosures, and Equipment**

(1) All metal cable trays, raceways, and enclosures for conductors shall be grounded, except for the following:

- metal enclosures that protect cables or conductors added to existing installations of open-wire knobs and tubes and
- metal enclosures that protect nonmetallic-sheathed cable with runs of less than 25 feet, in which enclosures are free from probable contact with ground or grounded metal and are guarded against accidental contacts.

29 CFR 1926.404(f)(7)(i)(A-D)

(2) Metal enclosures around service equipment shall be grounded.

29 CFR 1926.404(f)(7)(ii)

(3) Exposed noncurrent-carrying metal parts of fixed equipment that may become energized shall be grounded if they are

- subject to worker contact;
- within 8 feet vertically or 5 feet horizontally of ground or grounded objects;
- in damp or wet locations;
- in electrical contact with metal;
- in a hazardous (classified) location; or
- supplied by a metal-clad, metal-sheathed, or grounded-metal raceway.

29 CFR 1926.404(f)(7)(iii)(A-E)

(4) Equipment operating with any terminal rated at more than 150 volts to ground shall be grounded, except for the following:

- enclosures for switches or circuit breakers used for other than service equipment that are accessible only to qualified workers;
- metal frames of electrically heated appliances that are effectively insulated from ground; and
- distribution apparatus (transformers and capacitors) mounted on wooden poles more than 8 feet above the ground.

29 CFR 1926.404(f)(7)(iii)(F)(1-3)

**d. Requirements for Plug- and Cord-Connected Equipment**

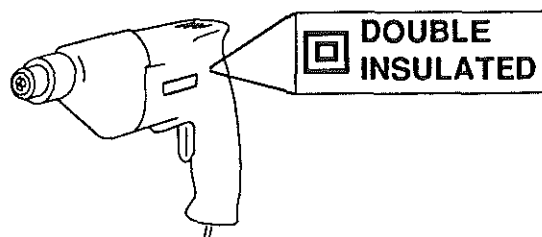
(1) Exposed noncurrent-carrying metal parts of equipment shall be grounded if they are in hazardous (classified) locations or operated at more than 150 volts to ground.

The following equipment shall also be grounded: hand-held, motor-operated tools; portable x-ray equipment; and portable hand lamps, tools, or equipment likely to be used in wet locations or by workers standing on the ground, on metal floors, or in metal tanks or boilers.

29 CFR 1926.404(f)(7)(iv)(A-C)

(2) Tools likely to be used in wet and/or conductive locations need not be grounded if they are supplied through an isolating transformer with an ungrounded secondary of not more than 50 volts. Listed or labeled portable double-insulated tools (or equivalent tools) and appliances need not be grounded. Double-insulated equipment shall be distinctively marked.

29 CFR 1926.404(f)(7)(iv)(C)(6)



(3) Nonelectrical metal parts of the following shall be grounded:

- frames and tracks of electrically driven cranes;
- frames of nonelectrically driven elevator cars with electric conductors attached;
- hand-operated metal shifting ropes and cables of electric elevators; and
- metal partitions, grill work, and metal enclosures around equipment of more than 1,000 volts between conductors.

29 CFR 1926.404(f)(7)(v)



## e. Grounding Methods

(1) If noncurrent-carrying metal parts of fixed equipment must be grounded, they shall be grounded by an equipment-grounding conductor contained within the same raceway, cable, or cord; or run with or enclosed in the circuit conductors.

29 CFR 1926.404(f)(8)(i)

(2) A conductor used for grounding fixed or moveable equipment shall have the capacity to safely conduct any fault current imposed on it.

29 CFR 1926.404(f)(8)(ii)

(3) Electrical equipment is considered to be properly grounded when it is secured to and in electrical contact with a metal rack or structure provided for its support. The metal rack or structure shall be grounded using the method specified in paragraph (1) above.

29 CFR 1926.404(f)(8)(iii)

(4) Bonding conductors used to ensure electrical continuity shall have the capacity to conduct any fault current that may be imposed on them.

29 CFR 1926.404(f)(9)

(5) Made electrodes shall be free of nonconductive coatings and, if practicable, shall be embedded below the permanent moisture level. A single electrode that has a resistance to ground greater than 25 ohms shall have an additional electrode installed at least 6 feet from the first electrode.

29 CFR 1926.404(f)(10)

## f. Grounding 1,000-Volt Supply or Greater

**Note:** Systems operating at 1000 volts or higher shall be grounded in accordance with the requirements discussed in paragraphs 11.a.-e. on preceding pages of this guide as supplemented or modified below.

(1) Systems supplying portable or mobile high-voltage equipment, other than substations installed on a temporary basis, shall comply with the following:

(a) Portable or mobile equipment shall be supplied from a system having its neutral grounded through an impedance. If a delta-connected, high-voltage system is used to supply the equipment, a system neutral shall be derived.

29 CFR 1926.404(f)(11)(ii)(A)

(b) Exposed noncurrent-carrying metal parts of portable or mobile equipment shall be connected by an equipment-grounding conductor to the point at which the system-neutral impedance is grounded.

29 CFR 1926.404(f)(11)(ii)(B)

(c) Ground-fault detection and relaying shall be provided to automatically de-energize any high-voltage system component that has developed a ground fault. The continuity of an equipment-grounding conductor shall be continuously monitored so as to automatically de-energize the high-voltage feeder to portable equipment if continuity of the equipment-grounding conductor is lost.

29 CFR 1926.404(f)(11)(ii)(C)

(d) The grounding electrode to which a portable or mobile-equipment-system neutral impedance is connected shall be isolated from and separated in the ground by at least 20 feet from any other system or equipment-grounding electrode. There shall be no direct connection between grounding electrodes, such as buried pipe, fence, or similar objects.

29 CFR 1926.404(f)(11)(ii)(D)

(e) All noncurrent-carrying metal parts of portable or fixed equipment including their associated fences, housings, enclosures, and supporting structures shall be grounded. Equipment that is guarded because of its location and isolated from the ground need not be grounded.

29 CFR 1926.404(f)(11)(iii)



**12. Power Transmission and Distribution**

*This section applies to the construction of new transmission and distribution lines and equipment and to the alteration, conversion, and improvement of existing lines and equipment.*

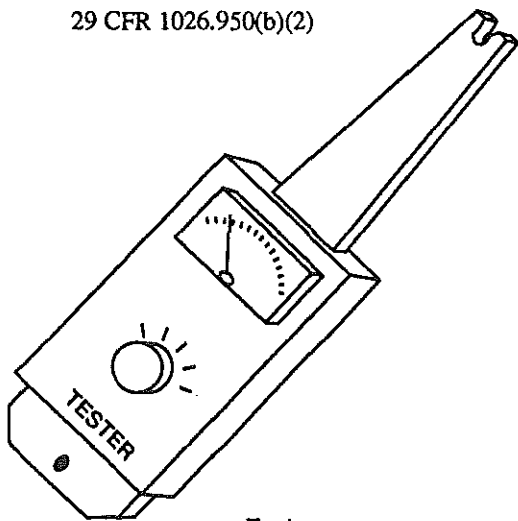
**a. General Requirements**

(1) Before work begins, energized lines and equipment, including utility poles, circuits, power and communication lines, cable television (CATV) lines, and fire alarm circuits shall be inspected or tested for existing conditions.

29 CFR 1926.950(b)(1)

(2) Electric equipment and lines shall be considered energized until they are tested and found not to be energized.

29 CFR 1026.950(b)(2)



Tester

*Note: Caution should be maintained in making immediate direct contact with live lines when using any type of testing device.*

(3) The operating voltage of lines or equipment shall be determined before workers may work on them or near their energized parts.

29 CFR 1926.950(b)(3)

**?VOLTAGE?**

Always check the voltage!

(4) When workers approach or touch exposed energized parts of a conductive object, they must

- use an approved insulating handle no closer than the minimum distances given in Table E-6; or
- be insulated or guarded from energized parts (gloves or sleeves rated for the voltage may be considered as insulated); or
- have the energized part insulated or guarded from the worker and from any other conductive object at a different potential; or
- have the energized part isolated, insulated, or guarded from any other conductive objectives as it would be during live-line, bare-hand work.

29 CFR 1926.950(c)(1)(i-iii)

(5) Conductor-support tools, such as link sticks, strain carriers, and insulator cradles, may be used, provided that the clear insulation is at least as long as the insulator string or is the minimum distance specified in Table E-6 for the operating voltage.

29 CFR 1926.950(c)(2)(ii)

**Table E-6. Alternating Current—Minimum Distances**

Voltage Range (Phase-to-Phase) Kilovolts(kV)	Minimum Working and Clear Hot-Stick Distance
2.1 to 15	2' 0"
15.1 to 35	2' 4"
35.1 to 46	2' 6"
46.1 to 72.5	3' 0"
72.6 to 121	3' 4"
138 to 145	3' 6"
161 to 169	3' 8"
230 to 242	5' 0"
345 to 362	7' 0" <sup>1</sup>
500 to 552	11' 0" <sup>1</sup>
700 to 765	15' 0" <sup>1</sup>

<sup>1</sup> NOTE: For 345–362 kV, 500–552 kV, and 700–765 kV, the minimum working distance and the minimum clear hot-stick distance may be reduced, provided that such distances are not less than the shortest distance between the energized part and a grounded surface.



(6) When lines and equipment rated higher than 600 volts are de-energized, and the means of disconnect are not visibly open or locked-out, steps shall be taken according to (6)(a-g) below.

29 CFR 1926.950(d)(1)



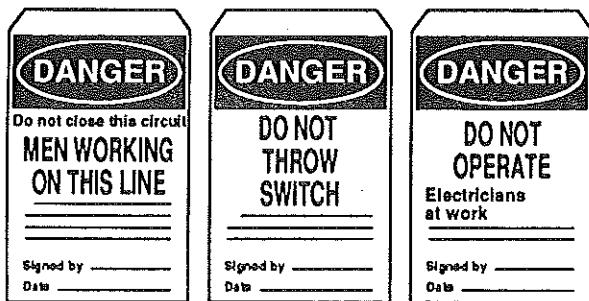
*Note: Although the use of locks to lockout electrical equipment and circuits is not required by 29 CFR 1926, the practice provides a greater degree of protection and is strongly recommended.*

(a) The section of line or equipment to be de-energized shall be clearly identified and isolated from all sources of power.

29 CFR 1926.950(d)(1)(i)

(b) A designated worker shall ensure that all switches and disconnectors for the line or equipment have been de-energized, tagged, and locked out and, when design permits, have been made inoperative.

29 CFR 1926.950(d)(1)(ii)(a-c)



Danger Tags

(c) Lines and equipment shall be visually inspected and tested to ensure that they have been de-energized.

29 CFR 1926.950(d)(1)(iii)

(d) Protective grounds shall be applied to the disconnected lines or equipment.

29 CFR 1926.950(d)(1)(iv)

(e) Guards or barriers shall be erected next to adjacent energized lines as necessary.

29 CFR 1926.950(d)(1)(v)

(f) When more than one independent crew requires the same line or equipment to be de-energized, a designated worker shall place a prominent tag and lock for each crew on the line or equipment.

29 CFR 1926.950(d)(1)(vi)

(g) Upon completion of work on de-energized lines or equipment, a designated worker shall ensure that all workers in the crew are away from the line and the crew's protective grounds are removed. The designated worker shall then report to the designated authority that all tags and locks protecting his or her crew may be removed.

29 CFR 1926.950(d)(1)(vii)

(7) When a crew working on lines or equipment rated over 600 volts can observe that the means of disconnect are visibly open or locked-out, the requirements in paragraphs (6)(c-g) above shall apply.

29 CFR 1926.950(d)(2)



(8) All workers on energized lines shall be proficient in procedures involving emergency situations and first aid fundamentals including resuscitation unless there is a first-aid trainer available on site to render first aid or the worksite is within 3 to 4 minutes of an infirmary, clinic, hospital, or physician.

29 CFR 1926.950(e)(1)(i,ii), (e)(2)

(9) Nighttime operations shall be carried out under spotlights or portable lights.

29 CFR 1926.950(f)

(10) Hydraulic fluids used for the insulated sections of derricks, trucks, aerial lifts, and hydraulic tools used on/or around energized lines and equipment shall be an insulating type. (The requirements for fire-resistant fluids do not apply to hydraulic tools covered by this paragraph.)

29 CFR 1926.950(i)

b. PPE and Tools

(1) PPE

(a) Rubber PPE shall meet the provisions of the American National Standard Institute as follows:

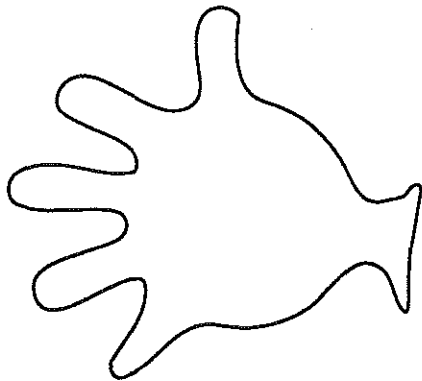
- rubber insulating gloves—ANSI/ASTM D 120-1984,
- rubber matting for use around electrical apparatus—ANSI /ASTM D 178-1981,
- rubber insulating blankets—ANSI/ASTM D 1048-1981, and
- rubber insulating line hose—ANSI/ASTM D-1050-1985.

29 CFR 1926.951(a)(1)(i)

(b) Rubber PPE shall be visually inspected before use, and rubber gloves shall be "air tested" before use, and at least annually according to ANSI/ASTM D 120-1984.

29 CFR 1926.951(a)(1)(ii-iii)





**Air-Leak Test of Lineman's Rubber Glove**

(c) Protective helmets (hard hats) shall meet the provisions of ANSI Z.89.2-1971 "Head Protection." See Section A.2 of this guide for more information.

29 CFR 1926.951(a)(2)

## (2) Tools

(a) Metal or conductive ladders shall not be used near energized electric lines or equipment except under special conditions, such as in high-voltage substations where nonconductive ladders might present a greater hazard than conductive ladders. Metal or conductive ladders shall be marked "CONDUCTIVE," and all necessary precautions shall be taken when they are used.

29 CFR 1926.951(c)(1)

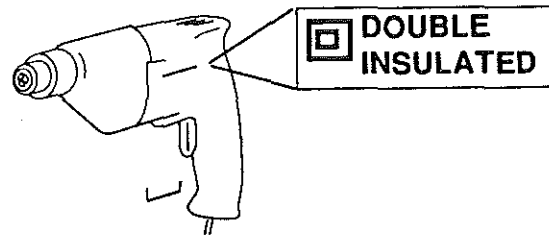
(b) Tools shall be wiped clean and inspected each day before use. If any hazardous defects are noted, the tool shall be removed from service.

29 CFR 1926.951(d)(2)

(c) Portable electric hand tools shall either be equipped with a three-wire cord having the ground wire permanently connected to the tool frame and a means for grounding the other end; or shall be double-insulated and permanently labeled "DOUBLE-INSULATED"; or shall be connected

to the power supply by means of an isolating transformer or other isolated power supply.

29 CFR 1926.951(f)(1),(f)(2)(i-iii)



(d) Measuring tapes or ropes that are metal or contain conductive metal strands shall not be used on or near energized parts.

29 CFR 1926.951(e)

(e) Hydraulic tools used on or around energized lines or equipment shall use nonconductive hoses having adequate strength for normal operating pressures.

29 CFR 1926.951(f)(3)

(f) Pneumatic tools used on or around energized lines or equipment shall have nonconducting hoses that are strong enough for normal operating pressures and shall have an accumulator on the compressor to collect moisture.

29 CFR 1926.951(f)(4)(i,ii)

## c. Mechanical Equipment

(1) All mechanical equipment used on the construction site (including vehicles in Section N of this guide) shall be visually inspected each time it is used.

29 CFR 1926.952(a)(1)

(2) Aerial-lift trucks working near energized lines shall be grounded, barricaded, and considered as energized equipment or shall be insulated from work being performed.

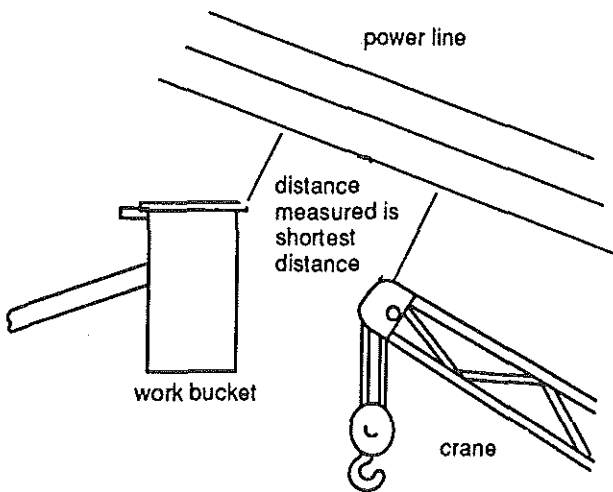
29 CFR 1926.952(b)(2)



(3) Line clearance from cranes, derricks, and other lifting and mechanical equipment are as follows:

- (a) Equipment or materials that are being operated or handled near power lines shall maintain a clearance between lines. Any part of the crane or load shall be
  - 10 feet for lines rated 50 kV or less;
  - 10 feet plus 0.4 inches for each 1 kV over 50 kV for lines rated 50 kV or more; except,
  - where electrical distribution or transmission lines have been de-energized and visibly grounded at the point of work; or
  - where insulating barriers (not part of an attachment to the equipment or machinery) have been erected to prevent physical contact with the lines.
 29 CFR 1926.550(a)(15)(i-ii)

- (b) With the exception of equipment certified for work on the proper voltage, mechanical equipment used in electrical distribution and transmission line work shall not be operated closer to any energized lines or equipment than the clearances set forth in Table E-6, unless
  - an insulated barrier is installed between the energized part and the mechanical equipment,
  - the mechanical equipment is grounded,
  - the mechanical equipment is insulated, or
  - the mechanical equipment is considered as energized.
 29 CFR 1926.952(c)(2)(i-iv)



Power Line Clearances

- (4) Equipment or material shall not be passed between the aerial-lift basket and utility poles or structures or on aerial lifts while a worker in the basket is within reaching distance of energized conductors or equipment that is not covered with insulation protective equipment.
- 29 CFR 1926.952(b)(3)

d. Material Handling

- (1) Before unloading steel poles, cross arms, or similar materials, the load shall be inspected to determine if it has shifted or become otherwise dangerous to workers.
- CFR 1926.953(a)
- (2) When poles are transported, all loads shall be secured well, and a red flag shall be attached to the end of the longest pole. Precautions shall be taken to prevent blocking roadways or endangering other traffic.
- CFR 1926.953(b)(1,2)
- (3) Materials shall not be stored under energized buses or conductors or near energized equipment, if it is practical to store the material elsewhere.
- 29 CFR 1926.953(c)(1)
- (4) When material or equipment is stored under energized lines or equipment, appropriate clearances, as found in Table E-6, shall be maintained. Extraordinary caution shall be taken when moving materials near any energized sources.
- 29 CFR 1926.953(c)(2)
- (5) Tag lines or other suitable devices shall be used when material is hoisted and when workers may be endangered. Tag lines or other devices shall be nonconductive when used near energized sources or lines.
- 29 CFR 1926.953(d); 955(a)(8)
- (6) During framing operations, employees shall not work under a pole or a structure that is suspended by a crane or by other hoisting equipment unless the pole or structure is adequately supported.
- 29 CFR 1926.953(f)

e. Grounding for Employee Protection

- (1) All conductors and equipment shall be treated as energized until tested or otherwise determined to be de-energized or until grounded.
- 29 CFR 1926.954(a)
- (2) New lines or equipment may be considered de-energized when the lines or equipment are grounded or the hazard of induced voltage is not present and adequate clearances or other means are implemented to prevent contact between energized lines or equipment and the new lines or equipment.
- 29 CFR 1926.954(b)(1-2)
- (3) Bare-wire communications conductors on power poles or structures shall be treated as energized lines unless protected by insulating materials.
- 29 CFR 1926.954(c)

(4) De-energized conductors or equipment to be grounded shall be voltage-tested; the results of the test shall determine the subsequent procedures, as noted in paragraphs 12.a.(3) and 12.a.(7) of this section.

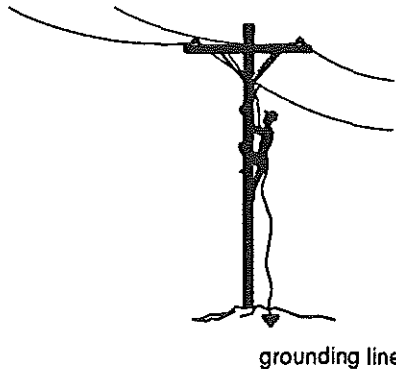
29 CFR 1926.954(d)

(5) When grounds are attached, the grounded end shall be attached first, and the other end shall be attached and removed with insulated tools or other suitable devices. When removing, remove the equipment end of the ground first, using insulated tools.

29 CFR 1926.954(e)

(6) Requirements for placement of grounds are as follows:

(a) Grounds shall be placed at the work locations or between the work location and all sources of energy and as close as practicable to the work location.



(b) If work is to be performed at more than one location in a line section, the line section must be grounded and short circuited at one location, and the conductor to be worked shall be grounded at each work location.

(c) The minimum distances in Table E-6 shall be maintained from ungrounded conductors at the work location.

(d) When making a ground is impracticable or the conditions resulting therefrom would be more hazardous than working on the line or equipment without grounding, the grounds may be omitted and the line or equipment worked as energized.

29 CFR 1926.954(f)

(7) Grounds may be temporarily removed only when necessary for testing purposes, and extreme caution shall be exercised during testing procedures.

29 CFR 1926.954(g)

(8) When grounding electrodes are used, they shall have a resistance to ground low enough (25 ohms maximum is generally accepted resistance) so that workers will not be harmed or to permit prompt operation of protective devices.

29 CFR 1926.954(h)

(9) Grounding to towers shall be made with a tower clamp capable of conducting the anticipated fault current.

29 CFR 1926.954(i)

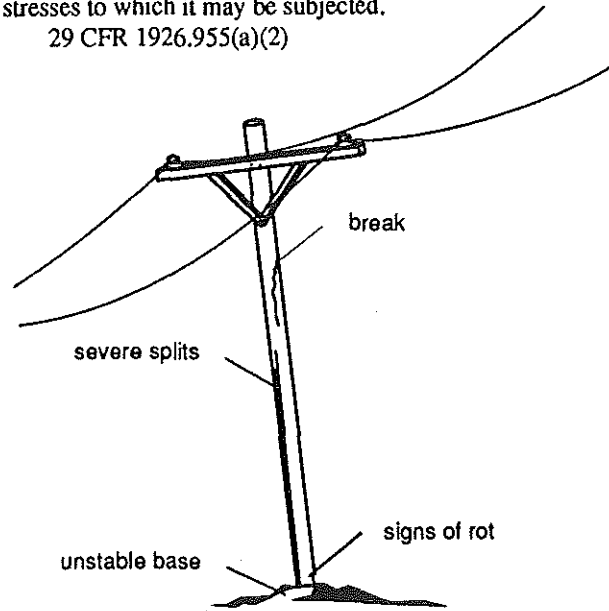
(10) A ground lead, which will be attached to either a tower ground or driven ground, shall be capable of conducting the anticipated fault current and shall have a minimum conductance of No. 2 AWG copper.

29 CFR 1926.954(j)

f. Overhead Lines

(1) Before workers climb poles, ladders, or other elevated structures, the structure shall be inspected to determine if it is capable of sustaining the additional or unbalanced stresses to which it may be subjected.

29 CFR 1926.955(a)(2)



Safety Inspection of Poles

(2) Poles or structures that are considered unsafe for climbing shall not be climbed until they are guyed, braced, or made safe in an equivalent way.

29 CFR 1926.955(a)(3)

(3) Before wire or cable is installed or removed, strains to which poles and structures will be subjected shall be considered, and action shall be taken to prevent failure of such supporting structures.

29 CFR 1926.955(a)(4)

(4) When poles are set, moved, or removed using hoists or other mechanical equipment near energized lines or equipment, precautions shall be taken to avoid contact with energized lines or equipment. This is not necessary in bare-hand live-line work or when barriers or protective devices are used.

29 CFR 1926.955(a)(5)(i)

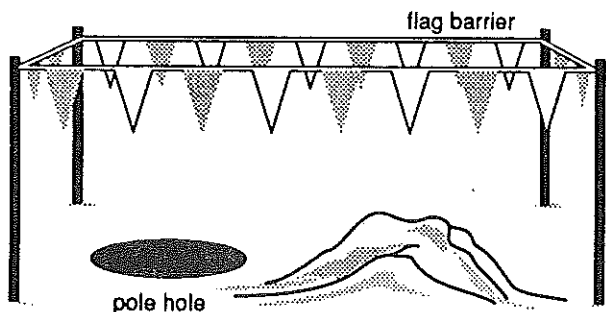


(5) Equipment and machinery operating adjacent to energized lines or equipment shall comply, as applicable, with paragraph 12.c.(3) (a,b) of this guide and Table E-6.  
29 CFR 1926.955(a)(5)(ii)

(6) Unless suitable protective equipment for the voltage involved is used, workers standing on the ground shall avoid touching equipment or machinery that is adjacent to energized lines or equipment.  
29 CFR 1926.955(a)(6)(i)

(7) Equipment for lifting shall be bonded to an effective ground or shall be considered energized and barricaded when used near energized equipment or lines.  
29 CFR 1926.955(a)(6)(ii)

(8) Pole holes shall not be left unattended or unguarded in areas where employees are currently working.  
29 CFR 1926.955(a)(7)



(9) When excavating or augering in unstable material, pad- or pile-type footings more than 5 feet deep shall be sloped to the angle of repose or shored if worker entry is required. Ladders shall be provided when footings in excavations are more than 4 feet deep. See Section C, "Excavations," of this guide.  
29 CFR 1926.955(b)(1,2)

(10) When towers are erected near energized lines, the lines shall be de-energized or appropriate clearances listed in Table E-6 shall be maintained. During lifts, a spotter shall determine the required clearances.  
29 CFR 1926.955(b)(5)(iii)

(11) Traffic shall be controlled in accordance with Sections G, "Signs, Signals, and Barricades," and N, "Demolition," of this guide.  
29 CFR 1926.955(b)(7)

(12) No one shall be permitted to remain in a footing while equipment is being spotted or moved for placement.  
29 CFR 1926.955(b)(3)(ii)

g. Stringing or Removing De-Energized Conductors

(1) Before stringing operations begin, all workers shall receive prephase training to include review of work assignments, equipment required, and precautions to be taken for the operation.  
29 CFR 1926.955(c)(2) **T**

(2) When there is a possibility of a conductor accidentally contacting an energized circuit, the conductor being installed or removed shall be grounded; or workers shall be insulated or isolated.  
29 CFR 1926.955(c)(3)

(3) If the existing line is de-energized, proper clearance authorization shall be secured and the line shall be grounded on both sides of the crossover; or the strung line shall be considered and worked as if it were energized.  
29 CFR 1926.955(c)(4)(i)

(4) When crossing over energized conductors of more than 600 volts, rope nets or guard structures shall be installed unless provisions are made to insulate or isolate the live conductor or worker. Where practical, the automatic reclosing feature of the circuit-interrupting device shall be made inoperative. In addition, the line being strung shall be grounded either side of the crossover or worked as energized.  
29 CFR 1926.955(c)(4)(ii)

(5) Conductors being strung or removed shall be controlled with tension reels, guard structures, tielines, or other equivalent means to prevent contact with energized lines.  
29 CFR 1926.955(c)(5)

(6) Conductor grips shall not be used on wire rope, unless the conductor grips are designed for this application.  
29 CFR 1926.955(c)(8)

(7) Clipping crews shall have a minimum of two structures clipped in between the crew and the conductor being sagged. When working on bare conductors, crews shall work between grounds at all times; and grounds shall remain intact until work is completed.  
29 CFR 1926.955(c)(10)

(8) Reliable communications between the reel tender and the pulling-rig operator shall be provided.  
29 CFR 1926.955(c)(12)(ii)

(9) Each pull shall be snubbed or dead-ended at both ends before subsequent pulls.  
29 CFR 1926.955(c)(12)(iii)



**h. Stringing Next to Energized Lines**

(1) Before stringing parallel to an existing live line, it shall be determined if dangerous induced-voltage build-ups will occur, especially during switching and ground-fault conditions. When there is a possibility of dangerous induced voltages, the requirements in this section shall be followed unless the lines are worked as energized.

29 CFR 1926.955(d)(1) **T**

(2) All pulling and tension equipment shall be isolated, insulated, or effectively grounded. A ground shall be installed between the tensioning reel and the first structure in order to ground each bare conductor, subconductor, or overhead ground during stringing operations.

29 CFR 1926.955(d)(3,4)

(3) During stringing operations, each of the conductors in paragraph (2) above shall be grounded at the first tower adjacent to both the tension and pulling setup and in increments so that no point is more than 2 miles from the ground. Grounds shall be left in place until work is completed, removed as a last phase of aerial cleanup, or removed with a hot stick. Such conductors shall be grounded at all dead-end or catch-off points.

29 CFR 1926.955(d)(5)(i-iii), (6)

(4) A ground shall be located on each side and within 10 feet from the working area where conductors, subconductors, or overhead ground conductors are being spliced. The two ends of the conductors to be spliced together shall be bonded together. It is recommended that splicing be carried out on an insulated platform or metallic grounding mat that is bonded to both grounds.

29 CFR 1926.955(d)(7)

(5) All conductors, subconductors, and ground conductors shall be bonded to the tower at any isolated tower when necessary to complete work on the transmission line. When deadend towers are worked, all de-energized lines shall be grounded.

29 CFR 1926.955(d)(8)(i-ii)

(6) When performing work from structures, all workers on conductors shall be protected by individual grounds at every work location.

29 CFR 1926.955(d)(9)

**i. Live-Line, Bare-hand Work**

(1) Workers shall be instructed and trained in live-line, bare-hand techniques and safety requirements before beginning such work.

29 CFR 1926.955(e)(1) **T**

(2) Handlines shall not be used between buckets, booms, or ground, and there shall be no conductive objects over 36 inches long in a bucket (except for appropriate length jumpers, armor rods, and tools).

29 CFR 1926.955(e)(18)(i,ii)

(3) Workers shall know the voltage rating of the circuit, clearances to ground and other energized parts, and the voltage limitations of the aerial-lift equipment before they begin live-line, bare-hand work.

29 CFR 1926.955(e)(2)(i-iii)

(4) Only equipment and tools designed, tested, and intended for live-line, bare-hand work shall be used. Tools and equipment shall be maintained clean and dry. All work shall be personally supervised by a trained and qualified worker in live-line, bare-hand work.

29 CFR 1926.955(e)(3,4,8) **T**

(5) When practical, the automatic reclosing feature of an interrupting device shall be made inoperative before working on any energized line or equipment.

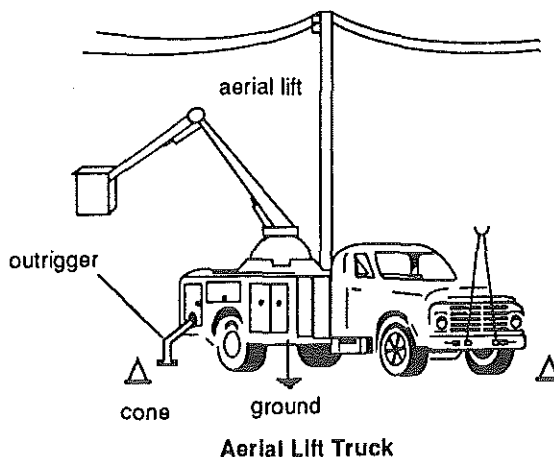
29 CFR 1926.955(e)(5)

(6) A conductive bucket liner or other conductive device shall be used for bonding the insulated aerial device to the live line or equipment. Workers shall be connected to the bucket liner with conductive shoes, leg clips, or other equivalent means. When necessary for electrostatic protections, appropriate electrostatic shielding or conductive clothing shall be provided.

29 CFR 1926.955(e)(7)(i,ii)

(7) Before the boom is elevated, the outriggers on the aerial truck shall be extended and adjusted to stabilize the truck, and the body of the truck shall be bonded to an effective ground or barricaded and considered as energized equipment. The controls of the aerial lift shall be inspected and tested (ground level and bucket) before it is moved into the work position.

29 CFR 1926.955(e)(9,10)





(8) Arm current tests shall be made before starting work each day and any time a new higher voltage is to be worked. See the below noted CFR for test requirements.  
29 CFR 1926.955(e)(11)

(9) Aerial lifts shall have upper and lower controls; lower controls shall have override capabilities. Bucket controls shall be within easy reach of workers; lower controls shall be located near the base of the boom. Controls shall be overriding, and the lower control shall not be used without approval of the worker in the bucket except in the event of an emergency.  
29 CFR 1926.955(e)(12,13)

(10) The minimum clearance distances for live-line, bare-hand work are specified in Table E-7. These distances shall be maintained from all grounded objects; from lines and equipment, including the grounded frame of the lift truck; and from lines of a different potential to those bonded to the insulated aerial device, unless these objects are covered by insulated guards. The clearance distances shall be maintained when live circuits are approached, or left, or when bonded to live circuits.  
29 CFR 1926.955(e)(15)

**Table E-7. Minimum Clearance Distances for Live-Line Bare-Hand Work (Alternating Current)**

Voltage Range (Phase-to-Phase) Kilovolts (kV)	Distance in Feet and Inches for Maximum Voltage	
	Phase to Ground	Phase to Phase
2.1 to 15	2' 0"	2' 0"
15.1 to 35	2' 4"	2' 4"
35.1 to 46	2' 6"	2' 6"
46.1 to 72.5	3' 0"	3' 0"
72.6 to 121	3' 4"	4' 6"
138 to 145	3' 6"	5' 0"
161 to 169	3' 8"	5' 6"
230 to 242	5' 0"	8' 4"
345 to 362*	7' 0"*	13' 4"*
500 to 552*	11' 0"*	20' 0"*
700 to 765*	15' 0"*	31' 0"*

\*For noted kVs, the minimum clearance distance may be reduced, provided the distances are not made less than the shortest distance between the energized part and a grounded surface.

(11) Before workers contact the energized parts to be worked, the conductive bucket liner shall be bonded to the energized conductor and remain so until work is completed.  
29 CFR 1926.955(e)(14)

(12) The minimum clearances as stated in Table E-7 shall be printed on durable, nonconductive material and posted inside the bucket where it may easily be seen by workers inside the bucket.  
29 CFR 1926.955(e)(20)(i)

**j. Underground Lines**

**(1) Requirements for Guarding and Ventilation**

(a) Warnings signs shall be posted when the cover of a manhole, handhole, or vault is removed; the type of warning sign will depend on the location and hazard involved.  
29 CFR 1926.956(a)(1)

(b) A street opening or vault shall be protected by barriers, temporary covers, or other suitable guards before workers enter.  
29 CFR 1926.956(a)(2)

(c) Workers shall not be permitted to enter manholes or unvented vaults until forced ventilation is provided and the atmosphere is tested for oxygen deficiency and presence of explosive gases or fumes and found safe. When unsafe conditions are found, the work area shall be ventilated, retested, and made safe before entry; and provisions shall be made for adequate exchange of air.  
29 CFR 1926.956(a)(3)(i-iii)

**(2) Requirements for Work in Holes**

(a) When workers are in a manhole, a safety watch shall be in the immediate vicinity to render emergency assistance; safety watch may occasionally enter the manhole to give other than emergency assistance. Although not recommended, the CFR does allow specific exemptions to this requirement. For information of specific exemptions, see the below noted CFR. **T**  
29 CFR 1926.956(b)(1)

(b) When open flames must be used in manholes, extra precautions shall be taken to provide adequate ventilation.  
29 CFR 1926.956(b)(2)

(c) Before open flames are used in a manhole or excavation in which combustible gases or liquids may be present (for example, in areas near gasoline stations), the atmosphere shall be tested and found safe or cleared of combustible gases or liquids. Adequate ventilation must be provided during use of open flame work.  
29 CFR 1926.956(b)(3)





## (3) Requirements for Trenching and Excavating

(a) Trenching and excavating requirements are outlined in Section C of this guide to include directing of mobile equipment next to excavations.

29 CFR 1926.956(c)(2)



(b) To prevent worker exposure to underground hazards during excavating or trenching operations, efforts shall be made to locate dangerous underground facilities and to prevent their damage.

29 CFR 1926.956(c)(1)

(c) When any underground facilities are exposed (electric, gas, water, telephone, and others), the facilities shall be protected as necessary to avoid damage.

29 CFR 1926.956(c)(3)

(d) When multiple cables are found in an excavation, all cables not being worked shall be protected.

29 CFR 1926.956(c)(4)

(e) When multiple cables are found in an excavation, the cable to be worked on shall be identified electrically, unless it has a distinctive appearance.

29 CFR 1926.956(c)(5)

(f) When working on buried cable or cable in manholes, metallic sheath continuity of a cable shall be maintained by bonding across the sheath opening or by equivalent means.

29 CFR 1026.956(c)(7)

## k. Construction in Energized Substations

## (1) General Requirements

(a) Only an authorized person may approve the start of construction in an energized substation.

29 CFR 1926.957(a)(1)



(b) Before construction begins, energized facilities shall be identified, and appropriate PPE shall be selected. The precautions necessary for worker safety shall also be determined.

29 CFR 1926.957(a)(2)(i,ii)

(c) Extraordinary caution shall be exercised when busbars and steel for towers and equipment are handled in the vicinity of the energized facilities. Specific guidance on appropriate precautionary measures is provided in Section E.12.a(4-5) "Power Transmission and Distribution" of this guide.

29 CFR 1926.957(a)(3)

(d) When it is necessary to de-energize equipment or lines for protection of workers, refer to the guidelines outlined in Section E.12.a.(6-8) "Power Transmission and Distribution," of this guide.

(e) Barricades and barriers shall be installed to prevent accidental worker contact with energized lines and equipment. Signs indicating the hazard shall be posted near the barricade or barrier.

29 CFR 1926.957(c)(1,2)

(f) Work on or near energized control panels shall be performed only by designated, qualified workers.

29 CFR 1926.957(d)(1)



(g) Precautions shall be taken to prevent jarring, vibration, or improper wiring from causing accidental operation of relays or other protective devices.

29 CFR 1926.957(d)(2)

## (2) Using Mechanical Equipment

(a) Use of vehicles, gin poles, cranes, and other equipment in restricted or hazardous areas shall be controlled by designated workers at all times.

29 CFR 1926.957(e)(1)



(b) All mobile cranes and derricks shall be effectively grounded when being moved or operated in close proximity to energized lines or equipment, or the equipment shall be considered energized.

29 CFR 1926.957(e)(2)

## (3) Substation Fences

(a) When a substation fence must be expanded or removed for construction purposes, a temporary fence affording similar protection (at least 8 feet in height) shall be provided when the site is unattended. Adequate interconnection with ground shall be maintained between the temporary fence and the permanent fence.

29 CFR 1926.957(g)(1)

(b) All gates to unattended substations shall be locked.

29 CFR 1926.957(g)(2)

## (4) Excavating Footings

(a) Excavation for auger-, pad- and piling-type footings for structures and towers shall require the same precautions as metal tower construction. See Section E.12.f.(9) "Power Transmission and Distribution, Overhead Lines." of this guide.

29 CFR 1926.957(h)(1)



(b) No worker shall enter an unsupported auger-type excavation made in unstable material for any purpose. Cleanout shall be done without workers entering.

29 CFR 1926.957(h)(2)

I. Lineman's Body Belts

(1) Lineman's belts, safety straps, and lanyards shall meet the requirements of the American Society of Testing Materials (ASTM) Standard B117-64. See Section A.9. of this guide for more details.

29 CFR 1926.951(b)(4)(i); 959(a)(1)

(2) PPE (body belts with straps and lanyards) shall be worn by those working at elevated locations, except in operations in which use of these items may create a greater hazard; then other safeguards shall be used.

29 CFR 1926.951(b)(1)

(3) Before each use, body belts and straps shall be inspected for a deformed buckle; cracked or broken "D" ring; failure of the snap hook; parted, torn, or cracked fabric or leather; and other damaged items. Specific inspection requirements can be found in the CFR noted below.

29 CFR 1926.951(b)(3), 959(a)(2-4), (b)(1)(i-ii)



(4) Safety lines are not intended for shock-loading; they are used to lower workers during an emergency rescue. Defective lines shall be replaced.

29 CFR 1926.951(b)(4,5)

(5) The cushion support of a body belt shall contain no exposed rivets on the inside.

29 CFR 1926.959(b)(2)(i)



## DEFINITIONS

**Acceptable** — Has been accepted, certified, listed, labeled, or otherwise specified as being safe by a nationally recognized testing laboratory, such as Underwriters' Laboratories (UL); or has been inspected or tested by a controlling authority and found to be in compliance with the provisions of the National Electrical Code (NEC)/or other regulatory requirements.

**Accessible** — Can be easily entered or reached; not guarded, locked away, placed at a high elevation, or in any way obstructed.

**Ampacity** — Current-carrying capacity measured in amperes.

**Approved** — Accepted by a controlling authority; or approved for a specific use in accordance with standard or code.

**Attachment Plug** — A fitting that can be inserted into an electric receptacle to establish a connection with the power supply.

**Bonding** — Using low-resistance material to electrically join metallic parts to form a permanent electrical connection or continuity.

**Branch Circuit** — The section of wiring that extends between the final overload protective device and the plug receptacle.

**Certified** — Acceptable (See "Acceptable" above).

**Circuit Breaker** — An automatic switch, which can also be manually opened or closed, that stops the flow of electric current in an overloaded circuit.

**Clearance Authorization** — The portion of an electrical line-stringing plan that includes permission from the power company to string across or near an existing line.

**Conductors** — Wires capable of and intended to conduct electricity.

**Bare** — Uncovered or uninsulated wires.

**Covered** — Wires encased in materials that do not meet the electrical insulation standard.

**Insulated** — Wires encased in materials that meet the electrical insulation standard.

**Open** — A condition or location of circuit wiring, for example, the physical location of wiring or circuit, i.e., wiring run in the open, across poles, etc.

**Disconnect Means** — A device or group of devices that can be used to disconnect circuits from their power source.

**Enclosed** — Surrounded by a case, housing, fence, wall, or other device that prevents individuals from accidentally contacting energized parts and that protects equipment from damage.

**Explosion-Proof Enclosure** — An equipment-enclosing case that can withstand an internal explosion of a specified gas or vapor without propagating the explosion to the environment outside the enclosure.



**Exposed** — Unprotected from individuals' inadvertent contact or approach; or not suitably guarded, isolated, or insulated.

**Feeder** — Power supplied to service equipment.

**Grounding Conductor** — A conductor used to connect equipment or the grounded circuit of a wiring system to the grounding electrode or electrode.

**Grounded Conductor** — A system or circuit conductor that is intentionally grounded. This conductor is white or gray and will normally have circuit flow.

**Ground (Grounding)** — A conducting path, either intentional or accidental, between an electric circuit or a piece of equipment and the earth or a conducting body that serves in place of the earth.

**Ground Fault Circuit Interrupter (GFCI)** — A sensitive, fast-acting circuit breaker that can sense and interrupt very small ground-fault currents (usually 5 milliamperes [mA] difference between hot and neutral).

**Guarded** — Covered, shielded, enclosed within fences or walls, or otherwise protected.

**Hot Stick** — A long, insulated tool used to hold or attach live power lines.

**Isolated** — Separated or removed; set apart.

**Locations** —

**Damp** — Partially protected areas, under canopies, porch roofs, or other coverings, that are subject to moderate amounts of moisture.

**Dry** — Locations that are not normally subject to dampness or wetness.

**Wet** — Underground areas, surrounded by concrete or masonry or in direct contact with the earth; or locations that are exposed to weather.

**Outlet** — A termination point on the wiring system from which electric power is taken to operate equipment.

**Premises-Wiring System** — Permanent or temporary interior and exterior wiring that extends from the lead end of a service drop to the outlets.

**Qualified Person** — A person who is familiar with the construction and operation of the equipment and who understands the hazards involved.

**Service-Entrance Conductors** — The supply conductors that extend to the service equipment from the street main or from transformers.

**Voltage, Nominal** — A nominal value assigned to a circuit or system for the purpose of conveniently designating its voltage class (for example, 120/240, 480Y/277, or 600).

**Watertight** — Constructed so that moisture cannot enter the enclosure.

**Weatherproof** — Constructed or protected so that exposure to the weather will not interfere with operations; or rainproof and watertight.

**KEY ITEMS CHECK LIST  
SECTION E. ELECTRICAL SAFETY**

Item	Paragraph	Notes
1. REQUIREMENTS FOR ALL SITE WORKERS	E.1	
Is the worksite surveyed for electrical hazards; are signs posted and workers advised?	E.1.a	
Are workers near electrical circuits? If so, is equipment guarded or power de-energized and grounded?	E.1.b	
Are tools inspected for hazardous defects?	E.1.i	
Are tools grounded or double insulated?	E.1.k	
Are double-insulated tools so labeled?	E.1.k	
Are flexible extension cords the correct size and type?	E.1.n	
Are flexible extension cords protected from damage?	E.1.n(5)	
Are cabinet clearances maintained?	E.1.e	
Is the location of underground electric power known prior to use of jack hammer or bar?	E.1.m	
Are signs posted and observed?	E.1.c	
2. REQUIREMENTS FOR ELECTRICAL WORKERS	E.2	
Are workers trained in electrical safety-related work practices and hazard recognition?	E.2.a	
Are only qualified workers inspecting and using electrical test equipment?	E.2.c E.2.d	
Are lockout/tagout procedures for electric work carried out?	E.2.f	
Are proper space requirements met for work near exposed live parts?	E.2.j	
3. ON-SITE ELECTRICAL SAFETY REQUIREMENTS	E.3	
Are ground-fault circuit interrupters (GFCIs) installed and used?	E.3.a	

KEY ITEMS CHECK LIST (continued)

Item	Paragraph	Notes
Where GFCIs are not installed, is an assured grounding program in effect?	E.3.a	
Are splices as strong and as well insulated as new cord?	E.3.g	
Are equipment and cords secured and installed correctly?	E.3.j E.3.k	
Is temporary wiring removed as soon as its purpose is served?	E.3.s	
Are listing and labeling instructions followed?	E.3.u	
Are new installations protected from accumulation of construction dust or fines that could cause fire or an explosion?	E.3.t	
4. GENERAL WIRING DESIGN AND PROTECTION	E.4	
Are metal raceways, cable armor, and other metal enclosures continuous and connected to boxes, fittings, or cabinets?	E.4.a	
Are wiring systems protected from damage, dampness, and flammable vapors?	E.4.b E.4.c	
Are receptacles and connectors the correct type?	E.4.d	
Are means for disconnecting appliances provided and correctly marked?	E.4.h	
Is the grounded conductor of every cable distinguishable?	E.4.i	
5. CABINETS, BOXES, AND SWITCHBOARDS	E.5	
Are cabinets and boxes fitted with bushings to prevent conductor damage?	E.5.a	
Are pull boxes, junction boxes, or fittings covered and grounded?	E.5.b	
Are all switches installed according to instructions?	E.5.d E.5.e	

KEY ITEMS CHECK LIST (continued)

Item	Paragraph	Notes
6. MOTORS AND PENDANTS	E.6	
Are disconnects within sight of controller location?	E.6.a	
	E.6.e	
Are all disconnects identified according to the equipment or motors they serve?	E.6.c	
	E.6.d	
Are the correct plugs, cords, and pendants used?	E.6.i	
7. TRANSFORMERS	E.7	
Are transformers correctly posted with operating voltage?	E.7.b	
Is access by workers and storage of material in transformer vaults prohibited?	E.7.c	
	E.7.d	
8. SPECIFIC PURPOSE EQUIPMENT AND INSTALLATIONS	E.8	
<i>a. Cranes and Hoists</i>	E.8.a	
Can the required switches be locked open?	E.8.a (1)	
Are the required limit switches installed?	E.8.a (4)	
Are disconnects and switches correctly located?	E.8.a (2)	
	E.8.a (3)	
<i>b. Elevators, Escalators, and Moving Walks</i>	E.8.b	
Are switches and disconnects correctly located?	E.8.b (1)	
	E.8.b (2)	
<i>c. Electric Welding Equipment</i>	E.8.c	
Are the required disconnects and switches provided?	E.8.c (1)	
Is the amperage rating of switches adequate?	E.8.c (2)	
<i>d. X-Ray and Radiographic Equipment</i>	E.8.d	
Are all the required interlocks and disconnects installed?	E.8.d (1)	
	E.8.d (2)	
9. HAZARDOUS LOCATIONS	E.9	
Is the type of wiring appropriate for the hazard?	E.9.a	

KEY ITEMS CHECK LIST (continued)

	Item	Paragraph	Notes
10.	SPECIAL SYSTEMS	E.10	
	a. <i>Systems, Cables, and Installations over 600 Volts, Nominal</i>	E.10.a	
	Are circuit breakers enclosed and clearly marked?	E.10.a (1)	
	Is there an equipment isolating means or warning on circuits when inspections or repairs are required?	E.10.a (3) E.10.a (5)	
	Are the correct cables and conductors for the machinery in use?	E.10.a	
	Are allowed splices molded or otherwise prepared to be as strong and as well insulated as new cable?	E.10.a (10)	
	Are the required clearances maintained?	E.10.a (13) E.10.a (14)	
	b. <i>Installations inside Tunnels</i>	E.10.b	
	Are proper electrical safety procedures followed during the installation of mobile shovels, trailers, cars, draglines, hoists, drills, dredges, compressors, pumps, conveyors, and underground excavators?	E.10.b (1)	
	c. <i>Communication Systems</i>	E.10.c	
	Are the specific requirements for each system followed?	E.10.c	
	d. <i>Battery Servicing</i>	E.10.d	
	Are battery areas ventilated?	E.10.d (1)	
	Are battery caps in place during charging?	E.10.d (9)	
11.	GROUNDING	E.11	
	a. <i>General Requirements</i>	E.11.a	
	Are systems grounded when it is required?	E.11.a	
	b. <i>Requirements for Portable and Vehicle-Mounted Generators</i>	E.11.b	
	Are noncurrent-carrying metal parts bonded to the frame?	E.11.b (1)	
	c. <i>Grounding of Supports, Enclosures, and Equipment</i>	E.11.c	
	Are all noncurrent-carrying metal parts grounded?	E.11.c (3)	



KEY ITEMS CHECK LIST (continued)

Item	Paragraph	Notes
<p>d. <i>Requirements for Plug and Cord Equipment</i> Are all noncurrent-carrying metal parts grounded?</p>	E.11.d	
	E.11.d (1)	
	E.11.d (2)	
<p>e. <i>Grounding Methods</i> Are grounding conductors contained within the raceway, cable, or cord that contains the circuit conductor?</p>	E.11.e	
	E.11.e (1)	
	E.11.e (2)	
	E.11.e (4)	
	E.11.e (5)	
<p>f. <i>Grounding 1,000-Volt Supply or Greater</i> Are the special grounding requirements for higher-voltage equipment considered?</p>	E.11.f	
	E.11.f	
<hr/>		
12. POWER TRANSMISSION AND DISTRIBUTION	E.12	
<p>a. <i>General Requirements</i> Are lines considered to be energized until they are tested?</p>	E.12.a	
	E.12.a (2)	
	E.12.a (1)	
	E.12.a (5)	
	E.12.a (6)(a)	
	E.12.a (6)	
	E.12.a (8)	
	E.12.a (8)	
	E.12.a (8)	
<p>b. <i>PPE and Tools</i> Do rubberized gloves, insulating blankets, and rubber matting meet ANSI standards?</p>	E.12.b	
	E.12.b (1)	
	E.12.b (1) (b)	

KEY ITEMS CHECK LIST (continued)

Item	Paragraph	Notes
Are metal ladders prohibited?	E.12.b (2) (a)	
Are tools clean?	E.12.b (2) (b)	
Are metal tape measures or ropes or such items containing conductive metal strands prohibited?	E.12.b (2) (d)	
Are the conductive properties of hand tools offset by double insulation or isolating circuits, or otherwise prepared for worker protection?	E.12.b (2) (c)	
<i>c. Mechanical Equipment</i>	E.12.c	
Are aerial-lift trucks, cranes, derricks, and other mechanical equipment inspected?	E.12.c (1)	
Are the correct clearances maintained for equipment near energized lines?	E.12.c (3) (a)	
Are the correct clearances maintained for equipment servicing energized lines?	E.12.c (3) (b)	
Is equipment that is operated closer to energized lines than the approved clearances certified for such use?	E.12.c (3) (b)	
<i>d. Material Handling</i>	E.12.d	
Are loads of poles, cross arms, or similar materials inspected for stability?	E.12.d (1)	
Is storage of materials near energized buses or conductors discouraged?	E.12.d (3)	
Are extraordinary precautions taken when conductive materials are handled near energized lines?	E.12.d (4)	
Are workers prohibited from working under inadequately supported structures during framing operations?	E.12.d (6)	
<i>e. Grounding for Employee Protection</i>	E.12.e	
Are the requirements for ground placement met?	E.12.e (6)	
Is extreme caution used when grounds are removed for testing?	E.12.e (7)	
Are grounding leads adequate?	E.12.e (10)	
<i>f. Overhead Lines</i>	E.12.f	
Are poles inspected for strength before they are climbed?	E.12.f (1)	

KEY ITEMS CHECK LIST (continued)

Item	Paragraph	Notes
Are auguring and excavation requirements met?	E.12.f (9)	
Are precautions taken to avoid energized lines or parts?	E.12.f (4)	
<i>g. Stringing or Removing De-Energized Conductors</i>	<i>E.12.g</i>	
Have workers received prephase training?	E.12.g (1)	
Is the potential for contacting live lines accounted for?	E.12.g (2) E.12.g (3)	
Is reliable communication provided?	E.12.g (8)	
<i>h. Stringing Next to Energized Lines</i>	<i>E.12.h</i>	
Are the hazards of induced current accounted for?	E.12.h (1)	
Are all conductors being strung bonded and grounded?	E.12.h (2) E.12.h (3)	
<i>i. Live-Line, Bare-Hand Work</i>	<i>E.12.i</i>	
Are workers trained?	E.12.i (1)	
Are long conductive objects prohibited in the bucket?	E.12.i (2)	
Are workers aware of voltage compared with the limitations of their equipment?	E.12.i (3)	
Is a bonded conductive bucket liner used?	E.12.2 (6)	
Are proper clearances maintained for the grounded parts of equipment?	E.12.i (10)	
Are lift controls located correctly, and do they have the required overrides?	E.12.i (9)	
Does the worker in the bucket have approval concerning use of the lower controls?	E.12.i (9)	
<i>j. Underground Lines</i>	<i>E.12.j</i>	
Do street openings have proper signs and barricades?	E.12.j (1) (a) E.12.j (1) (b)	
Have workers met requirements before entering confined spaces?	E.12.j (1) (c)	
Are workers observing excavation procedures?	E.12.j (3)	

KEY ITEMS CHECK LIST (continued)

Item	Paragraph	Notes
<i>k. Construction in Energized Substations</i>	<i>E.12.k</i>	
Is construction in energized substations under the control of an authorized person?	E.12.k (1) (a)	
Are extraordinary precautions taken in handling conductive materials near energized facilities?	E.12.k (1) (c)	
Are signs posted and barricades erected to protect workers?	E.12.k (1) (d) E.12.k (1) (e)	
Are precautions taken against accidental relay activation?	E.12.k (1) (g)	
Is the use of vehicles, gin poles, cranes, and other equipment controlled by an authorized person?	E.12.k (2) (a) E.12.k (2) (b)	
Are fence openings guarded and gates locked?	E.12.k (3) (a) E.12.k (3) (b)	
Are proper precautions taken for excavations and footings?	E.12.k (4) (a) E.12.k (4) (b)	
<i>l. Lifelines and Body Belts</i>	<i>E.12.l</i>	
Are the types of lifelines, belts, safety straps, and lanyards approved by the ASTM?	E.12.l (1)	
Is equipment inspected?	E.12.l (3)	
Are belts used in electrical work free of exposed rivets?	E.12.l (5)	

KEY ITEMS CHECK LIST (continued)

Item	Paragraph	Notes
<i>k. Construction in Energized Substations</i>	<i>E.12.k</i>	
Is construction in energized substations under the control of an authorized person?	E.12.k (1) (a)	
Are extraordinary precautions taken in handling conductive materials near energized facilities?	E.12.k (1) (c)	
Are signs posted and barricades erected to protect workers?	E.12.k (1) (d) E.12.k (1) (e)	
Are precautions taken against accidental relay activation?	E.12.k (1) (g)	
Is the use of vehicles, gin poles, cranes, and other equipment controlled by an authorized person?	E.12.k (2) (a) E.12.k (2) (b)	
Are fence openings guarded and gates locked?	E.12.k (3) (a) E.12.k (3) (b)	
Are proper precautions taken for excavations and footings?	E.12.k (4) (a) E.12.k (4) (b)	
<i>l. Lifelines and Body Belts</i>	<i>E.12.l</i>	
Are the types of lifelines, belts, safety straps, and lanyards approved by the ASTM?	E.12.l (1)	
Is equipment inspected?	E.12.l (3)	
Are belts used in electrical work free of exposed rivets?	E.12.l (5)	

KEY ITEMS CHECK LIST (continued)

Item	Paragraph	Notes
Are auguring and excavation requirements met?	E.12.f (9)	
Are precautions taken to avoid energized lines or parts?	E.12.f (4)	
g. <i>Stringing or Removing De-Energized Conductors</i> Have workers received prephase training?	E.12.g E.12.g (1)	
Is the potential for contacting live lines accounted for?	E.12.g (2) E.12.g (3)	
Is reliable communication provided?	E.12.g (8)	
h. <i>Stringing Next to Energized Lines</i> Are the hazards of induced current accounted for?	E.12.h E.12.h (1)	
Are all conductors being strung bonded and grounded?	E.12.h (2) E.12.h (3)	
i. <i>Live-Line, Bare-Hand Work</i> Are workers trained?	E.12.i E.12.i (1)	
Are long conductive objects prohibited in the bucket?	E.12.i (2)	
Are workers aware of voltage compared with the limitations of their equipment?	E.12.i (3)	
Is a bonded conductive bucket liner used?	E.12.2 (6)	
Are proper clearances maintained for the grounded parts of equipment?	E.12.i (10)	
Are lift controls located correctly, and do they have the required overrides?	E.12.i (9)	
Does the worker in the bucket have approval concerning use of the lower controls?	E.12.i (9)	
j. <i>Underground Lines</i> Do street openings have proper signs and barricades?	E.12.j E.12.j (1) (a) E.12.j (1) (b)	
Have workers met requirements before entering confined spaces?	E.12.j (1) (c)	
Are workers observing excavation procedures?	E.12.j (3)	

KEY ITEMS CHECK LIST (continued)

Item	Paragraph	Notes
Are metal ladders prohibited?	E.12.b (2) (a)	
Are tools clean?	E.12.b (2) (b)	
Are metal tape measures or ropes or such items containing conductive metal strands prohibited?	E.12.b (2) (d)	
Are the conductive properties of hand tools offset by double insulation or isolating circuits, or otherwise prepared for worker protection?	E.12.b (2) (c)	
<i>c. Mechanical Equipment</i>	<i>E.12.c</i>	
Are aerial-lift trucks, cranes, derricks, and other mechanical equipment inspected?	E.12.c (1)	
Are the correct clearances maintained for equipment near energized lines?	E.12.c (3) (a)	
Are the correct clearances maintained for equipment servicing energized lines?	E.12.c (3) (b)	
Is equipment that is operated closer to energized lines than the approved clearances certified for such use?	E.12.c (3) (b)	
<i>d. Material Handling</i>	<i>E.12.d</i>	
Are loads of poles, cross arms, or similar materials inspected for stability?	E.12.d (1)	
Is storage of materials near energized buses or conductors discouraged?	E.12.d (3)	
Are extraordinary precautions taken when conductive materials are handled near energized lines?	E.12.d (4)	
Are workers prohibited from working under inadequately supported structures during framing operations?	E.12.d (6)	
<i>e. Grounding for Employee Protection</i>	<i>E.12.e</i>	
Are the requirements for ground placement met?	E.12.e (6)	
Is extreme caution used when grounds are removed for testing?	E.12.e (7)	
Are grounding leads adequate?	E.12.e (10)	
<i>f. Overhead Lines</i>	<i>E.12.f</i>	
Are poles inspected for strength before they are climbed?	E.12.f (1)	

KEY ITEMS CHECK LIST (continued)

Item	Paragraph	Notes
<p>d. <i>Requirements for Plug and Cord Equipment</i> Are all noncurrent-carrying metal parts grounded?</p>	E.11.d	
	E.11.d (1)	
	E.11.d (2)	
<p>e. <i>Grounding Methods</i> Are grounding conductors contained within the raceway, cable, or cord that contains the circuit conductor?</p>	E.11.e	
	E.11.e (1)	
	E.11.e (2)	
	E.11.e (4)	
	E.11.e (5)	
<p>f. <i>Grounding 1,000-Volt Supply or Greater</i> Are the special grounding requirements for higher-voltage equipment considered?</p>	E.11.f	
	E.11.f	
<hr/>		
12. POWER TRANSMISSION AND DISTRIBUTION	E.12	
<p>a. <i>General Requirements</i> Are lines considered to be energized until they are tested?</p>	E.12.a	
	E.12.a (2)	
	E.12.a (1)	
	E.12.a (5)	
	E.12.a (6)(a)	
	E.12.a (6)	
	E.12.a (8)	
	E.12.a (8)	
	E.12.a (8)	
<p>b. <i>PPE and Tools</i> Do rubberized gloves, insulating blankets, and rubber matting meet ANSI standards?</p>	E.12.b	
	E.12.b (1)	
	E.12.b (1) (b)	



KEY ITEMS CHECK LIST (continued)

Item	Paragraph	Notes
10. SPECIAL SYSTEMS	E.10	
a. <i>Systems, Cables, and Installations over 600 Volts, Nominal</i>	E.10.a	
Are circuit breakers enclosed and clearly marked?	E.10.a (1)	
Is there an equipment isolating means or warning on circuits when inspections or repairs are required?	E.10.a (3) E.10.a (5)	
Are the correct cables and conductors for the machinery in use?	E.10.a	
Are allowed splices molded or otherwise prepared to be as strong and as well insulated as new cable?	E.10.a (10)	
Are the required clearances maintained?	E.10.a (13) E.10.a (14)	
b. <i>Installations inside Tunnels</i>	E.10.b	
Are proper electrical safety procedures followed during the installation of mobile shovels, trailers, cars, draglines, hoists, drills, dredges, compressors, pumps, conveyors, and underground excavators?	E.10.b (1)	
c. <i>Communication Systems</i>	E.10.c	
Are the specific requirements for each system followed?	E.10.c	
d. <i>Battery Servicing</i>	E.10.d	
Are battery areas ventilated?	E.10.d (1)	
Are battery caps in place during charging?	E.10.d (9)	
11. GROUNDING	E.11	
a. <i>General Requirements</i>	E.11.a	
Are systems grounded when it is required?	E.11.a	
b. <i>Requirements for Portable and Vehicle-Mounted Generators</i>	E.11.b	
Are noncurrent-carrying metal parts bonded to the frame?	E.11.b (1)	
c. <i>Grounding of Supports, Enclosures, and Equipment</i>	E.11.c	
Are all noncurrent-carrying metal parts grounded?	E.11.c (3)	

KEY ITEMS CHECK LIST (continued)

Item	Paragraph	Notes
6. MOTORS AND PENDANTS	E.6	
Are disconnects within sight of controller location?	E.6.a	
	E.6.e	
Are all disconnects identified according to the equipment or motors they serve?	E.6.c	
	E.6.d	
Are the correct plugs, cords, and pendants used?	E.6.i	
7. TRANSFORMERS	E.7	
Are transformers correctly posted with operating voltage?	E.7.b	
Is access by workers and storage of material in transformer vaults prohibited?	E.7.c	
	E.7.d	
8. SPECIFIC PURPOSE EQUIPMENT AND INSTALLATIONS	E.8	
a. <i>Cranes and Hoists</i>	E.8.a	
Can the required switches be locked open?	E.8.a (1)	
Are the required limit switches installed?	E.8.a (4)	
Are disconnects and switches correctly located?	E.8.a (2)	
	E.8.a (3)	
b. <i>Elevators, Escalators, and Moving Walks</i>	E.8.b	
Are switches and disconnects correctly located?	E.8.b (1)	
	E.8.b (2)	
c. <i>Electric Welding Equipment</i>	E.8.c	
Are the required disconnects and switches provided?	E.8.c (1)	
Is the amperage rating of switches adequate?	E.8.c (2)	
d. <i>X-Ray and Radiographic Equipment</i>	E.8.d	
Are all the required interlocks and disconnects installed?	E.8.d (1)	
	E.8.d (2)	
9. HAZARDOUS LOCATIONS	E.9	
Is the type of wiring appropriate for the hazard?	E.9.a	

KEY ITEMS CHECK LIST (continued)

Item	Paragraph	Notes
Where GFCIs are not installed, is an assured grounding program in effect?	E.3.a	
Are splices as strong and as well insulated as new cord?	E.3.g	
Are equipment and cords secured and installed correctly?	E.3.j E.3.k	
Is temporary wiring removed as soon as its purpose is served?	E.3.s	
Are listing and labeling instructions followed?	E.3.u	
Are new installations protected from accumulation of construction dust or fines that could cause fire or an explosion?	E.3.t	
<hr/> <b>4. GENERAL WIRING DESIGN AND PROTECTION</b>		
Are metal raceways, cable armor, and other metal enclosures continuous and connected to boxes, fittings, or cabinets?	E.4	
Are wiring systems protected from damage, dampness, and flammable vapors?	E.4.a E.4.b E.4.c	
Are receptacles and connectors the correct type?	E.4.d	
Are means for disconnecting appliances provided and correctly marked?	E.4.h	
Is the grounded conductor of every cable distinguishable?	E.4.i	
<hr/> <b>5. CABINETS, BOXES, AND SWITCHBOARDS</b>		
Are cabinets and boxes fitted with bushings to prevent conductor damage?	E.5	
Are pull boxes, junction boxes, or fittings covered and grounded?	E.5.a E.5.b	
Are all switches installed according to instructions?	E.5.d E.5.e	

**KEY ITEMS CHECK LIST  
SECTION E. ELECTRICAL SAFETY**

Item	Paragraph	Notes
<b>1. REQUIREMENTS FOR ALL SITE WORKERS</b>	<b>E.1</b>	
Is the worksite surveyed for electrical hazards; are signs posted and workers advised?	E.1.a	
Are workers near electrical circuits? If so, is equipment guarded or power de-energized and grounded?	E.1.b	
Are tools inspected for hazardous defects?	E.1.i	
Are tools grounded or double insulated?	E.1.k	
Are double-insulated tools so labeled?	E.1.k	
Are flexible extension cords the correct size and type?	E.1.n	
Are flexible extension cords protected from damage?	E.1.n(5)	
Are cabinet clearances maintained?	E.1.e	
Is the location of underground electric power known prior to use of jack hammer or bar?	E.1.m	
Are signs posted and observed?	E.1.c	
<b>2. REQUIREMENTS FOR ELECTRICAL WORKERS</b>	<b>E.2</b>	
Are workers trained in electrical safety-related work practices and hazard recognition?	E.2.a	
Are only qualified workers inspecting and using electrical test equipment?	E.2.c E.2.d	
Are lockout/tagout procedures for electric work carried out?	E.2.f	
Are proper space requirements met for work near exposed live parts?	E.2.j	
<b>3. ON-SITE ELECTRICAL SAFETY REQUIREMENTS</b>	<b>E.3</b>	
Are ground-fault circuit interrupters (GFCIs) installed and used?	E.3.a	



**Exposed** — Unprotected from individuals' inadvertent contact or approach; or not suitably guarded, isolated, or insulated.

**Feeder** — Power supplied to service equipment.

**Grounding Conductor** — A conductor used to connect equipment or the grounded circuit of a wiring system to the grounding electrode or electrode.

**Grounded Conductor** — A system or circuit conductor that is intentionally grounded. This conductor is white or gray and will normally have circuit flow.

**Ground (Grounding)** — A conducting path, either intentional or accidental, between an electric circuit or a piece of equipment and the earth or a conducting body that serves in place of the earth.

**Ground Fault Circuit Interrupter (GFCI)** — A sensitive, fast-acting circuit breaker that can sense and interrupt very small ground-fault currents (usually 5 milliamperes [mA] difference between hot and neutral).

**Guarded** — Covered, shielded, enclosed within fences or walls, or otherwise protected.

**Hot Stick** — A long, insulated tool used to hold or attach live power lines.

**Isolated** — Separated or removed; set apart.

**Locations** —

**Damp** — Partially protected areas, under canopies, porch roofs, or other coverings, that are subject to moderate amounts of moisture.

**Dry** — Locations that are not normally subject to dampness or wetness.

**Wet** — Underground areas, surrounded by concrete or masonry or in direct contact with the earth; or locations that are exposed to weather.

**Outlet** — A termination point on the wiring system from which electric power is taken to operate equipment.

**Premises-Wiring System** — Permanent or temporary interior and exterior wiring that extends from the lead end of a service drop to the outlets.

**Qualified Person** — A person who is familiar with the construction and operation of the equipment and who understands the hazards involved.

**Service-Entrance Conductors** — The supply conductors that extend to the service equipment from the street main or from transformers.

**Voltage, Nominal** — A nominal value assigned to a circuit or system for the purpose of conveniently designating its voltage class (for example, 120/240, 480Y/277, or 600).

**Watertight** — Constructed so that moisture cannot enter the enclosure.

**Weatherproof** — Constructed or protected so that exposure to the weather will not interfere with operations; or rainproof and watertight.



## DEFINITIONS

**Acceptable** — Has been accepted, certified, listed, labeled, or otherwise specified as being safe by a nationally recognized testing laboratory, such as Underwriters' Laboratories (UL); or has been inspected or tested by a controlling authority and found to be in compliance with the provisions of the National Electrical Code (NEC)/or other regulatory requirements.

**Accessible** — Can be easily entered or reached; not guarded, locked away, placed at a high elevation, or in any way obstructed.

**Ampacity** — Current-carrying capacity measured in amperes.

**Approved** — Accepted by a controlling authority; or approved for a specific use in accordance with standard or code.

**Attachment Plug** — A fitting that can be inserted into an electric receptacle to establish a connection with the power supply.

**Bonding** — Using low-resistance material to electrically join metallic parts to form a permanent electrical connection or continuity.

**Branch Circuit** — The section of wiring that extends between the final overload protective device and the plug receptacle.

**Certified** — Acceptable (See "Acceptable" above).

**Circuit Breaker** — An automatic switch, which can also be manually opened or closed, that stops the flow of electric current in an overloaded circuit.

**Clearance Authorization** — The portion of an electrical line-stringing plan that includes permission from the power company to string across or near an existing line.

**Conductors** — Wires capable of and intended to conduct electricity.

**Bare** — Uncovered or uninsulated wires.

**Covered** — Wires encased in materials that do not meet the electrical insulation standard.

**Insulated** — Wires encased in materials that meet the electrical insulation standard.

**Open** — A condition or location of circuit wiring, for example, the physical location of wiring or circuit, i.e., wiring run in the open, across poles, etc.

**Disconnect Means** — A device or group of devices that can be used to disconnect circuits from their power source.

**Enclosed** — Surrounded by a case, housing, fence, wall, or other device that prevents individuals from accidentally contacting energized parts and that protects equipment from damage.

**Explosion-Proof Enclosure** — An equipment-enclosing case that can withstand an internal explosion of a specified gas or vapor without propagating the explosion to the environment outside the enclosure.



(b) No worker shall enter an unsupported auger-type excavation made in unstable material for any purpose. Cleanout shall be done without workers entering.

29 CFR 1926.957(h)(2)

1. Lineman's Body Belts

(1) Lineman's belts, safety straps, and lanyards shall meet the requirements of the American Society of Testing Materials (ASTM) Standard B117-64. See Section A.9. of this guide for more details.

29 CFR 1926.951(b)(4)(i); 959(a)(1)

(2) PPE (body belts with straps and lanyards) shall be worn by those working at elevated locations, except in operations in which use of these items may create a greater hazard; then other safeguards shall be used.

29 CFR 1926.951(b)(1)

(3) Before each use, body belts and straps shall be inspected for a deformed buckle; cracked or broken "D" ring; failure of the snap hook; parted, torn, or cracked fabric or leather; and other damaged items. Specific inspection requirements can be found in the CFR noted below.

29 CFR 1926.951(b)(3), 959(a)(2-4), (b)(1)(i-ii)



(4) Safety lines are not intended for shock-loading; they are used to lower workers during an emergency rescue. Defective lines shall be replaced.

29 CFR 1926.951(b)(4,5)

(5) The cushion support of a body belt shall contain no exposed rivets on the inside.

29 CFR 1926.959(b)(2)(i)



## (3) Requirements for Trenching and Excavating

(a) Trenching and excavating requirements are outlined in Section C of this guide to include directing of mobile equipment next to excavations.

29 CFR 1926.956(c)(2)



(b) To prevent worker exposure to underground hazards during excavating or trenching operations, efforts shall be made to locate dangerous underground facilities and to prevent their damage.

29 CFR 1926.956(c)(1)

(c) When any underground facilities are exposed (electric, gas, water, telephone, and others), the facilities shall be protected as necessary to avoid damage.

29 CFR 1926.956(c)(3)

(d) When multiple cables are found in an excavation, all cables not being worked shall be protected.

29 CFR 1926.956(c)(4)

(e) When multiple cables are found in an excavation, the cable to be worked on shall be identified electrically, unless it has a distinctive appearance.

29 CFR 1926.956(c)(5)

(f) When working on buried cable or cable in manholes, metallic sheath continuity of a cable shall be maintained by bonding across the sheath opening or by equivalent means.

29 CFR 1026.956(c)(7)

## k. Construction in Energized Substations

## (1) General Requirements

(a) Only an authorized person may approve the start of construction in an energized substation.

29 CFR 1926.957(a)(1)



(b) Before construction begins, energized facilities shall be identified, and appropriate PPE shall be selected. The precautions necessary for worker safety shall also be determined.

29 CFR 1926.957(a)(2)(i,ii)

(c) Extraordinary caution shall be exercised when busbars and steel for towers and equipment are handled in the vicinity of the energized facilities. Specific guidance on appropriate precautionary measures is provided in Section E.12.a(4-5) "Power Transmission and Distribution" of this guide.

29 CFR 1926.957(a)(3)

(d) When it is necessary to de-energize equipment or lines for protection of workers, refer to the guidelines outlined in Section E.12.a.(6-8) "Power Transmission and Distribution," of this guide.

(e) Barricades and barriers shall be installed to prevent accidental worker contact with energized lines and equipment. Signs indicating the hazard shall be posted near the barricade or barrier.

29 CFR 1926.957(c)(1,2)

(f) Work on or near energized control panels shall be performed only by designated, qualified workers.

29 CFR 1926.957(d)(1)



(g) Precautions shall be taken to prevent jarring, vibration, or improper wiring from causing accidental operation of relays or other protective devices.

29 CFR 1926.957(d)(2)

## (2) Using Mechanical Equipment

(a) Use of vehicles, gin poles, cranes, and other equipment in restricted or hazardous areas shall be controlled by designated workers at all times.

29 CFR 1926.957(e)(1)



(b) All mobile cranes and derricks shall be effectively grounded when being moved or operated in close proximity to energized lines or equipment, or the equipment shall be considered energized.

29 CFR 1926.957(e)(2)

## (3) Substation Fences

(a) When a substation fence must be expanded or removed for construction purposes, a temporary fence affording similar protection (at least 8 feet in height) shall be provided when the site is unattended. Adequate interconnection with ground shall be maintained between the temporary fence and the permanent fence.

29 CFR 1926.957(g)(1)

(b) All gates to unattended substations shall be locked.

29 CFR 1926.957(g)(2)

## (4) Excavating Footings

(a) Excavation for auger-, pad- and piling-type footings for structures and towers shall require the same precautions as metal tower construction. See Section E.12.f.(9) "Power Transmission and Distribution. Overhead Lines." of this guide.

29 CFR 1926.957(h)(1)





(8) Arm current tests shall be made before starting work each day and any time a new higher voltage is to be worked. See the below noted CFR for test requirements.

29 CFR 1926.955(e)(11)

(9) Aerial lifts shall have upper and lower controls; lower controls shall have override capabilities. Bucket controls shall be within easy reach of workers; lower controls shall be located near the base of the boom. Controls shall be overriding, and the lower control shall not be used without approval of the worker in the bucket except in the event of an emergency.

29 CFR 1926.955(e)(12,13)

(10) The minimum clearance distances for live-line, bare-hand work are specified in Table E-7. These distances shall be maintained from all grounded objects; from lines and equipment, including the grounded frame of the lift truck; and from lines of a different potential to those bonded to the insulated aerial device, unless these objects are covered by insulated guards. The clearance distances shall be maintained when live circuits are approached, or left, or when bonded to live circuits.

29 CFR 1926.955(e)(15)

Table E-7. Minimum Clearance Distances for Live-Line Bare-Hand Work (Alternating Current)

Voltage Range (Phase-to-Phase) Kilovolts (kV)	Distance in Feet and Inches for Maximum Voltage	
	Phase to Ground	Phase to Phase
2.1 to 15	2' 0"	2' 0"
15.1 to 35	2' 4"	2' 4"
35.1 to 46	2' 6"	2' 6"
46.1 to 72.5	3' 0"	3' 0"
72.6 to 121	3' 4"	4' 6"
138 to 145	3' 6"	5' 0"
161 to 169	3' 8"	5' 6"
230 to 242	5' 0"	8' 4"
345 to 362*	7' 0"*	13' 4"*
500 to 552*	11' 0"*	20' 0"*
700 to 765*	15' 0"*	31' 0"*

\*For noted kVs, the minimum clearance distance may be reduced, provided the distances are not made less than the shortest distance between the energized part and a grounded surface.

(11) Before workers contact the energized parts to be worked, the conductive bucket liner shall be bonded to the energized conductor and remain so until work is completed.

29 CFR 1926.955(e)(14)

(12) The minimum clearances as stated in Table E-7 shall be printed on durable, nonconductive material and posted inside the bucket where it may easily be seen by workers inside the bucket.

29 CFR 1926.955(e)(20)(i)

j. Underground Lines

(1) Requirements for Guarding and Ventilation

(a) Warnings signs shall be posted when the cover of a manhole, handhole, or vault is removed; the type of warning sign will depend on the location and hazard involved.

29 CFR 1926.956(a)(1)

(b) A street opening or vault shall be protected by barriers, temporary covers, or other suitable guards before workers enter.

29 CFR 1926.956(a)(2)

(c) Workers shall not be permitted to enter manholes or unvented vaults until forced ventilation is provided and the atmosphere is tested for oxygen deficiency and presence of explosive gases or fumes and found safe. When unsafe conditions are found, the work area shall be ventilated, retested, and made safe before entry; and provisions shall be made for adequate exchange of air.

29 CFR 1926.956(a)(3)(i-iii)

(2) Requirements for Work in Holes

(a) When workers are in a manhole, a safety watch shall be in the immediate vicinity to render emergency assistance; safety watch may occasionally enter the manhole to give other than emergency assistance. Although not recommended, the CFR does allow specific exemptions to this requirement. For information of specific exemptions, see the below noted CFR.

29 CFR 1926.956(b)(1)



(b) When open flames must be used in manholes, extra precautions shall be taken to provide adequate ventilation.

29 CFR 1926.956(b)(2)

(c) Before open flames are used in a manhole or excavation in which combustible gases or liquids may be present (for example, in areas near gasoline stations), the atmosphere shall be tested and found safe or cleared of combustible gases or liquids. Adequate ventilation must be provided during use of open flame work.

29 CFR 1926.956(b)(3)



## h. Stringing Next to Energized Lines

(1) Before stringing parallel to an existing live line, it shall be determined if dangerous induced-voltage build-ups will occur, especially during switching and ground-fault conditions. When there is a possibility of dangerous induced voltages, the requirements in this section shall be followed unless the lines are worked as energized.

29 CFR 1926.955(d)(1) **T**

(2) All pulling and tension equipment shall be isolated, insulated, or effectively grounded. A ground shall be installed between the tensioning reel and the first structure in order to ground each bare conductor, subconductor, or overhead ground during stringing operations.

29 CFR 1926.955(d)(3,4)

(3) During stringing operations, each of the conductors in paragraph (2) above shall be grounded at the first tower adjacent to both the tension and pulling setup and in increments so that no point is more than 2 miles from the ground. Grounds shall be left in place until work is completed, removed as a last phase of aerial cleanup, or removed with a hot stick. Such conductors shall be grounded at all dead-end or catch-off points.

29 CFR 1926.955(d)(5)(i-iii), (6)

(4) A ground shall be located on each side and within 10 feet from the working area where conductors, subconductors, or overhead ground conductors are being spliced. The two ends of the conductors to be spliced together shall be bonded together. It is recommended that splicing be carried out on an insulated platform or metallic grounding mat that is bonded to both grounds.

29 CFR 1926.955(d)(7)

(5) All conductors, subconductors, and ground conductors shall be bonded to the tower at any isolated tower when necessary to complete work on the transmission line. When deadend towers are worked, all de-energized lines shall be grounded.

29 CFR 1926.955(d)(8)(i-ii)

(6) When performing work from structures, all workers on conductors shall be protected by individual grounds at every work location.

29 CFR 1926.955(d)(9)

## i. Live-Line, Bare-hand Work

(1) Workers shall be instructed and trained in live-line, bare-hand techniques and safety requirements before beginning such work.

29 CFR 1926.955(e)(1) **T**

(2) Handlines shall not be used between buckets, booms, or ground, and there shall be no conductive objects over 36 inches long in a bucket (except for appropriate length jumpers, armor rods, and tools).

29 CFR 1926.955(e)(18)(i,ii)

(3) Workers shall know the voltage rating of the circuit, clearances to ground and other energized parts, and the voltage limitations of the aerial-lift equipment before they begin live-line, bare-hand work.

29 CFR 1926.955(e)(2)(i-iii)

(4) Only equipment and tools designed, tested, and intended for live-line, bare-hand work shall be used. Tools and equipment shall be maintained clean and dry. All work shall be personally supervised by a trained and qualified worker in live-line, bare-hand work.

29 CFR 1926.955(e)(3,4,8) **T**

(5) When practical, the automatic reclosing feature of an interrupting device shall be made inoperative before working on any energized line or equipment.

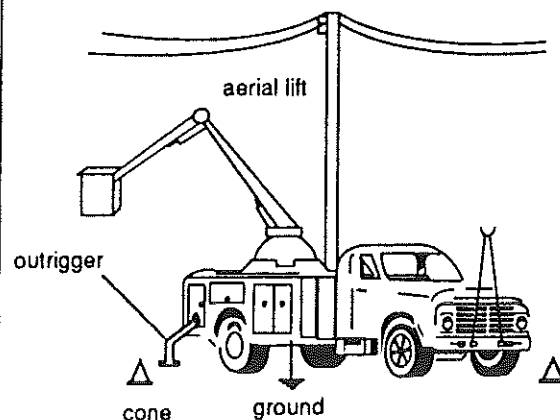
29 CFR 1926.955(e)(5)

(6) A conductive bucket liner or other conductive device shall be used for bonding the insulated aerial device to the live line or equipment. Workers shall be connected to the bucket liner with conductive shoes, leg clips, or other equivalent means. When necessary for electrostatic protections, appropriate electrostatic shielding or conductive clothing shall be provided.

29 CFR 1926.955(e)(7)(i,ii)

(7) Before the boom is elevated, the outriggers on the aerial truck shall be extended and adjusted to stabilize the truck, and the body of the truck shall be bonded to an effective ground or barricaded and considered as energized equipment. The controls of the aerial lift shall be inspected and tested (ground level and bucket) before it is moved into the work position.

29 CFR 1926.955(e)(9,10)



Aerial Lift Truck

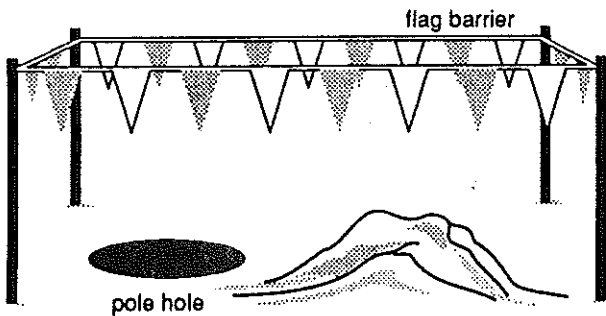


(5) Equipment and machinery operating adjacent to energized lines or equipment shall comply, as applicable, with paragraph 12.c.(3) (a,b) of this guide and Table E-6. 29 CFR 1926.955(a)(5)(ii)

(6) Unless suitable protective equipment for the voltage involved is used, workers standing on the ground shall avoid touching equipment or machinery that is adjacent to energized lines or equipment. 29 CFR 1926.955(a)(6)(i)

(7) Equipment for lifting shall be bonded to an effective ground or shall be considered energized and barricaded when used near energized equipment or lines. 29 CFR 1926.955(a)(6)(ii)

(8) Pole holes shall not be left unattended or unguarded in areas where employees are currently working. 29 CFR 1926.955(a)(7)



(9) When excavating or augering in unstable material, pad- or pile-type footings more than 5 feet deep shall be sloped to the angle of repose or shored if worker entry is required. Ladders shall be provided when footings in excavations are more than 4 feet deep. See Section C, "Excavations," of this guide. 29 CFR 1926.955(b)(1,2)

(10) When towers are erected near energized lines, the lines shall be de-energized or appropriate clearances listed in Table E-6 shall be maintained. During lifts, a spotter shall determine the required clearances. 29 CFR 1926.955(b)(5)(iii)

(11) Traffic shall be controlled in accordance with Sections G, "Signs, Signals, and Barricades," and N, "Demolition," of this guide. 29 CFR 1926.955(b)(7)

(12) No one shall be permitted to remain in a footing while equipment is being spotted or moved for placement. 29 CFR 1926.955(b)(3)(ii)

g. Stringing or Removing De-Energized Conductors

(1) Before stringing operations begin, all workers shall receive prephase training to include review of work assignments, equipment required, and precautions to be taken for the operation. 29 CFR 1926.955(c)(2) **T**

(2) When there is a possibility of a conductor accidentally contacting an energized circuit, the conductor being installed or removed shall be grounded; or workers shall be insulated or isolated. 29 CFR 1926.955(c)(3)

(3) If the existing line is de-energized, proper clearance authorization shall be secured and the line shall be grounded on both sides of the crossover; or the strung line shall be considered and worked as if it were energized. 29 CFR 1926.955(c)(4)(i)

(4) When crossing over energized conductors of more than 600 volts, rope nets or guard structures shall be installed unless provisions are made to insulate or isolate the live conductor or worker. Where practical, the automatic reclosing feature of the circuit-interrupting device shall be made inoperative. In addition, the line being strung shall be grounded either side of the crossover or worked as energized. 29 CFR 1926.955(c)(4)(ii)

(5) Conductors being strung or removed shall be controlled with tension reels, guard structures, tielines, or other equivalent means to prevent contact with energized lines. 29 CFR 1926.955(c)(5)

(6) Conductor grips shall not be used on wire rope, unless the conductor grips are designed for this application. 29 CFR 1926.955(c)(8)

(7) Clipping crews shall have a minimum of two structures clipped in between the crew and the conductor being sagged. When working on bare conductors, crews shall work between grounds at all times; and grounds shall remain intact until work is completed. 29 CFR 1926.955(c)(10)

(8) Reliable communications between the reel tender and the pulling-rig operator shall be provided. 29 CFR 1926.955(c)(12)(ii)

(9) Each pull shall be snubbed or dead-ended at both ends before subsequent pulls. 29 CFR 1926.955(c)(12)(iii)



(4) De-energized conductors or equipment to be grounded shall be voltage-tested; the results of the test shall determine the subsequent procedures, as noted in paragraphs 12.a.(3) and 12.a.(7) of this section.

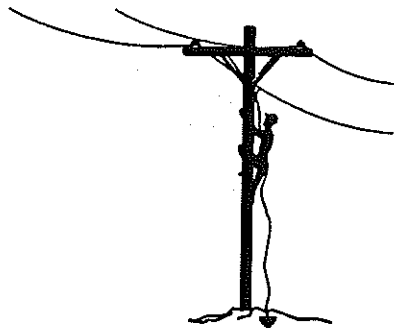
29 CFR 1926.954(d)

(5) When grounds are attached, the grounded end shall be attached first, and the other end shall be attached and removed with insulated tools or other suitable devices. When removing, remove the equipment end of the ground first, using insulated tools.

29 CFR 1926.954(e)

(6) Requirements for placement of grounds are as follows:

(a) Grounds shall be placed at the work locations or between the work location and all sources of energy and as close as practicable to the work location.



grounding line

(b) If work is to be performed at more than one location in a line section, the line section must be grounded and short circuited at one location, and the conductor to be worked shall be grounded at each work location.

(c) The minimum distances in Table E-6 shall be maintained from ungrounded conductors at the work location.

(d) When making a ground is impracticable or the conditions resulting therefrom would be more hazardous than working on the line or equipment without grounding, the grounds may be omitted and the line or equipment worked as energized.

29 CFR 1926.954(f)

(7) Grounds may be temporarily removed only when necessary for testing purposes, and extreme caution shall be exercised during testing procedures.

29 CFR 1926.954(g)

(8) When grounding electrodes are used, they shall have a resistance to ground low enough (25 ohms maximum is generally accepted resistance) so that workers will not be harmed or to permit prompt operation of protective devices.

29 CFR 1926.954(h)

(9) Grounding to towers shall be made with a tower clamp capable of conducting the anticipated fault current.

29 CFR 1926.954(i)

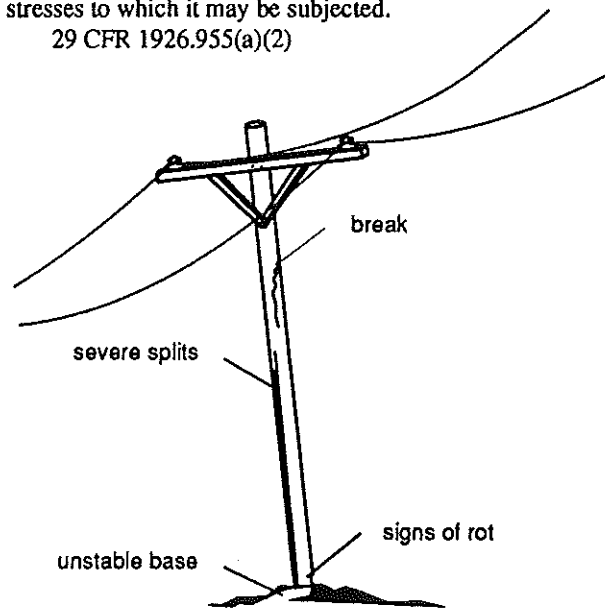
(10) A ground lead, which will be attached to either a tower ground or driven ground, shall be capable of conducting the anticipated fault current and shall have a minimum conductance of No. 2 AWG copper.

29 CFR 1926.954(j)

#### f. Overhead Lines

(1) Before workers climb poles, ladders, or other elevated structures, the structure shall be inspected to determine if it is capable of sustaining the additional or unbalanced stresses to which it may be subjected.

29 CFR 1926.955(a)(2)



Safety Inspection of Poles

(2) Poles or structures that are considered unsafe for climbing shall not be climbed until they are guyed, braced, or made safe in an equivalent way.

29 CFR 1926.955(a)(3)

(3) Before wire or cable is installed or removed, strains to which poles and structures will be subjected shall be considered, and action shall be taken to prevent failure of such supporting structures.

29 CFR 1926.955(a)(4)

(4) When poles are set, moved, or removed using hoists or other mechanical equipment near energized lines or equipment, precautions shall be taken to avoid contact with energized lines or equipment. This is not necessary in bare-hand live-line work or when barriers or protective devices are used.

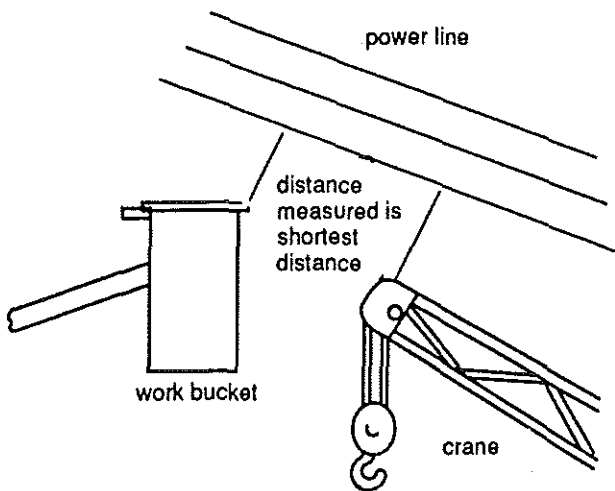
29 CFR 1926.955(a)(5)(i)



(3) Line clearance from cranes, derricks, and other lifting and mechanical equipment are as follows:

- (a) Equipment or materials that are being operated or handled near power lines shall maintain a clearance between lines. Any part of the crane or load shall be
- 10 feet for lines rated 50 kV or less;
  - 10 feet plus 0.4 inches for each 1 kV over 50 kV for lines rated 50 kV or more; except,
  - where electrical distribution or transmission lines have been de-energized and visibly grounded at the point of work; or
  - where insulating barriers (not part of an attachment to the equipment or machinery) have been erected to prevent physical contact with the lines.
- 29 CFR 1926.550(a)(15)(i-ii)

- (b) With the exception of equipment certified for work on the proper voltage, mechanical equipment used in electrical distribution and transmission line work shall not be operated closer to any energized lines or equipment than the clearances set forth in Table E-6, unless
- an insulated barrier is installed between the energized part and the mechanical equipment,
  - the mechanical equipment is grounded,
  - the mechanical equipment is insulated, or
  - the mechanical equipment is considered as energized.
- 29 CFR 1926.952(c)(2)(i-iv)



Power Line Clearances

- (4) Equipment or material shall not be passed between the aerial-lift basket and utility poles or structures or on aerial lifts while a worker in the basket is within reaching distance of energized conductors or equipment that is not covered with insulation protective equipment.
- 29 CFR 1926.952(b)(3)

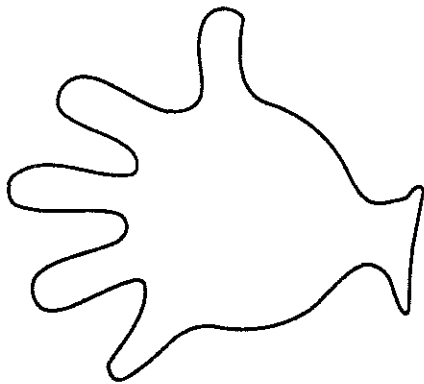
d. Material Handling

- (1) Before unloading steel poles, cross arms, or similar materials, the load shall be inspected to determine if it has shifted or become otherwise dangerous to workers.
- CFR 1926.953(a)
- (2) When poles are transported, all loads shall be secured well, and a red flag shall be attached to the end of the longest pole. Precautions shall be taken to prevent blocking roadways or endangering other traffic.
- CFR 1926.953(b)(1,2)
- (3) Materials shall not be stored under energized buses or conductors or near energized equipment, if it is practical to store the material elsewhere.
- 29 CFR 1926.953(c)(1)
- (4) When material or equipment is stored under energized lines or equipment, appropriate clearances, as found in Table E-6, shall be maintained. Extraordinary caution shall be taken when moving materials near any energized sources.
- 29 CFR 1926.953(c)(2)
- (5) Tag lines or other suitable devices shall be used when material is hoisted and when workers may be endangered. Tag lines or other devices shall be nonconductive when used near energized sources or lines.
- 29 CFR 1926.953(d);.955(a)(8)

- (6) During framing operations, employees shall not work under a pole or a structure that is suspended by a crane or by other hoisting equipment unless the pole or structure is adequately supported.
- 29 CFR 1926.953(f)

e. Grounding for Employee Protection

- (1) All conductors and equipment shall be treated as energized until tested or otherwise determined to be de-energized or until grounded.
- 29 CFR 1926.954(a)
- (2) New lines or equipment may be considered de-energized when the lines or equipment are grounded or the hazard of induced voltage is not present and adequate clearances or other means are implemented to prevent contact between energized lines or equipment and the new lines or equipment.
- 29 CFR 1926.954(b)(1-2)
- (3) Bare-wire communications conductors on power poles or structures shall be treated as energized lines unless protected by insulating materials.
- 29 CFR 1926.954(c)



**Air-Leak Test of Lineman's Rubber Glove**

(c) Protective helmets (hard hats) shall meet the provisions of ANSI Z.89.2-1971 "Head Protection." See Section A.2 of this guide for more information.  
29 CFR 1926.951(a)(2)

**(2) Tools**

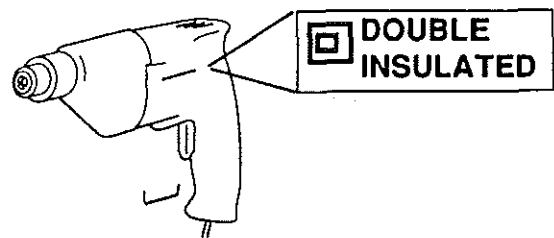
(a) Metal or conductive ladders shall not be used near energized electric lines or equipment except under special conditions, such as in high-voltage substations where nonconductive ladders might present a greater hazard than conductive ladders. Metal or conductive ladders shall be marked "CONDUCTIVE," and all necessary precautions shall be taken when they are used.  
29 CFR 1926.951(c)(1)

(b) Tools shall be wiped clean and inspected each day before use. If any hazardous defects are noted, the tool shall be removed from service.  
29 CFR 1926.951(d)(2)

(c) Portable electric hand tools shall either be equipped with a three-wire cord having the ground wire permanently connected to the tool frame and a means for grounding the other end; or shall be double-insulated and permanently labeled "DOUBLE-INSULATED"; or shall be connected

to the power supply by means of an isolating transformer or other isolated power supply.

29 CFR 1926.951(f)(1),(f)(2)(i-iii)



(d) Measuring tapes or ropes that are metal or contain conductive metal strands shall not be used on or near energized parts.

29 CFR 1926.951(e)

(e) Hydraulic tools used on or around energized lines or equipment shall use nonconductive hoses having adequate strength for normal operating pressures.

29 CFR 1926.951(f)(3)

(f) Pneumatic tools used on or around energized lines or equipment shall have nonconducting hoses that are strong enough for normal operating pressures and shall have an accumulator on the compressor to collect moisture.

29 CFR 1926.951(f)(4)(i,ii)

**c. Mechanical Equipment**

(1) All mechanical equipment used on the construction site (including vehicles in Section N of this guide) shall be visually inspected each time it is used.

29 CFR 1926.952(a)(1)

(2) Aerial-lift trucks working near energized lines shall be grounded, barricaded, and considered as energized equipment or shall be insulated from work being performed.

29 CFR 1926.952(b)(2)



(6) When lines and equipment rated higher than 600 volts are de-energized, and the means of disconnect are not visibly open or locked-out, steps shall be taken according to (6)(a-g) below.

29 CFR 1926.950(d)(1)



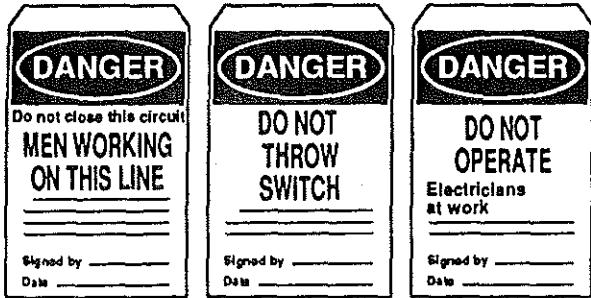
*Note: Although the use of locks to lockout electrical equipment and circuits is not required by 29 CFR 1926, the practice provides a greater degree of protection and is strongly recommended.*

(a) The section of line or equipment to be de-energized shall be clearly identified and isolated from all sources of power.

29 CFR 1926.950(d)(1)(i)

(b) A designated worker shall ensure that all switches and disconnectors for the line or equipment have been de-energized, tagged, and locked out and, when design permits, have been made inoperative.

29 CFR 1926.950(d)(1)(ii)(a-c)



Danger Tags

(c) Lines and equipment shall be visually inspected and tested to ensure that they have been de-energized.

29 CFR 1926.950(d)(1)(iii)

(d) Protective grounds shall be applied to the disconnected lines or equipment.

29 CFR 1926.950(d)(1)(iv)

(e) Guards or barriers shall be erected next to adjacent energized lines as necessary.

29 CFR 1926.950(d)(1)(v)

(f) When more than one independent crew requires the same line or equipment to be de-energized, a designated worker shall place a prominent tag and lock for each crew on the line or equipment.

29 CFR 1926.950(d)(1)(vi)

(g) Upon completion of work on de-energized lines or equipment, a designated worker shall ensure that all workers in the crew are away from the line and the crew's protective grounds are removed. The designated worker shall then report to the designated authority that all tags and locks protecting his or her crew may be removed.

29 CFR 1926.950(d)(1)(vii)

(7) When a crew working on lines or equipment rated over 600 volts can observe that the means of disconnect are visibly open or locked-out, the requirements in paragraphs (6)(c-g) above shall apply.

29 CFR 1926.950(d)(2)



(8) All workers on energized lines shall be proficient in procedures involving emergency situations and first aid fundamentals including resuscitation unless there is a first-aid trainer available on site to render first aid or the worksite is within 3 to 4 minutes of an infirmary, clinic, hospital, or physician.

29 CFR 1926.950(e)(1)(i,ii), (e)(2)

(9) Nighttime operations shall be carried out under spotlights or portable lights.

29 CFR 1926.950(f)

(10) Hydraulic fluids used for the insulated sections of derricks, trucks, aerial lifts, and hydraulic tools used on or around energized lines and equipment shall be an insulating type. (The requirements for fire-resistant fluids do not apply to hydraulic tools covered by this paragraph.)

29 CFR 1926.950(i)

b. PPE and Tools

(1) PPE

(a) Rubber PPE shall meet the provisions of the American National Standard Institute as follows:

- rubber insulating gloves—ANSI/ASTM D 120-1984,
- rubber matting for use around electrical apparatus—ANSI /ASTM D 178-1981,
- rubber insulating blankets—ANSI/ASTM D 1048-1981, and
- rubber insulating line hose—ANSI/ASTM D-1050-1985.

29 CFR 1926.951(a)(1)(i)

(b) Rubber PPE shall be visually inspected before use, and rubber gloves shall be "air tested" before use, and at least annually according to ANSI/ASTM D 120-1984.

29 CFR 1926.951(a)(1)(ii-iii)





12. Power Transmission and Distribution

*This section applies to the construction of new transmission and distribution lines and equipment and to the alteration, conversion, and improvement of existing lines and equipment.*

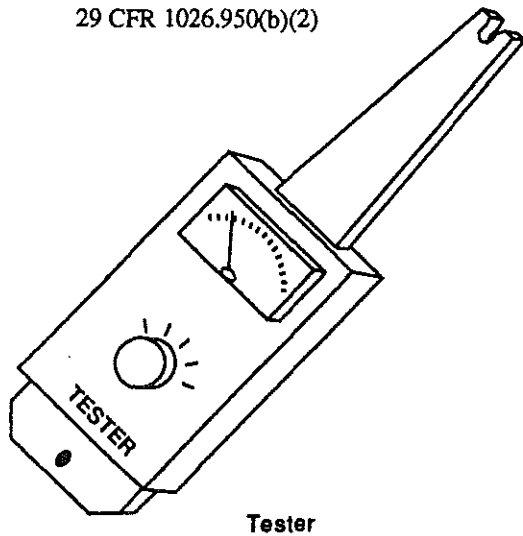
a. General Requirements

(1) Before work begins, energized lines and equipment, including utility poles, circuits, power and communication lines, cable television (CATV) lines, and fire alarm circuits shall be inspected or tested for existing conditions.

29 CFR 1926.950(b)(1)

(2) Electric equipment and lines shall be considered energized until they are tested and found not to be energized.

29 CFR 1026.950(b)(2)



Tester

*Note: Caution should be maintained in making immediate direct contact with live lines when using any type of testing device.*

(3) The operating voltage of lines or equipment shall be determined before workers may work on them or near their energized parts.

29 CFR 1926.950(b)(3)

**?VOLTAGE?**

Always check the voltage!

(4) When workers approach or touch exposed energized parts of a conductive object, they must

- use an approved insulating handle no closer than the minimum distances given in Table E-6; or
- be insulated or guarded from energized parts (gloves or sleeves rated for the voltage may be considered as insulated); or
- have the energized part insulated or guarded from the worker and from any other conductive object at a different potential; or
- have the energized part isolated, insulated, or guarded from any other conductive objectives as it would be during live-line, bare-hand work.

29 CFR 1926.950(c)(1)(i-iii)

(5) Conductor-support tools, such as link sticks, strain carriers, and insulator cradles, may be used, provided that the clear insulation is at least as long as the insulator string or is the minimum distance specified in Table E-6 for the operating voltage.

29 CFR 1926.950(c)(2)(ii)

**Table E-6. Alternating Current—Minimum Distances**

Voltage Range (Phase-to-Phase) Kilovolts(kV)	Minimum Working and Clear Hot-Stick Distance
2.1 to 15	2' 0"
15.1 to 35	2' 4"
35.1 to 46	2' 6"
46.1 to 72.5	3' 0"
72.6 to 121	3' 4"
138 to 145	3' 6"
161 to 169	3' 8"
230 to 242	5' 0"
345 to 362	7' 0" <sup>1</sup>
500 to 552	11' 0" <sup>1</sup>
700 to 765	15' 0" <sup>1</sup>

<sup>1</sup> NOTE: For 345–362 kV, 500–552 kV, and 700–765 kV, the minimum working distance and the minimum clear hot-stick distance may be reduced, provided that such distances are not less than the shortest distance between the energized part and a grounded surface.





## e. Grounding Methods

(1) If noncurrent-carrying metal parts of fixed equipment must be grounded, they shall be grounded by an equipment-grounding conductor contained within the same raceway, cable, or cord; or run with or enclosed in the circuit conductors.

29 CFR 1926.404(f)(8)(i)

(2) A conductor used for grounding fixed or moveable equipment shall have the capacity to safely conduct any fault current imposed on it.

29 CFR 1926.404(f)(8)(ii)

(3) Electrical equipment is considered to be properly grounded when it is secured to and in electrical contact with a metal rack or structure provided for its support. The metal rack or structure shall be grounded using the method specified in paragraph (1) above.

29 CFR 1926.404(f)(8)(iii)

(4) Bonding conductors used to ensure electrical continuity shall have the capacity to conduct any fault current that may be imposed on them.

29 CFR 1926.404(f)(9)

(5) Made electrodes shall be free of nonconductive coatings and, if practicable, shall be embedded below the permanent moisture level. A single electrode that has a resistance to ground greater than 25 ohms shall have an additional electrode installed at least 6 feet from the first electrode.

29 CFR 1926.404(f)(10)

## f. Grounding 1,000-Volt Supply or Greater

**Note:** Systems operating at 1000 volts or higher shall be grounded in accordance with the requirements discussed in paragraphs 11.a.-e. on preceding pages of this guide as supplemented or modified below.

(1) Systems supplying portable or mobile high-voltage equipment, other than substations installed on a temporary basis, shall comply with the following:

(a) Portable or mobile equipment shall be supplied from a system having its neutral grounded through an impedance. If a delta-connected, high-voltage system is used to supply the equipment, a system neutral shall be derived.

29 CFR 1926.404(f)(11)(ii)(A)

(b) Exposed noncurrent-carrying metal parts of portable or mobile equipment shall be connected by an equipment-grounding conductor to the point at which the system-neutral impedance is grounded.

29 CFR 1926.404(f)(11)(ii)(B)

(c) Ground-fault detection and relaying shall be provided to automatically de-energize any high-voltage system component that has developed a ground fault. The continuity of an equipment-grounding conductor shall be continuously monitored so as to automatically de-energize the high-voltage feeder to portable equipment if continuity of the equipment-grounding conductor is lost.

29 CFR 1926.404(f)(11)(ii)(C)

(d) The grounding electrode to which a portable or mobile-equipment-system neutral impedance is connected shall be isolated from and separated in the ground by at least 20 feet from any other system or equipment-grounding electrode. There shall be no direct connection between grounding electrodes, such as buried pipe, fence, or similar objects.

29 CFR 1926.404(f)(11)(ii)(D)

(e) All noncurrent-carrying metal parts of portable or fixed equipment including their associated fences, housings, enclosures, and supporting structures shall be grounded. Equipment that is guarded because of its location and isolated from the ground need not be grounded.

29 CFR 1926.404(f)(11)(iii)



- (7) All grounds shall be permanent and continuous.  
29 CFR 1926.404(f)(6)

**b. Requirements for Portable and Vehicle-Mounted Generators**

- (1) The frame of portable or vehicle-mounted generators need not be grounded if the following conditions are met:

- the generator supplies only equipment powered by and mounted on the generator including cord- and/or plug-connected equipment connected to receptacles mounted on the generator, and
- the noncurrent-carrying parts of equipment and receptacles are bonded to the generator frame.

29 CFR 1926.404(f)(3)(i)(A-B)

- (2) The vehicle frame may serve as the ground for a system supplied by a generator and located on the vehicle, if the generator and vehicle frames are bonded together and meet the conditions of paragraph (1) above.

29 CFR 1926.404(f)(3)(ii)(A-B)

**c. Grounding of Supports, Enclosures, and Equipment**

- (1) All metal cable trays, raceways, and enclosures for conductors shall be grounded, except for the following:

- metal enclosures that protect cables or conductors added to existing installations of open-wire knobs and tubes and
- metal enclosures that protect nonmetallic-sheathed cable with runs of less than 25 feet, in which enclosures are free from probable contact with ground or grounded metal and are guarded against accidental contacts.

29 CFR 1926.404(f)(7)(i)(A-D)

- (2) Metal enclosures around service equipment shall be grounded.

29 CFR 1926.404(f)(7)(ii)

- (3) Exposed noncurrent-carrying metal parts of fixed equipment that may become energized shall be grounded if they are

- subject to worker contact;
- within 8 feet vertically or 5 feet horizontally of ground or grounded objects;
- in damp or wet locations;
- in electrical contact with metal;
- in a hazardous (classified) location; or
- supplied by a metal-clad, metal-sheathed, or grounded-metal raceway.

29 CFR 1926.404(f)(7)(iii)(A-E)

- (4) Equipment operating with any terminal rated at more than 150 volts to ground shall be grounded, except for the following:

- enclosures for switches or circuit breakers used for other than service equipment that are accessible only to qualified workers;
- metal frames of electrically heated appliances that are effectively insulated from ground; and
- distribution apparatus (transformers and capacitors) mounted on wooden poles more than 8 feet above the ground.

29 CFR 1926.404(f)(7)(iii)(F)(1-3)

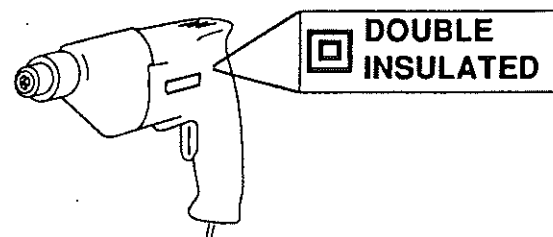
**d. Requirements for Plug- and Cord-Connected Equipment**

- (1) Exposed noncurrent-carrying metal parts of equipment shall be grounded if they are in hazardous (classified) locations or operated at more than 150 volts to ground. The following equipment shall also be grounded: hand-held, motor-operated tools; portable x-ray equipment; and portable hand lamps, tools, or equipment likely to be used in wet locations or by workers standing on the ground, on metal floors, or in metal tanks or boilers.

29 CFR 1926.404(f)(7)(iv)(A-C)

- (2) Tools likely to be used in wet and/or conductive locations need not be grounded if they are supplied through an isolating transformer with an ungrounded secondary of not more than 50 volts. Listed or labeled portable double-insulated tools (or equivalent tools) and appliances need not be grounded. Double-insulated equipment shall be distinctively marked.

29 CFR 1926.404(f)(7)(iv)(C)(6)



- (3) Nonelectrical metal parts of the following shall be grounded:

- frames and tracks of electrically driven cranes;
- frames of nonelectrically driven elevator cars with electric conductors attached;
- hand-operated metal shifting ropes and cables of electric elevators; and
- metal partitions, grill work, and metal enclosures around equipment of more than 1,000 volts between conductors.

29 CFR 1926.404(f)(7)(v)



### 11. Grounding

#### a. General Requirements

(1) AC and DC wiring systems shall be appropriately grounded.

29 CFR 1926.404(f)

(2) AC systems between 50 and 1,000 volts shall be grounded under any of the following conditions, unless exempted under paragraph (3) below:

- if the system can be grounded so that the maximum voltage to ground on the ungrounded conductors does not exceed 150 volts;
- if the system is nominally rated 480Y/277-volt, 3-phase, 4-wire in which the neutral is used as a circuit conductor;
- if the system is nominally rated 240/120-volt, 3-phase, 4-wire in which the midpoint of one phase is used as a circuit conductor; or
- if a service conductor is not insulated.

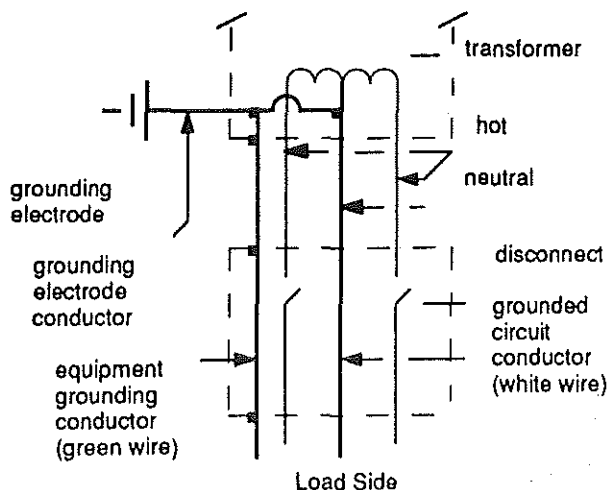
29 CFR 1926.404(f)(1)(iv)(A-D)

(3) AC systems between 50 and 1,000 volts do not require grounding if the system is separately derived, is supplied by a transformer that has a primary voltage rating of less than 1,000 volts, and meets the following requirements:

- The system is used exclusively for control circuits.
- Only qualified workers service the system.
- Continuity of control power to the control circuits is required.
- Ground detectors are installed on the control system.

29 CFR 1926.404(f)(1)(v)(A-D)

(4) For a grounded system, a grounding-electrode conductor shall be used to connect both the equipment-grounding conductor and the grounded-circuit conductor to the grounding electrode. Both the equipment-grounding conductor and the grounding-electrode conductor shall be



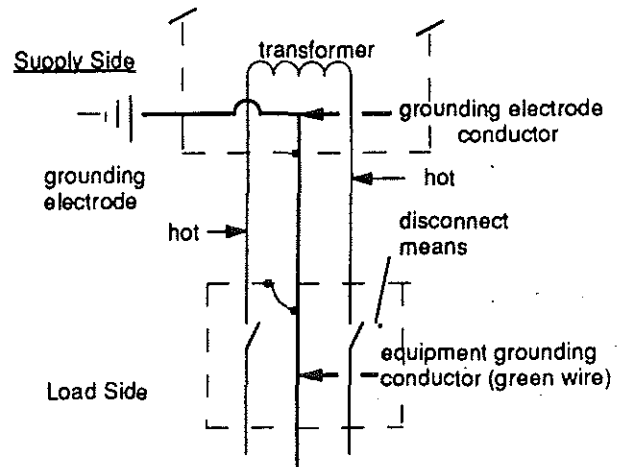
Grounded System - Service Supplied

connected to the grounded-circuit conductor on the supply side of the service disconnect, or on the supply side of the system disconnect or overcurrent device if the system is separately derived.

29 CFR 1926.404(f)(5)(i)

(5) In ungrounded, service-supplied systems, the equipment-grounding conductor shall be connected to the grounding-electrode conductor at the service equipment.

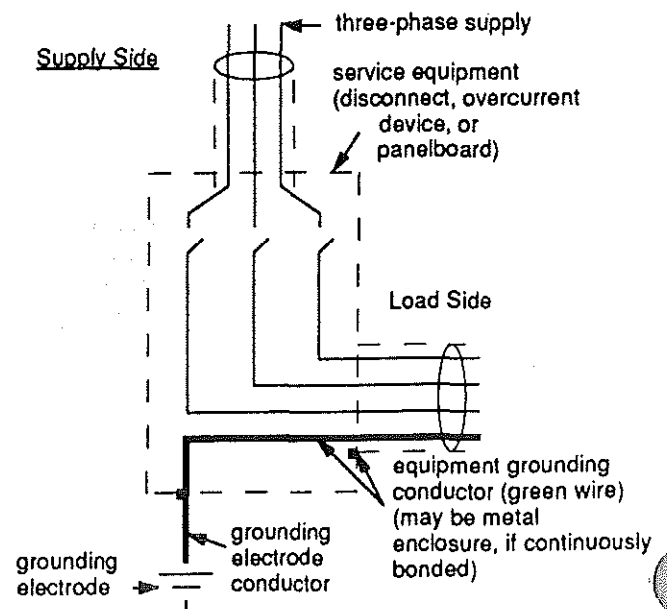
29 CFR 1926.404(f)(5)(ii)



Ungrounded System - Separately Derived

(6) In ungrounded, separately derived systems, the equipment-grounding conductor shall be connected to the grounding-electrode conductor at or ahead of the system disconnecting means or overcurrent devices.

29 CFR 1926.404(f)(5)(ii)



Ungrounded Service - Supplied System



(2) Each communication system has specific wiring and installation requirements. NFPA 70-800 lists requirements for specific types of equipment.

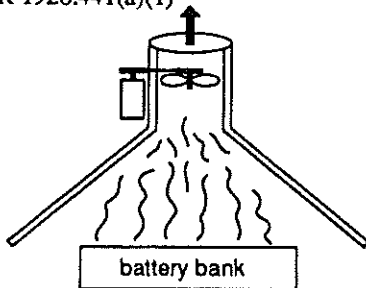
(3) Workers shall be protected from static discharge from outdoor radio transmission antenna lead-in conductors by an antenna discharge unit or other means that will drain static charges from the antenna system. For further information, see NFPA 70-800.

29 CFR 1926.408(c)(2)(ii)

d. Battery Servicing

(1) Unsealed batteries shall be located in enclosures with outside vents or in well-ventilated rooms. Batteries shall be arranged in such a way that fumes, gases, or electrolyte spray do not escape into the work area.

29 CFR 1926.441(a)(1)



Forced Ventilation for Battery Charging

(2) To prevent an explosion, ventilation shall be provided to diffuse the gases and fumes from batteries.

29 CFR 1926.441(a)(2)

(3) Battery racks and trays shall be substantial and treated to resist electrolytes.

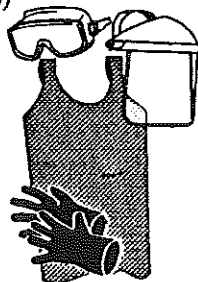
29 CFR 1926.441(a)(3)

(4) Floors shall be constructed of an acid-resistant material or coating unless they are protected from acid build-up.

29 CFR 1926.441(a)(4)

(5) Protective equipment such as aprons, rubber gloves, safety-approved glasses, and/or face shields shall be used by workers handling batteries or acids. See Section A of this guide for more details on personal protective equipment (PPE).

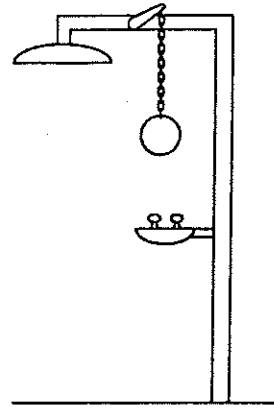
29 CFR 1926.441(a)(5)



Use personal protective equipment (PPE).

(6) Facilities for drenching the eyes and body shall be provided within 25 feet of an area in which batteries are handled or serviced.

29 CFR 1926.441(a)(6)



Eye-Wash/Safety Shower

(7) Facilities and supplies shall be provided for flushing and neutralizing spilled electrolyte and for fire protection.

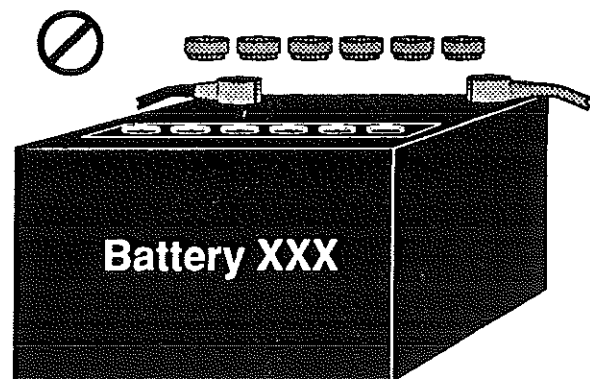
29 CFR 1926.441(a)(7)

(8) Batteries shall be charged in areas designed for this purpose, and the charging apparatus shall be protected from moving vehicles and equipment.

29 CFR 1926.441(b)(1,2)

(9) Battery caps shall be kept in place when batteries are charged; the caps shall be kept in good condition.

29 CFR 1926.441(b)(3)



Do not remove battery caps during charging.



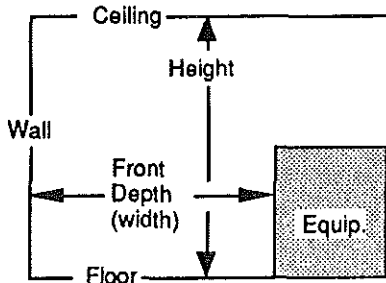
Conductors and equipment used on circuits exceeding 600 volts, nominal, shall be used in accordance with requirements in the following paragraphs. The requirements do not apply to equipment on the supply side of the service conductors.

(12) Electrical installations open to unqualified persons shall be enclosed in metal, vaults, or other enclosure with access limited by a lock; appropriate caution signs shall be posted.

29 CFR 1926.403(j)(2)(ii)

(13) The minimum clear workspace around exposed energized parts shall be at least 6 1/2 feet high and 3 feet wide. For higher voltage work depth (width) requirements, see Table E-2 of this section.

29 CFR 1926.403(j)(3)



Live Equipment Work Clearance

(14) When rear access is required to work on de-energized parts on the back of enclosed equipment, a minimum workspace of 30 inches horizontal shall be provided.

29 CFR 1926.403(j)(3)(i)

(15) Workspaces in which energized parts of electrical equipment may be exposed shall be barricaded or other means provided to ensure that these spaces are not used as passageways.

29 CFR 1926.416(b)(1)

(16) Lighting outlets and controls shall be located so that workers changing lights or repairing the lighting system will not be exposed to live parts or equipment.

29 CFR 1926.403(j)(3)(ii)

(17) Unguarded live parts of more than 600 volts, nominal, above a work surface shall be maintained at heights not less than 8' 6" for 601 to 7,500 volts, 9' 0" for 7,501 to 35,000 volts; 9' 0" plus 0.37 inches per 1,000 volts for more than 35,000 volts.

29 CFR 1926.403(j)(3)(iii)

Capacitors rated more than 600 volts, nominal, shall comply with the following:

(18) To prevent workers from switching load current, isolating or disconnecting switches that have no interrupting rating shall be interlocked with a load-interrupting device; or caution signs shall be prominently displayed.

29 CFR 1926.405(j)(6)(ii)(A)

(19) For series capacitors, at least one of the following shall be used to ensure proper switching: (1) mechanically sequenced isolating and by-pass switches, (2) interlocks, or (3) a switching procedure that is prominently displayed at the switching location.

29 CFR 1926.405(j)(6)(ii)(B)

b. Installations Inside Tunnels

(1) This section refers to installing and using portable and/or mobile, high-voltage power distribution equipment inside tunnels. Such equipment includes substations, trailers, cars, mobile shovels, drag lines, hoists, drills, dredges, compressors, pumps, conveyors, and underground excavators.

29 CFR 1926.408(a)(4)(i)

(2) Conductors inside tunnels shall be installed in metal conduit or raceways or in type MC cables or other suitable multiconductor cables and shall be placed in a safe location or guarded.

29 CFR 1926.408(a)(4)(ii)

(3) Nonenergized metal parts of electrical equipment, metal raceways, and cable sheaths shall be grounded and bonded to all metal pipes and rails at the entrance to the tunnel and at intervals of 1,000 feet or less.

29 CFR 1926.408(a)(4)(v)

(4) Bare terminals in transformers, switches, motor controllers, and other equipment shall be enclosed to prevent accidental worker contact with energized parts. Enclosures that are used in tunnels shall be drip-proof, weatherproof, or submersible, according to the environmental conditions in the tunnel.

29 CFR 1926.408(a)(4)(iii)

(5) There shall be a disconnecting means to simultaneously open all ungrounded conductors at each transformer and motor.

29 CFR 1926.408(a)(4)(iv)

c. Communication Systems

(1) Communication systems include central-station- and noncentral-station-connected telephone circuits, radio receivers and transmitters, outside wiring for fire and burglar alarms, and similar equipment.

29 CFR 1926.408(c)(1)

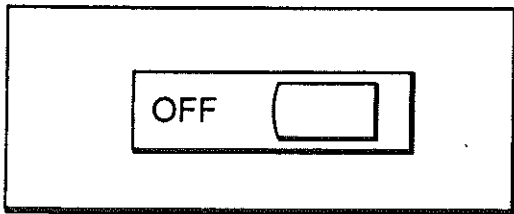


**10. Special Systems**

**a. Systems, Cables, and Installations of More than 600 Volts, Nominal**

(1) Indoor circuit breakers shall be cell-mounted, metal-enclosed, or fire-resistant units. In areas where only qualified personnel are allowed, circuit breakers need not be enclosed. The open and closed positions of circuit breakers shall be clearly marked.

29 CFR 1926.408(a)(2)(i)



**Marked Circuit Breaker**

(2) Fused cutouts installed in buildings or transformer vaults shall be of a type identified by the manufacturer as suitable for this purpose. Fuse cutouts shall be designed to allow fuses to easily be changed.

29 CFR 1926.408(a)(2)(ii)

(3) A means shall be provided to completely isolate equipment for inspection or repair. If the isolating means are not designed to interrupt the load current of the circuit, they shall be interlocked with a circuit interrupter or be posted with a sign warning against opening under load.

29 CFR 1926.408(a)(2)(iii)

(4) Cable connectors that are connected to power cables on a mobile machine shall be enclosed in metal. The enclosure shall include a solid connection for the ground-wire terminal so that the machine frame is safely grounded. The enclosure shall be provided with a lock so that only authorized or qualified personnel may open the enclosure, and a sign warning of energized parts shall be posted.

29 CFR 1926.408(a)(3)(i)

(5) All energized switching and control equipment for mobile and portable equipment shall be enclosed in locked, grounded metal cabinets or enclosures. The means to operate circuit breakers and protective equipment shall project through the cabinets or enclosures so they can be reset without opening the locked doors. Enclosures shall be provided with a lock, so that only authorized or qualified personnel may open the enclosure; and signs shall be posted warning workers of energized parts.

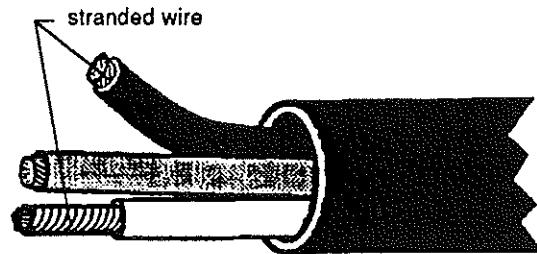
29 CFR 1926.408(a)(3)(ii)

(6) Collector ring assemblies on revolving-type machines, such as shovels and drag lines, shall be guarded.

29 CFR 1926.408(a)(3)(ii)

(7) Multiconductor portable cable used for supplying power to portable or mobile equipment at more than 600 volts, nominal, shall consist of No. 8 or larger flexible, stranded wire.

29 CFR 1926.405(h)



**Multiconductor Portable Cable**

(8) Portable cables operated at more than 2,000 volts shall be shielded so that voltage stress is confined to the insulation.

29 CFR 1926.405(h)

(9) Grounding conductors and locking-type connectors that cannot open or close while energized shall be used for portable cables of more than 600 volts, nominal. Strain relief shall be provided at the connections and terminations of these cables.

29 CFR 1926.405(h)

(10) Portable cables that have been spliced shall not be used unless the splices are permanently molded, vulcanized, or treated in an equivalent way.

29 CFR 1926.405(h)

(11) Termination enclosures for portable cables over 600 volts shall be marked with a high voltage hazard warning, and shall be accessible only to authorized and qualified workers.

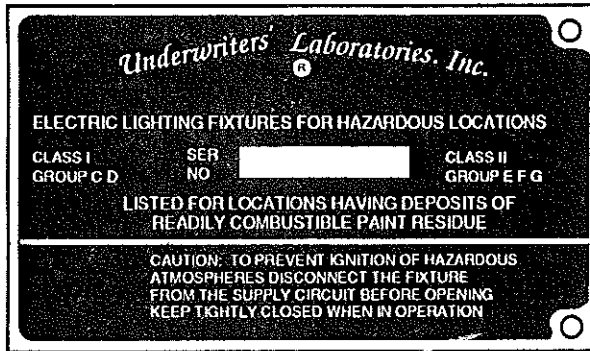
29 CFR 1926.405(h)





### 9. Hazardous Locations

a. Electrical equipment and wiring installed in hazardous locations shall be classified according to the kinds of flammable vapors, liquids, gases, or combustible dust or fibers present. Each room, section, or area shall be classified individually. See Table E-5 for basic hazard locations classifications. For detailed information refer to NFPA 70, Chapter 5, or 29 CFR 1926.449.  
29 CFR 1926.407(a)



Underwriters' Label

b. Equipment and its associated wiring approved as intrinsically safe are permitted in the hazardous (classified) locations included in its listing or labeling.  
29 CFR 1926.407(b)(1)

c. Equipment shall be approved both for class of location and type of ignitable or combustible gas, vapor, dust, or fiber that will be present.  
29 CFR 1926.407(b)(2)(i)

d. Equipment shall not be used in a hazardous location unless it is marked to show the class, group, and operating temperature or temperature range.  
29 CFR 1926.407(b)(2)(ii)

e. All conduits shall be threaded and shall be made wrench-tight. When it is impractical to make a threaded joint tight, a bonding jumper shall be used.  
29 CFR 1926.407(c)

Table E-5. Basic Hazardous Location Classification

Classes	Division 1	Division 2	Groups
I. Flammable gases, vapors, or liquids.	Ignitable concentrations may exist under normal operating conditions or in the event of equipment failure or faulty operations.	Areas adjacent to Class I, Div. 1 areas; areas where flammable liquids or gas are present in closed containers but could be released in an accident, or areas where concentrations are controlled by mechanical ventilation the failure of which could result in ignitable concentrations.	A-Acetylene B-Hydrogen C-Ether, etc. D-Hydrocarbons
II. Combustible, ignitable or conductive dusts.	Ignitable or explosive concentrations may be in suspension under normal operating conditions or in the event equipment failure or faulty operations.	Not normally enough dust suspended to ignite but may infrequently exist in ignitable quantities due to malfunction of handling or processing equipment. Includes areas adjacent to Class II, Div. 1 locations and areas where accumulations of ignitable dust are on equipment or other surfaces.	E-Metal dust* F-Carbon black*, coke* or charcoal* G-Flour, grain, starch, combustible plastic, or chemical dust**
III. Ignitable fibers or flyings.	Areas where handled, used, or manufactured.	Areas where stored or handled (except in process of manufacturing).	Cotton, rayon, hemp, cocoa, other textiles

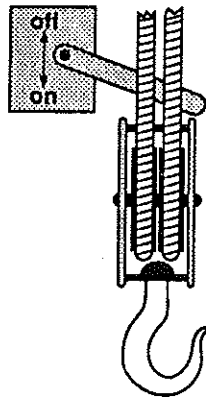
\* Could have conductive qualities and be explosive with mixture and ignition source.  
\*\* Could be explosive with mixture and ignition source.

For further information see definitions in 29 CFR 1926.449 and NFPA Art. 500.



(4) There shall be a limit switch to stop the load block from going higher than what is considered safe for each crane or a hoist.

29 CFR 1926.406(a)(2)



Block Limit Switch

*For additional crane information see Section H.I.i. and j of this guide.*

**b. Elevators, Escalators, and Moving Walks**

(1) There shall be one switch to disconnect all ungrounded main power supply conductors for each elevator, escalator, or moving walk.

29 CFR 1926.406(b)(1)

(2) If control panels are not in the same space as the drive machine, they shall be in cabinets with doors that can be locked closed.

29 CFR 1926.406(b)(2)

**c. Electric Welding Equipment**

(1) The supply circuit shall have a switch that disconnects each arc-welding unit, unless there is a disconnect switch on the unit itself.

29 CFR 1926.406(c)(1)

(2) There shall be a switch or circuit breaker to cut off each resistance welder from the supply circuit. The ampere rating of the switch or circuit breaker shall not be less than the current capacity of the supply conductor.

29 CFR 1926.406(c)(2)

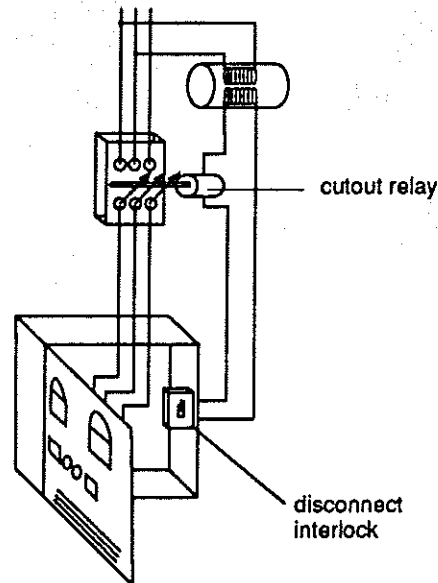
**d. X-ray and Radiographic Equipment**

(1) There shall be a switch accessible from an x-ray control to disconnect the supply circuit.

29 CFR 1926.406(d)(1)(i)

(2) To prevent workers from contacting live current-carrying parts, radiographic and fluoroscopic equipment shall always be enclosed or have interlocks that de-energize the equipment automatically.

29 CFR 1926.406(d)(2)



Radiographic and Fluoroscopic Equipment Interlock

(3) If more than one piece of x-ray equipment is operated from the same high-voltage circuit, each piece of equipment or equipment group shall be provided with a high-voltage switch.

29 CFR 1926.406(d)(1)(ii)





i. The rating of an attachment plug or receptacle used for connecting a motor, by cord or plug, to a branch circuit shall not exceed 15 amperes at 125 volts or 10 amperes at 250 volts, if individual overload protection is not provided.

29 CFR 1926.404(b)(2)(iii)

### 7. Transformers

a. This section covers all transformers except current transformers; dry-type transformers installed as a component part of other apparatus; transformers that are an integral part of an x-ray, high-frequency, or electrostatic-coating apparatus; transformers used with Class 2 and Class 3 circuits; sign and outline lighting; and power-limited fire-protective signaling circuits.

29 CFR 1926.405(j)(5)(i)(A-D)

b. The operating voltage of exposed live parts of transformers shall be indicated by warning signs on the equipment or structure.

29 CFR 1926.405(j)(5)(ii)

c. Transformer vaults shall be constructed so that fire and combustible liquids are contained within the vault and unauthorized access is prevented. Locks and latches shall be installed so that the door can be easily opened from the inside.

29 CFR 1926.405(j)(5)(vi)

d. Material shall not be stored in transformer vaults.

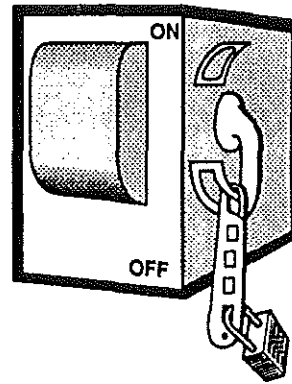
29 CFR 1926.405(j)(5)(viii)

### 8. Specific Purpose Equipment and Installations

a. Cranes and Hoists

(1) There shall be a switch, which can be locked open, to disconnect the power supply of any crane or monorail hoist.

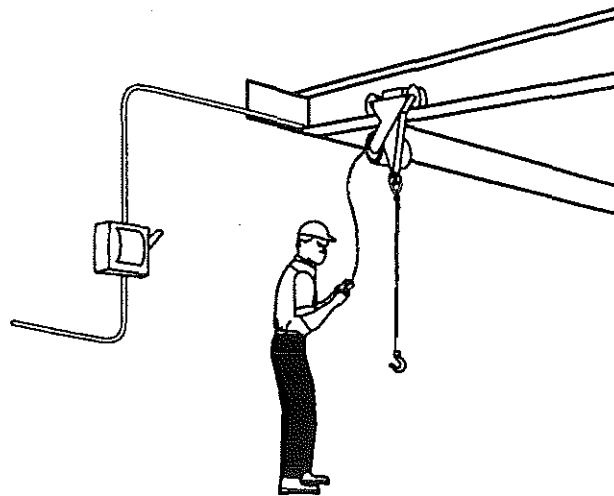
29 CFR 1926.406(a)(1)(i,ii)



Power Supply Switch

(2) The switch to disconnect the runway conductor from its power supply shall be easy to find and operate.

29 CFR 1926.406(a)(1)(i)



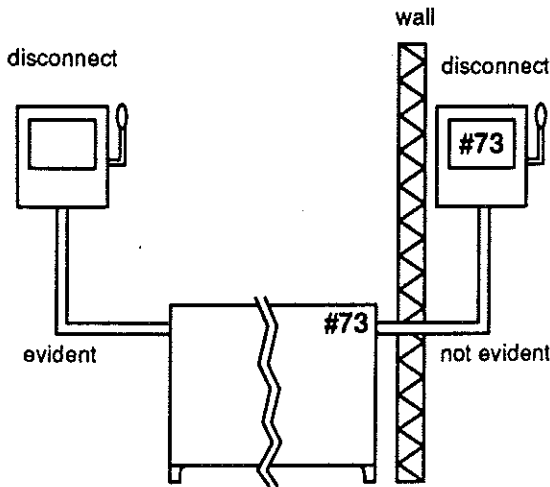
Readily Accessible Disconnect Switch

(3) If the disconnecting switch is not in the crane or monorail operating station, it shall be possible to open the power circuits to all crane or monorail hoist motors from the operating station.

29 CFR 1926.406(a)(1)(ii)(A)

c. Unless the disconnect is located so that the purpose or feed service is evident, each disconnect means shall be legibly marked to indicate its purpose or identify the equipment it feeds.

**NOTE:** To avoid any mistake, it is best to identify all disconnects to equipment.



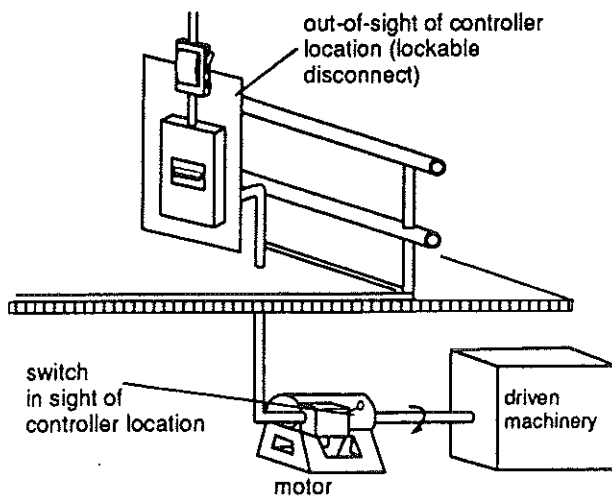
**Equipment Disconnect Evident or Identified**

29 CFR 1910.303(f)

d. If a motor and the machinery it drives are not visible from the controller's location, the installation shall

- be capable of being locked open or
- have a manually operated switch that will disconnect the motor from its supply source in sight of the motor location.

29 CFR 1926.405(j)(4)(ii)(C)(1,2)



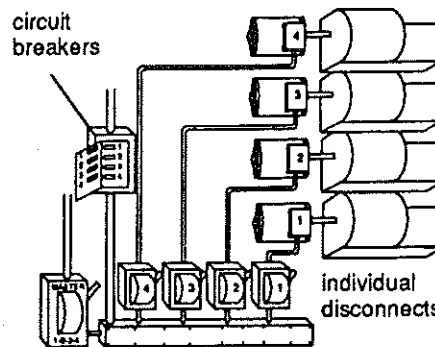
**Out-of-Sight Disconnect to Motor**

e. The means of disconnect shall be readily accessible. If more than one means of disconnect is provided for the same equipment, only one need be readily accessible.

29 CFR 1926.405(j)(4)(ii)(E)

f. Each motor shall be equipped with a means of disconnect; however, a single means of disconnect may be used for a group of motors, if they drive special parts of a single piece of equipment or are protected by one set of branch-circuit protection devices, or if they are in a single room in sight of the disconnect.

29 CFR 1926.405(j)(4)(ii)(F)(1-3)



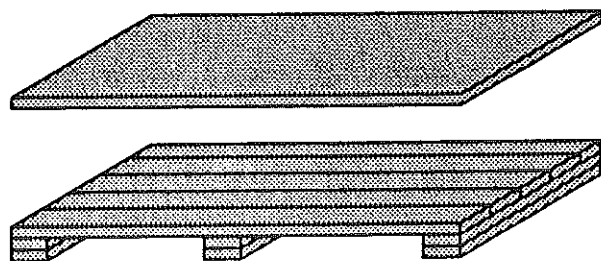
**Various Means of Disconnect**

g. To prevent accidental worker contact, exposed live parts of motors or controllers operating at 50 volts or more between terminals shall be installed in a room or enclosure that is accessible only to qualified persons; on a balcony, gallery, or platform elevated and arranged to exclude unqualified persons; or at an elevation of 8 feet or more above the floor.

29 CFR 1926.405(j)(4)(iv)(A)(1-3)

h. When live parts of motors or controllers operating at more than 150 volts to ground are protected as in paragraph g. above, and where adjustment or attendance may be necessary during the operation of the apparatus, insulating mats or a platform shall be provided so that a worker cannot touch live parts unless he or she is standing on the mats or platform.

29 CFR 1926.405(j)(4)(iv)(B)



**Insulated Mat or Platform**



Table E-4. Service Feeder Clearance, 600 Volts, Nominal, or Less

Activity and Location	Minimum Clearance
Horizontal Clearance for Pole Climbing	
Open power below communications conductors	30 in.
Open power alone or above communications conductors	
300 volts or less	24 in.
More than 300 volts	30 in.
Communications below open power conductors	
300 volts or less	24 in.
More than 300 volts	30 in.
Clearance Between Grounded Surface and Open Conductors	
Above grade sidewalks or platforms	10 ft
Over vehicles traffic	12 ft
Over truck traffic	15 ft
Over public streets, roads, alleys, and driveways	18 ft
Clearance from Buildings in Which Workers are Exposed	
Open conductor from windows, doors, fire escapes, or similar locations	3 ft
Over roofs (highest point of roof)	
Insulated conductor vertical clearance	8 ft
Covered conductor vertical or diagonal	10 ft
Bare conductor	15 ft
Other	
Open conductor - roof with vehicular traffic (vertical)	18 ft
Insulated conductor - roof not normally open to workers	3 ft
Roof slope not less than 4 inches in 12 inches with voltage between conductors	
300 volts or less	3 ft
300 volts or less between conductors that do not pass over more than 4 feet of a roof overhang, terminates in a through-the-roof raceway or support.	18 in.
29 CFR 1926.404(c)(1)(i-iv)	

**6. Motors and Pendants**

a. A disconnecting means shall be located in sight of the controller location. The controller means of disconnect for motor branch circuits of more than 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.

29 CFR 1926.405(j)(4)(ii)(A)

*Note: If specified that one piece of motorized equipment shall be "in sight of" another piece of control equipment, one shall be visible from and not more than 50 feet from the other.*

29 CFR 1926.405(j)(4)(i)

b. The disconnect means shall cut off the motor and controller from all ungrounded supply conductors; it shall be designed so that none of the poles can be operated independently.

29 CFR 1926.405(j)(4)(ii)(B)



c. Covers for outlet boxes with holes through which flexible cord pendants pass shall have specially designed bushings or smooth, well-rounded surfaces on which the cord may rest to avoid insulation damage.

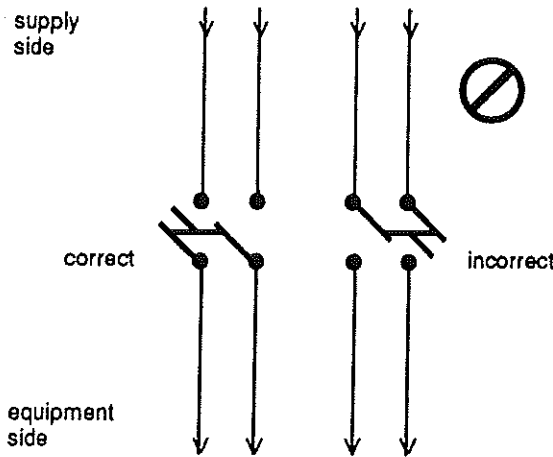
29 CFR 1926.405(b)(2)

d. For systems with more than 600 volts, nominal, pull and junction boxes shall have securely fastened covers and shall completely enclose conductors or cables. The covers shall be permanently marked, "High Voltage."

29 CFR 1926.405(b)(3)(i,ii)

e. Single-throw knife switches shall be connected so that the blades are dead when the switch is in the open position and placed so that gravity will not tend to close them. Single-throw knife switches approved for use in the inverted position shall be provided with a locking device to ensure that the blades remain in the open position when so set.

29 CFR 1926.405(c)



Connect knife switches properly.

f. Double-throw knife switches shall be mounted so that the throw will be either vertical or horizontal. If the throw is vertical, a locking device shall be provided to ensure that the blades remain in the open position when so set.

29 CFR 1926.405(c)

g. Switchboards with exposed live parts shall be installed in permanently dry locations and accessible only to qualified persons. Panel boards shall be mounted in cabinets, cutout boxes, or enclosures designed for the purpose and shall be dead front. Panel boards that are not dead front and are externally operated are permitted where accessible to qualified persons only.

29 CFR 1926.405(d)

h. Cabinets, cutout boxes, fittings, boxes, and panel board enclosures located in damp areas shall be installed so that moisture or water cannot enter or accumulate inside them. In wet locations, the enclosure shall be waterproof.

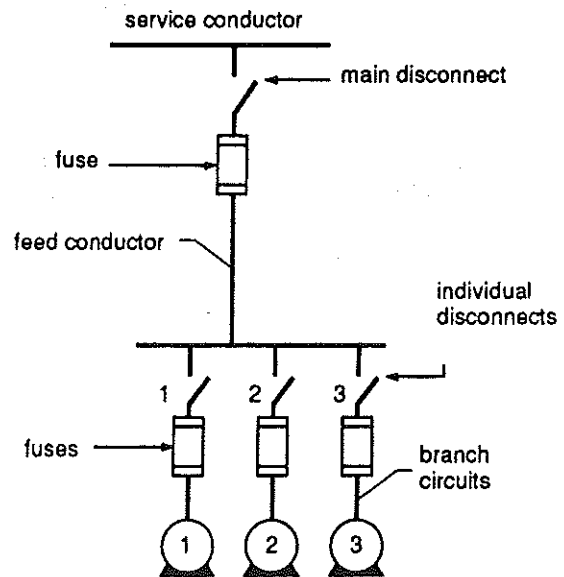
29 CFR 1926.405(e)(1)

i. A means to disconnect all conductors in a building from the service-entrance conductors shall be installed near the point where the service-entrance conductors enter the building.

29 CFR 1926.404(d)(1)(i)

j. Except for current-limiting devices on the supply side of the service disconnect means, all fuses and thermal cutouts on circuits over 150 volts to ground and all cartridge fuses accessible to other than qualified persons shall be provided with a disconnect means. The disconnect 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.

29 CFR 1926.404(e)(1)(iii)



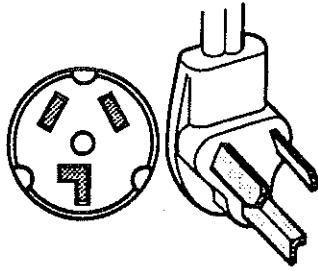
Disconnects for overcurrent devices

k. Open wire service-entrance conductors over 600 volts, nominal, shall be guarded and accessible only to qualified persons. Warning signs shall be posted in areas where unauthorized workers might contact live parts.

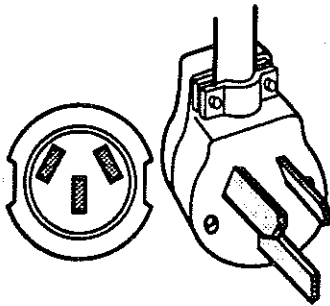
29 CFR 1926.404(d)(2)(i,ii)

l. Outside open conductors run as a branch circuit, feeder, or service conductors operating at 600 volts, nominal, or less shall have clearance requirements specified in Table E-4.

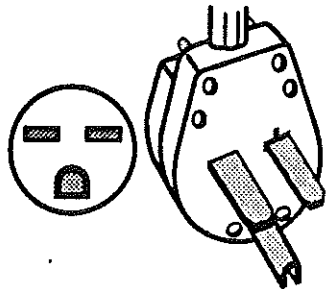
29 CFR 1926.404(c)(1)



Plug and Cord Connectors



120/240-Volt, 50-Ampere Receptacle and Plug



240-Volt, 30-Ampere Receptacle and Plug

e. Control equipment and busways that are approved only for dry locations shall be protected during construction. All electrical equipment and accessories shall be suitable for the environment in which they are to be used.

29 CFR 1926.432(a)(2),(b)

f. Fixture wires shall be suitable for the voltage, temperature, and location of use and may be used for

- installation in lighting, fixtures, and similar equipment where enclosed or protected and not subject to bending or twisting and
- connecting light fixtures to the branch-circuit conductors.

29 CFR 1926.405(i)(1),(2)(i,ii)

g. Fixture wires may not be used as branch-circuit conductors except as permitted for Class 1 power-limited circuits.

29 CFR 1926.405(i)(3)

h. A means shall be provided for disconnecting appliances. Each appliance shall be marked with its rating in volts and amperes or volts and watts.

29 CFR 1926.405(j)(3)(ii)

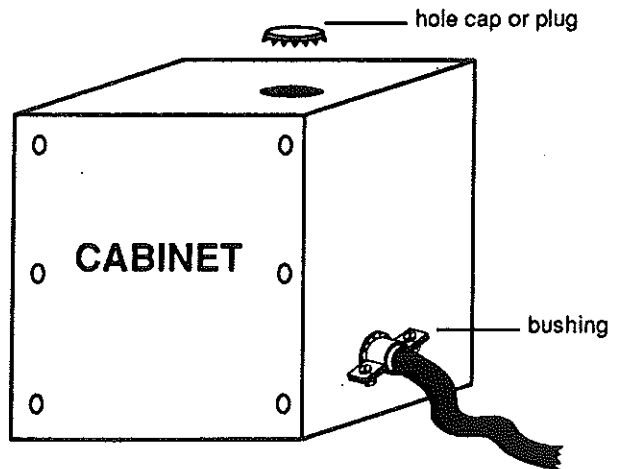
i. The grounding conductor of any cable or cord shall be distinguishable from all other conductors.

29 CFR 1926.405(g)(2)(i)

### 5. Cabinets, Boxes, and Switchboards

a. Conductors that enter boxes, cabinets, or fittings shall be protected from abrasion by bushings or fittings. Unused holes in the boxes shall be closed or plugged.

29 CFR 1926.405(b)(1)



Protected Cords/Covered Holes

b. Pull boxes, junction boxes, cabinets, or fittings shall have covers; if metal covers are used, they shall be grounded. In energized installations, each outlet box shall have a cover, faceplate, or fixture canopy.

29 CFR 1926.405(b)(2)

#### 4. General Wiring Design and Protection

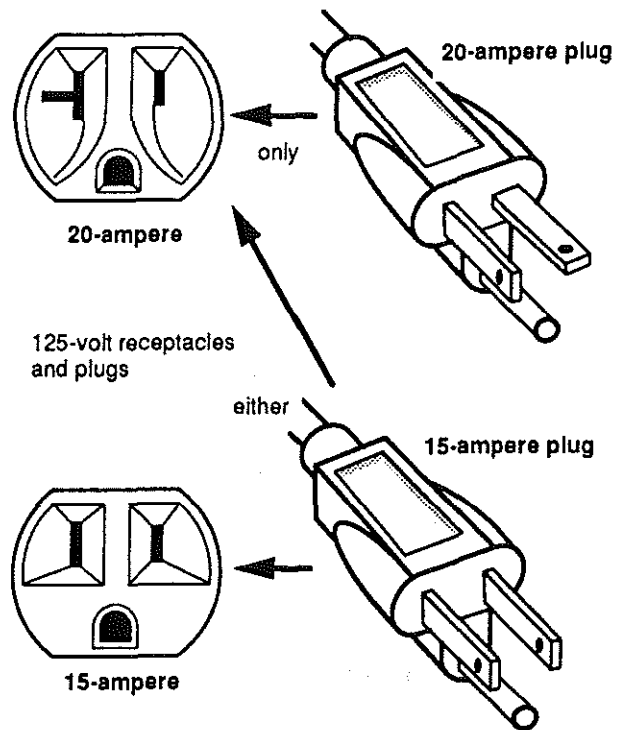
*The requirements in this section do not apply to conductors that are integral parts of factory-assembled equipment such as motors and controllers.*  
 29 CFR 1926.405(a)

a. Metal raceways, cable armor, and other metal enclosures for conductors shall be electrically continuous and shall be connected to all boxes, fittings, and cabinets.  
 29 CFR 1926.405(a)(1)(i)

b. Wiring systems of any type shall not be installed in ducts or shafts used to transport dust, loose stock, or flammable vapors.  
 29 CFR 1926.405(a)(1)(ii)

c. A receptacle installed in a wet or damp location shall be designed for the location.  
 29 CFR 1926.405(j)(2)(ii)

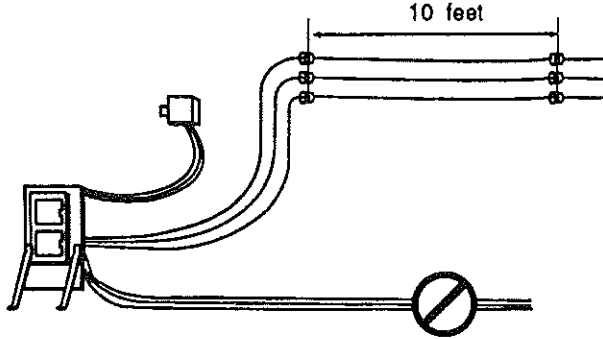
d. Receptacles connected to circuits having different voltages, frequencies, or types of current (DC or AC) on the same premises shall be designed so that the attachment plugs used on the circuits may not be interchanged.  
 29 CFR 1926.405(j)(2)(i)





(2) Branch circuits shall originate in a power outlet or panel board. All conductors shall be protected by overcurrent devices at their ampacity; no branch-circuit conductors shall be laid on the floor.

29 CFR 1926.405(a)(2)(ii)(B)



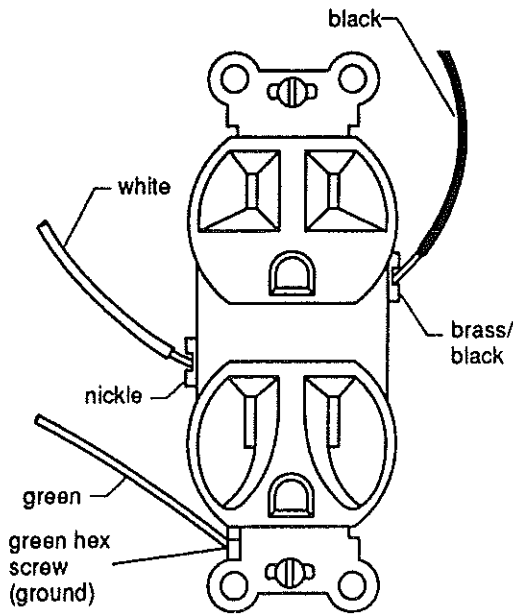
Branch Circuit on Ground

(3) Each branch circuit that supplies receptacles or fixed equipment and is run as an open conductor shall contain a separate equipment grounding conductor.

29 CFR 1926.405(a)(2)(ii)(B)

(4) All receptacles shall be a grounding type. Unless they are installed in a complete metallic conductive raceway providing a continuous path to ground, each branch circuit shall contain a separate equipment grounding conductor, and all receptacles shall be electrically connected to the grounding conductor.

29 CFR 1926.405(a)(2)(ii)(C)



Approved Receptacle

(5) Receptacles used for other than temporary lighting shall not be installed on branch circuits that supply temporary lighting. Receptacles shall not be connected to the same ungrounded conductor of multiwire circuits that supply temporary lighting.

29 CFR 1926.405(a)(2)(ii)(C)

(6) Disconnecting switches or plug connectors shall be installed to permit the ungrounded conductors of each temporary circuit to be disconnected.

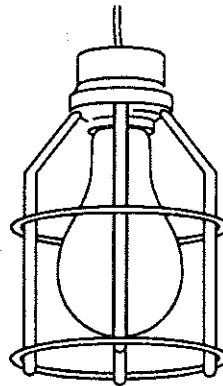
29 CFR 1926.405(a)(2)(ii)(D)

(7) Lamps for general illumination shall be protected from accidental contact or breakage. Metal-cased lamp sockets shall be grounded.

29 CFR 1926.405(a)(2)(ii)(E)

(8) Lampholders installed in wet or damp locations shall be of the waterproof type.

29 CFR 1926.405(j)(1)(iv)



Protected Lamp

(9) Temporary lights shall not be suspended by their electric cords, unless designed for such suspension.

29 CFR 1926.405(a)(2)(ii)(F)

(10) Portable electric lights used in wet and other conductive locations shall be operated at 12 volts or less. If they are protected by ground-fault circuit interrupters, 120-volt lights may be used.

29 CFR 1926.405(a)(2)(ii)(G)

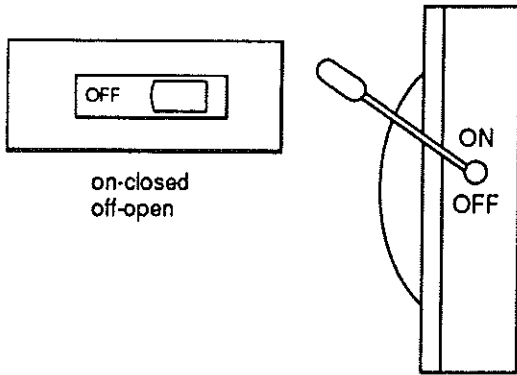
t. Care must be taken to protect electric circuits from construction dust and fines, which could cause electrical explosion when power is switched on.

u. Equipment shall be installed according to listing, labeling, or certification found in instructions.

29 CFR 1926.403(b)(2); NFPA 70-110,3(g)

l. The disconnecting means shall indicate the open (off) or closed (on) position and shall simultaneously disconnect all ungrounded conductors. The "up" position will be the closed (on) position for circuit breaker handles that are operated vertically.

29 CFR 1926.404(e)(1)(vi)(A,B)



Disconnects

m. Circuit protection, including circuit breakers and fuses, shall not be bypassed or replaced with higher rated protective devices that would allow currents in excess of the load rating of the circuit wiring.

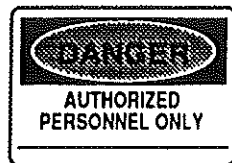
29 CFR 1926.416(c)

n. Overcurrent devices shall be kept readily accessible. They shall be located away from ignitable material and not exposed to damage by chemicals, equipment, or by other operations that can cause physical damage.

29 CFR 1926.404(e)(1)(iv)

o. Any room, vault, or other guarded location containing exposed live parts shall be posted with warning signs forbidding unqualified or unauthorized persons to enter. Installations of more than 600 volts, nominal, shall be kept locked or under the observation of a qualified person at all times.

29 CFR 1926.403(i)(2)(iii); 403(j)(2)



Warning Signs

p. When enclosed live parts are exposed for inspection or service and the workspace is in a passageway or open space, the space shall be guarded, and there shall be at least one unobstructed entrance to the area.

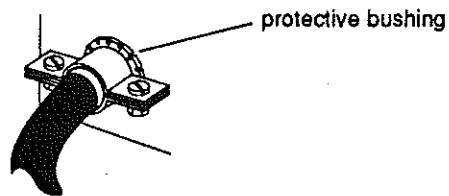
29 CFR 1926.403(i)(1)(ii,iii)

q. Live electrical equipment operating at 50 volts or more shall be guarded from accidental contact. Approved means of such guarding include cabinets or other enclosures; screens or partitions; placing the equipment in a room or vault; or locating the equipment on a balcony, gallery, or elevated platform (8 feet or more) and so arranged as to exclude unauthorized persons.

29 CFR 1926.403(i)(2)(i)(A-D)

r. Flexible cords shall be connected to devices and fittings so that, if strained, they will not pull on joints or terminal screws. Flexible cords shall be protected by bushings if they pass through holes in enclosures.

29 CFR 1926.405(g)(2)(iv,v)



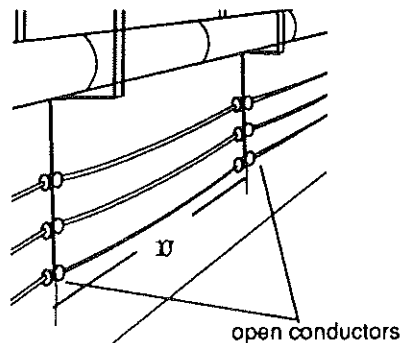
Enclosure Cord and Bushing

s. All requirements for permanent wiring shall apply to temporary wiring installations unless specifically modified according to paragraphs (1) through (9) below. Temporary wiring shall be removed as soon as the job for which the wiring was installed is completed.

29 CFR 1926.405(a)(2)(i)

(1) Feeders shall originate in a distribution center, and conductors shall be run as multiconductor cords or cable assemblies or within raceways. If conductors are not subject to damage or accidental contact, they may be run as open conductors on insulators spaced not more than 10 feet apart.

29 CFR 1926.405(a)(2)(ii)(A)







d. When two or more receptacles are served by a branch circuit, the ampere rating shall meet the specifications in Table E-3.

Table E-3. Receptacle Ratings for Various Size Circuits

Circuit Rating Amperes	Receptacle Rating Amperes
15	Not over 15
20	15 or 20
30	30
40	40 to 50
50	50

29 CFR 1926.404(b)(2)(ii)

e. All electrical conductors and equipment shall be approved and free of hazards that may cause death or serious physical harm.

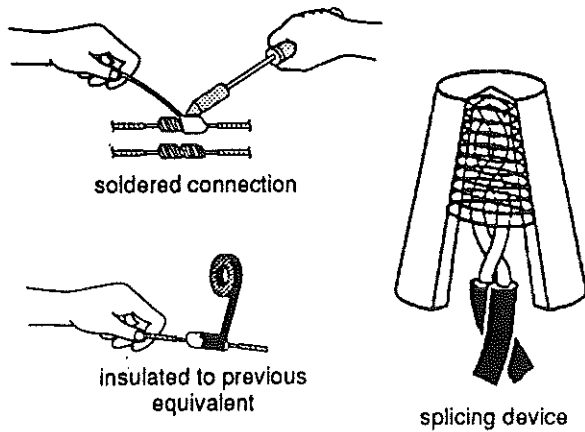
29 CFR 1926.403(a,b)

f. Circuit breakers, fuses, and other equipment intended to interrupt circuits shall have an interrupting rating sufficient for the current to be interrupted.

29 CFR 1926.403(c); NFPA 70,110-9

g. Conductors shall be spliced using approved splicing methods (welding, soldering, braising, or splicing devices).

29 CFR 1926.403(e)



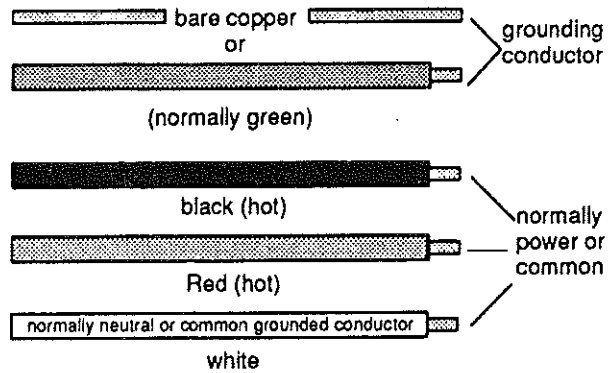
Approved Splicing Methods

h. All conductors used for general wiring shall be insulated for the voltage carried, unless otherwise specified.

29 CFR 1926.405(f)

i. Insulated grounded conductors, ungrounded conductors, and equipment-grounding conductors shall be distinguishable from each other by their colors.

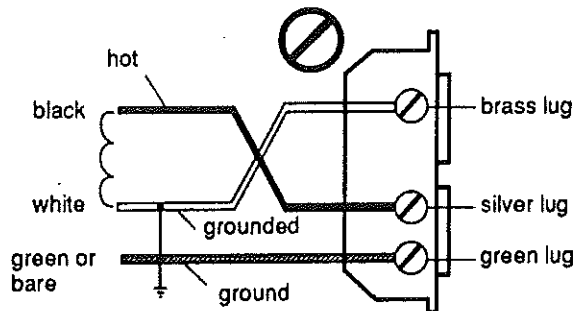
29 CFR 1926.405(f)



Distinguishable Colored Wire

j. No conductor shall be connected to a lead so as to reverse the designated polarity. Grounding terminals or grounding-type devices shall not be used for purposes other than grounding.

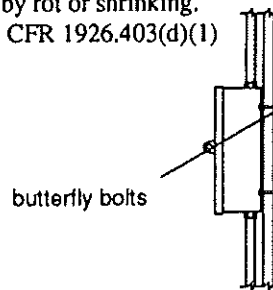
29 CFR 1926.404(a)(2,3)



Reverse Polarity Wiring

k. Equipment shall be firmly secured to its mounting surface. Equipment mounted on masonry, concrete, plaster, or similar material shall not be secured by wooden plugs because wooden plugs tend to loose anchoring ability by rot or shrinking.

29 CFR 1926.403(d)(1)



Wall-Mounted Enclosure Method

**Table E-1. Clearance for Energized Parts, Workspace < 600 Volts**

Nominal Voltage	Minimum Clear Distance		
	(a)*	(b)	(c)*
0-150	3 ft	3 ft	3 ft
151-600	3 ft	3.5 ft	4 ft

**Table E-2. Minimum Depth of Clear Working Space in Front of Electrical Equipment, > 600 Volts**

Nominal Voltage to Ground	Conditions		
	(a)*	(b)*	(c)*
601-2,500	3 ft	4 ft	5 ft
2,500-9,000	4 ft	5 ft	6 ft
9,001-25,000	5 ft	6 ft	9 ft
25,001-75 kV	6 ft	8 ft	10 ft
Above 75 kV	8 ft	10 ft	12 ft

\*Conditions: Tables E-1 and E-2

\*(a) Exposed live parts on one side and no live or grounded parts on the other side of the working space, or exposed live parts on both sides effectively guarded by insulating materials. Insulated wire or insulated busbars operating at not more than 300 volts are not considered live parts.

\*(b) Exposed live parts on one side and grounded parts on the other side. Walls of concrete, block, or tile are considered grounded surfaces.

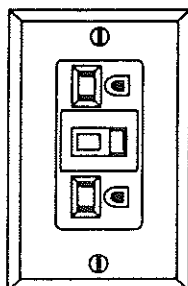
\*(c) Exposed live parts on both sides of the workspace [not guarded as specified in (a) above] with the operator between.

k. Special voltage-rated tools or fuse pullers shall be used to remove or install fuses in energized terminals.

29 CFR 1926.416(d); NFPA 70E II 1, B (2)(e)(i)

### 3. On-Site Electrical Safety Requirements

a. To protect workers from electric shock, the construction site shall be protected by ground-fault circuit interrupters, and/or an assured equipment-grounding conductor program.



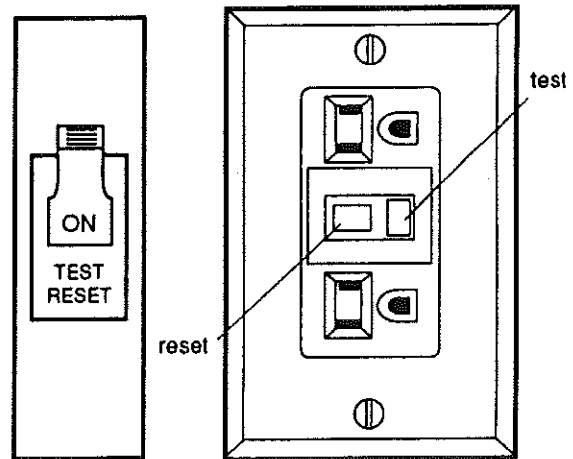
GFCI Outlet

*The DOE-recommended method for worker protection from electric shock is the use of ground-fault circuit interrupters because of their greater effectiveness and ease in implementation and verification. If, however, an assured equipment grounding program is selected, refer to 29 CFR 1926.404(b)(1)(iii).*

29 CFR 1926.404(b)(1)(i)

b. Single-phase, 120-volt, 15- and 20-ampere receptacle outlets that are not part of the permanent wiring of a building or structure shall have approved ground-fault circuit interrupters for workers' protection from electrical shock.

Note: A ground-fault circuit interrupter may be installed in the feeder to protect all branch circuits connected to that feeder.



Ground-Fault Circuit Interrupter

29 CFR 1926.404(b)(1)(ii)

c. Receptacles on a 2-wire, single-phase portable or vehicle-mounted generator rated at 5 kilowatt or below, in which the circuit conductors are insulated from the generator frame and all other grounded surfaces, need not be protected with a ground-fault circuit interrupter.

29 CFR 1926.404(b)(1)(ii)



## 2. Requirements for Electrical Workers

a. Workers shall be trained in the safety-related work practices, safety procedures, and other safety requirements that pertain to their respective job assignments and shall not be permitted to work in an area likely to encounter electrical hazards unless they have been trained to recognize and avoid the hazards to which they will be exposed.

NFPA 70E II,1,A



b. Only qualified workers may work on electric circuit parts or equipment that has not been de-energized. Such workers 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 insulating tools.

29 CFR 1910.333(c)(2)

c. Only qualified workers trained to use test instruments shall test circuits or equipment.

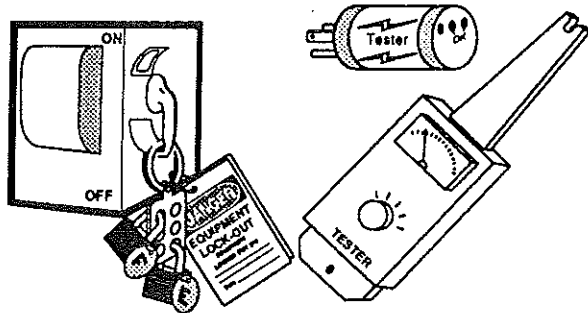
29 CFR 1910.334(c)(1)



d. Test equipment shall be visually inspected for external defects or damage before it is used; and, if there is evidence of a defect or damage, the equipment shall not be used. Test equipment shall be kept dry and damage-free.

29 CFR 1910.334(c)(2)

e. Electrical workers should test or observe electrical equipment or circuits to be worked on, to confirm if they are energized or de-energized.



f. Workers shall lockout and tagout any circuit or equipment that is being worked on to prevent the circuit or equipment from being energized accidentally. Workers shall verify that the equipment is de-energized.

29 CFR 1926.417(a-c)

g. Electrical workers shall not wear conductive apparel, such as metal watch bands, bracelets, rings, necklaces, or head gear.

NFPA 70E II,1,B,(2)(c)

h. Rubber personal protective equipment (PPE), such as gloves, blankets, hoods, line hoses, sleeves, and mats shall be used as prescribed for protection from energized sources. The PPE shall be inspected before use and kept dry and damage-free. Care must be taken to ensure that the correct class of rubber protective equipment is used, in accordance with the rated voltage and application. The manufacturer's recommendations should be followed for care, testing, and use.

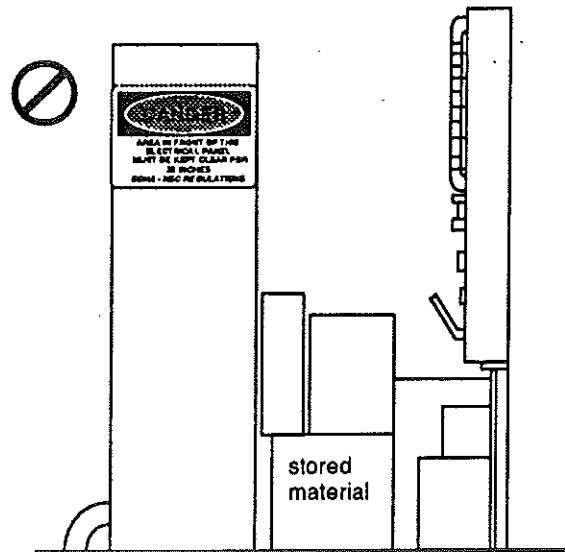
29 CFR 1926.951(a)(1)(i-iii)

i. Portable metal ladders or ladders with longitudinal metallic reinforcement shall not be used on or near exposed energized parts, circuits, or equipment.

NFPA 70E II,1,B,(2),(g)

j. There shall be sufficient space maintained in front of electrical equipment, and materials shall not be stored in this space. Space shall be maintained in accordance with Table E-1 for 600 volts, nominal, or less and Table E-2 for more than 600 volts, nominal.

29 CFR 1926.403(i)(1)(i),(j)(3)(i)



Improper Storage



m. Where the exact location of underground electric power lines is unknown, workers who break ground with jack hammers, metal bars, or similar tools shall use specially insulated gloves to prevent injury. Prior to breaking unmarked ground, the employer shall ascertain by inquiry, observation, or instrument whether there is an underground power source.

29 CFR 1926.416(a)(2,3)

n. The following requirements for flexible cords and extension cords shall be followed:

(1) Flexible cords and cables shall be suitable for the condition and location in which they are used and shall only be used for pendants, fixture wiring, portable lamps and appliances, elevator cables, cranes and hoists, applications to prevent the transmission of vibration or noise, and stationary equipment that requires frequent interchange or removal for maintenance or repair.

29 CFR 1926.405(g)(1)(i)

(2) Three-wire extension cords shall be used with portable electric tools and appliances and shall be designed for hard or extra-hard use. Flexible cords used with temporary or portable lights shall be designed for hard or extra-hard use.

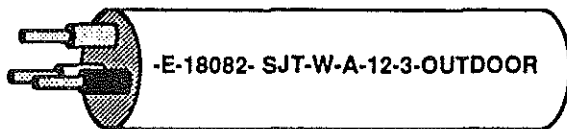
29 CFR 1926.405(a)(2)(ii)(J)



Three-Wire Hard-Use Cord

(3) Only type SJ, SJO, SJT, SJTO, S, SO, ST, and STO extension and flexible cords shall be used on the construction site. Each cord shall have the type, size, and number of conductors durably marked on its surface.

29 CFR 1926.405(g)(2)(ii)



Common Wire Marking

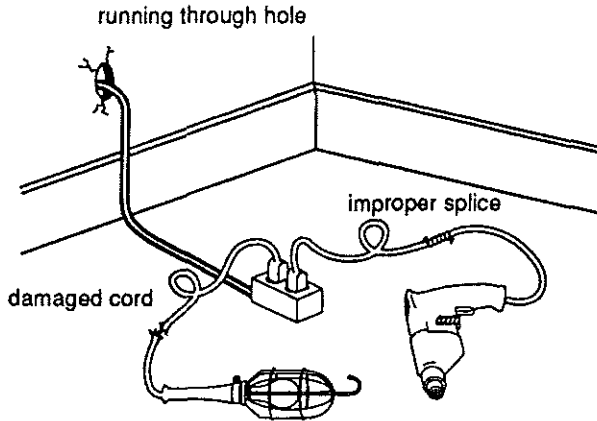
(4) Flexible and extension cords shall be used only in continuous lengths, without splices or taps. Hard-service flexible cords No. 12 or larger may be repaired, if the insulation and outer sheath properties remain the same and the usage characteristics of the original cord are retained.

29 CFR 1926.405(g)(2)(iii)

(5) Unless otherwise permitted, flexible cords and cables shall not be used for the following: as substitutes for fixed wiring; run through holes in walls, ceilings, or floors; run through doorways, windows, or similar openings except as

indicated in (6) below; as attachments to buildings or structures; or in concealed areas behind building walls, ceilings, or floors.

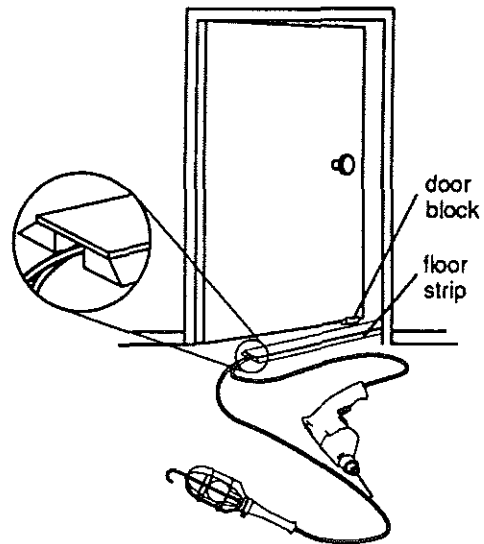
29 CFR 1926.405(g)(1)(iii)(A-E)



Unsafe Portable Cord Methods

(6) Flexible cords and cables may pass through doorways and other pinch points, if protection is provided to prevent damage.

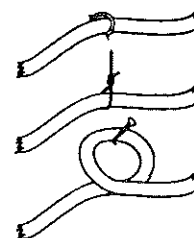
29 CFR 1926.405(a)(2)(ii)(I)



Cord Protection

(7) Extension cords shall not be fastened with staples, hung with nails, or suspended on wires.

29 CFR 1926.416(e)(2)



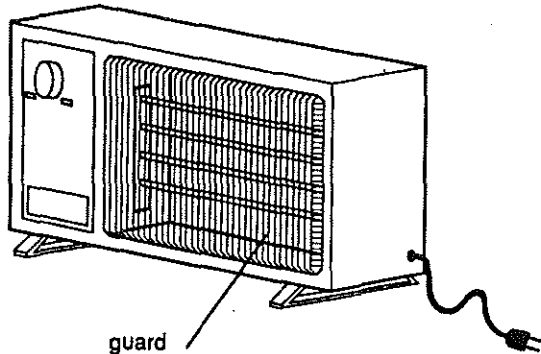


e. Workers shall not store material in or around electrical cabinets or equipment, if the material blocks the service space.

29 CFR 1926.403(i)(1)(i,ii)

f. Appliances shall have no live parts exposed to worker contact. Guards which prevent worker exposure to live parts shall not be removed or altered.

29 CFR 1926.405(j)(3)(i)



Guarded Appliance

g. Workers using electrically powered equipment shall confirm that such equipment is free of recognized hazards.

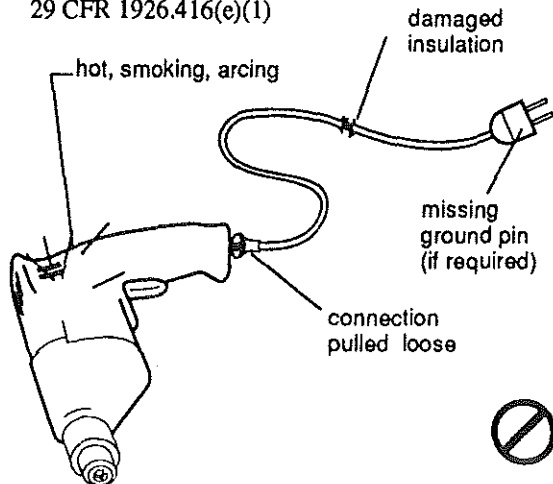
29 CFR 1926.300(a); .403(b)

h. Workers shall inspect electric power tools and equipment (including extension cords and plugs) for the following hazards:

- missing ground pins on plugs (except double insulated);
- insulation pulled free from plugs or support connections;
- damaged insulation (breaks, cuts, or cracks);
- exposed wires; and
- evidence of arcing, sparking, or smoking.

i. If the hazards in paragraph h. above are evident in electric power tools or equipment, the tool or equipment shall be removed from the construction site until repaired.

29 CFR 1926.416(e)(1)



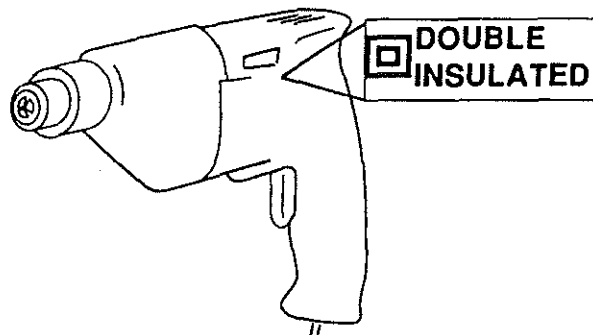
j. Electrically powered equipment shall be connected only to approved outlets or sources that meet the requirements.

29 CFR 1926, subpart K

k. Electric power tools shall be grounded or double insulated. If double insulated, they shall be permanently labeled "DOUBLE INSULATED."

29 CFR 1926.302(a)(1); .404(f)(7)(iv)(C)(6);

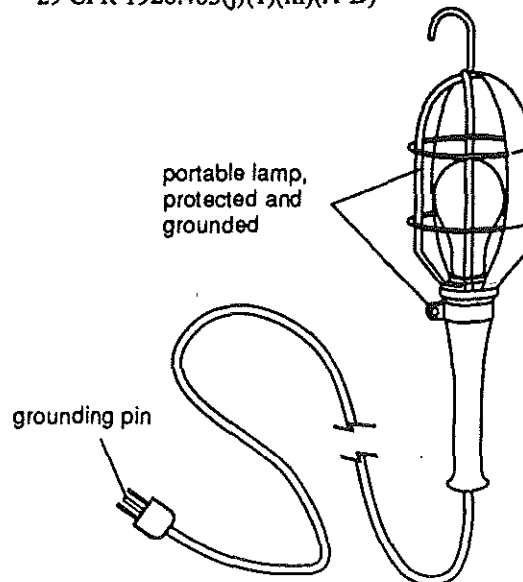
.951(f)(2)(i-ii)



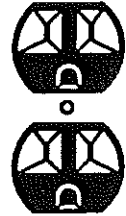
*Note: The use of double-insulated electrical hand tools does not alter the requirements for a ground-fault circuit interrupter (GFCI) system or an assured equipment grounding program for a worksite-supplied electric power system as required in 29 CFR 1926.404(b)(1)(i).*

l. Portable lampholders used by workers shall be wired with flexible cord and a polarized or grounding-type attachment plug; they shall be equipped with an insulated, molded-composition handle. A substantial guard (if metal, it shall be grounded by a conductor run inside the power cord) shall be attached to the handle or lampholder.

29 CFR 1926.405(j)(1)(iii)(A-D)



## Section E. Electrical Safety



*Electrical safety is an important component of a construction safety program. To minimize personal injury from contact with energized sources, construction workers shall be trained in the fundamentals of electrical safety; and all electrical hazards found on the construction site must be recorded and corrected immediately.*

*The following section covers safety requirements for users of electricity (general site workers and tradespeople) and electrical workers (electricians). Additional installation requirements, interpretations, and definitions may be found in 29 Code of Federal Regulations (CFR) 1926.400-449 and the National Electric Code (National Fire Protection Association [NFPA 70]); other national, state, and local codes; and manufacturer's instructions attached to equipment. All appropriate requirements shall be followed.*

### 1. Requirements for All Site Workers

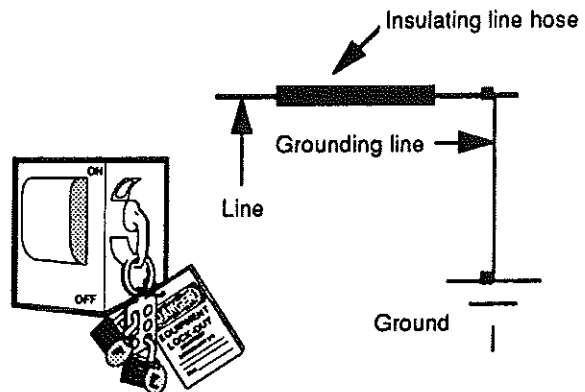
a. Before work begins it shall be determined by inquiry, direct observation, or by instrument that the electric power circuit, exposed or concealed, is so located that work may bring a worker, tools, or machine into physical or electrical contact with the circuit. Where such a circuit exists, warning signs shall be posted and maintained, and workers shall be advised of such circuit locations, the hazard involved, and the protective means to be taken.

29 CFR 1926.416(a)(3)



b. Workers shall not be permitted to work near any part of an electrical power circuit where there could be contact with the circuit in the course of their work unless the worker is protected against shock by guarding or de-energizing and grounding the circuit.

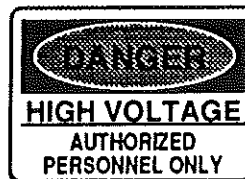
29 CFR 1926.416(a)(1)



De-energizing, Guarding, and Grounding Methods

c. Entrances to rooms and other guarded locations of exposed live parts shall be posted with warnings forbidding entry of unqualified persons. Workers shall obey all warning signs and tags.

29 CFR 1926.403(i)(2)(iii)



Obey Warnings

d. Workspaces, walkways, and similar locations shall be clear of electric cords and tools, so that workers can pass freely.

29 CFR 1926.416(b)(2)