

TABLE S-2—MINIMUM DEPTH OF CLEAR WORKING SPACE IN FRONT OF ELECTRIC EQUIPMENT—Continued

Nominal voltage to ground	Conditions ² (ft)		
	(a)	(b)	(c)
9,001 to 25,000	5	6	9
25,001 to 75kV ¹	6	8	10
Above 75kV ¹	8	10	12

¹Minimum depth of clear working space in front of electric equipment with a nominal voltage to ground above 25,000 volts may be the same as for 25,000 volts under Conditions (a), (b), and (c) for installations built prior to April 16, 1981.

²Conditions (a), (b), and (c) are as follows: (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 suitable wood or other insulating materials. Insulated wire or insulated busbars operating at not over 300 volts are not considered live parts. (b) Exposed live parts on one side and grounded parts on the other side. Concrete, brick, or tile walls will be considered as grounded surfaces. (c) Exposed live parts on both sides of the workspace not guarded as provided in Condition (a) with the operator between.

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

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

TABLE S-3—ELEVATION OF UNGUARDED ENERGIZED PARTS ABOVE WORKING SPACE

Nominal voltage between phases	Minimum elevation
601 to 7,500	*8 feet 6 inches.
7,501 to 35,000	9 feet.
Over 35kV	9 feet + 0.37 inches per kV above 35kV.

*Note.—Minimum elevation may be 8 feet 0 inches for installations built prior to April 16, 1981 if the nominal voltage between phases is in the range of 601–6600 volts.

(4) *Entrance and access to workspace.* (See § 1910.302(b)(3).)

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

volts are located adjacent to such entrance, they shall be suitably guarded.

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

[46 FR 4056, Jan. 16, 1981; 46 FR 40185, Aug. 7, 1981]

§ 1910.304 Wiring design and protection.

(a) *Use and identification of grounded and grounding conductors.* (1) *Identification of conductors.* A conductor used as a grounded conductor shall be identifiable and distinguishable from all other conductors. A conductor used as an equipment grounding conductor shall be identifiable and distinguishable from all other conductors.

(2) *Polarity of connections.* No grounded conductor may be attached to any terminal or lead so as to reverse designated polarity.

(3) *Use of grounding terminals and devices.* A grounding terminal or grounding-type device on a receptacle, cord connector, or attachment plug may not be used for purposes other than grounding.

(b) *Branch circuits*—(1) [Reserved]

(2) *Outlet devices.* Outlet devices shall have an ampere rating not less than the load to be served.

(c) *Outside conductors, 600 volts, nominal, or less.* Paragraphs (c)(1), (c)(2), (c)(3), and (c)(4) of this section apply to branch circuit, feeder, and service conductors rated 600 volts, nominal, or less and run outdoors as open conductors. Paragraph (c)(5) applies to lamps installed under such conductors.

(1) *Conductors on poles.* Conductors supported on poles shall provide a horizontal climbing space not less than the following:

(i) Power conductors below communication conductors—30 inches.

(ii) Power conductors alone or above communication conductors: 300 volts or less—24 inches; more than 300 volts—30 inches.

(iii) Communication conductors below power conductors with power conductors 300 volts or less—24 inches; more than 300 volts—30 inches.

(2) *Clearance from ground.* Open conductors shall conform to the following minimum clearances:

- (i) 10 feet—above finished grade, sidewalks, or from any platform or projection from which they might be reached.
- (ii) 12 feet—over areas subject to vehicular traffic other than truck traffic.
- (iii) 15 feet—over areas other than those specified in paragraph (c)(2)(iv) of this section that are subject to truck traffic.

(iv) 18 feet—over public streets, alleys, roads, and driveways.

(3) *Clearance from building openings.* Conductors shall have a clearance of at least 3 feet from windows, doors, porches, fire escapes, or similar locations. Conductors run above the top level of a window are considered to be out of reach from that window and, therefore, do not have to be 3 feet away.

(4) *Clearance over roofs.* Conductors shall have a clearance of not less than 8 feet from the highest point of roofs over which they pass, except that:

(i) Where the voltage between conductors is 300 volts or less and the roof has a slope of not less than 4 inches in 12, the clearance from roofs shall be at least 3 feet, or

(ii) Where the voltage between conductors is 300 volts or less and the conductors do not pass over more than 4 feet of the overhang portion of the roof and they are terminated at a through-the-roof raceway or approved support, the clearance from roofs shall be at least 18 inches.

(5) *Location of outdoor lamps.* Lamps for outdoor lighting shall be located below all live conductors, transformers, or other electric equipment, unless such equipment is controlled by a disconnecting means that can be locked in the open position or unless adequate clearances or other safeguards are provided for relamping operations.

(d) *Services—(1) Disconnecting means—*
(i) *General.* Means shall be provided to disconnect all conductors in a building or other structure from the service-entrance conductors. The disconnecting means shall plainly indicate whether it is in the open or closed position and shall be installed at a readily accessible location nearest the point of entrance of the service-entrance conductors.

(ii) *Simultaneous opening of poles.* Each service disconnecting means shall simultaneously disconnect all ungrounded conductors.

(2) *Services over 600 volts, nominal.* The following additional requirements apply to services over 600 volts, nominal.

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

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

(e) *Overcurrent protection. (1) 600 volts, nominal, or less.* The following requirements apply to overcurrent protection of circuits rated 600 volts, nominal, or less.

(i) *Protection of conductors and equipment.* Conductors and equipment shall be protected from overcurrent in accordance with their ability to safely conduct current.

(ii) *Grounded conductors.* Except for motor running overload protection, overcurrent devices may not interrupt the continuity of the grounded conductor unless all conductors of the circuit are opened simultaneously.

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

(iv) *Location in or on premises.* Overcurrent devices shall be readily accessible to each employee or authorized building management personnel. These overcurrent devices may not be located where they will be exposed to physical damage nor in the vicinity of easily ignitable material.

(v) *Arcing or suddenly moving parts.* Fuses and circuit breakers shall be so located or shielded that employees will not be burned or otherwise injured by their operation.

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

(B) Where circuit breaker handles on switchboards are operated vertically rather than horizontally or rotationally, the up position of the handle shall be the closed (on) position. (See § 1910.302(b)(3).)

(C) If used as switches in 120-volt, fluorescent lighting circuits, circuit breakers shall be approved for the purpose and marked "SWD." (See § 1910.302(b)(3).)

(2) *Over 600 volts, nominal.* Feeders and branch circuits over 600 volts, nominal, shall have short-circuit protection.

(f) *Grounding.* Paragraphs (f)(1) through (f)(7) of this section contain grounding requirements for systems, circuits, and equipment.

(1) *Systems to be grounded.* The following systems which supply premises wiring shall be grounded:

(i) All 3-wire DC systems shall have their neutral conductor grounded.

(ii) Two-wire DC systems operating at over 50 volts through 300 volts between conductors shall be grounded unless:

(A) They supply only industrial equipment in limited areas and are equipped with a ground detector; or

(B) They are rectifier-derived from an AC system complying with paragraphs (f)(1)(iii), (f)(1)(iv), and (f)(1)(v) of this section; or

(C) They are fire-protective signaling circuits having a maximum current of 0.030 amperes.

(iii) AC circuits of less than 50 volts shall be grounded if they are installed as overhead conductors outside of buildings or if they are supplied by transformers and the transformer primary supply system is ungrounded or exceeds 150 volts to ground.

(iv) AC systems of 50 volts to 1000 volts shall be grounded under any of the following conditions, unless exempted by paragraph (f)(1)(v) of this section:

(A) If the system can be so grounded that the maximum voltage to ground on the ungrounded conductors does not exceed 150 volts;

(B) If the system is nominally rated 480Y/277 volt, 3-phase, 4-wire in which the neutral is used as a circuit conductor;

(C) 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

(D) If a service conductor is uninsulated.

(v) AC systems of 50 volts to 1000 volts are not required to be grounded under any of the following conditions:

(A) If the system is used exclusively to supply industrial electric furnaces for melting, refining, tempering, and the like.

(B) If the system is separately derived and is used exclusively for rectifiers supplying only adjustable speed industrial drives.

(C) If the system is separately derived and is supplied by a transformer that has a primary voltage rating less than 1000 volts, provided all of the following conditions are met:

(1) The system is used exclusively for control circuits,

(2) The conditions of maintenance and supervision assure that only qualified persons will service the installation,

(3) Continuity of control power is required, and

(4) Ground detectors are installed on the control system.

(D) If the system is an isolated power system that supplies circuits in health care facilities.

(2) *Conductors to be grounded.* For AC premises wiring systems the identified conductor shall be grounded.

(3) *Grounding connections.* (i) 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 connected to the grounded circuit conductor on the supply side of the service disconnecting means, or on the supply side of the system disconnecting means or overcurrent devices if the system is separately derived.

(ii) For an ungrounded service-supplied system, the equipment grounding

conductor shall be connected to the grounding electrode conductor at the service equipment. For an ungrounded separately derived system, the equipment grounding conductor shall be connected to the grounding electrode conductor at, or ahead of, the system disconnecting means or overcurrent devices.

(iii) On extensions of existing branch circuits which do not have an equipment grounding conductor, grounding-type receptacles may be grounded to a grounded cold water pipe near the equipment.

(4) *Grounding path.* The path to ground from circuits, equipment, and enclosures shall be permanent and continuous.

(5) *Supports, enclosures, and equipment to be grounded—(i) Supports and enclosures for conductors.* Metal cable trays, metal raceways, and metal enclosures for conductors shall be grounded, except that:

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

(B) Metal enclosures for conductors added to existing installations of open wire, knob-and-tube wiring, and non-metallic-sheathed cable need not be grounded if all of the following conditions are met: (1) Runs are less than 25 feet; (2) enclosures are free from probable contact with ground, grounded metal, metal laths, or other conductive materials; and (3) enclosures are guarded against employee contact.

(ii) *Service equipment enclosures.* Metal enclosures for service equipment shall be grounded.

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

(iv) *Fixed equipment.* Exposed non-current-carrying metal parts of fixed equipment which may become energized shall be grounded under any of the following conditions:

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

(B) If located in a wet or damp location and not isolated.

(C) If in electrical contact with metal.

(D) If in a hazardous (classified) location.

(E) If supplied by a metal-clad, metal-sheathed, or grounded metal raceway wiring method.

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

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

(2) Metal frames of electrically heated appliances which are permanently and effectively insulated from ground; and

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

(v) *Equipment connected by cord and plug.* Under any of the conditions described in paragraphs (f)(5)(v)(A) through (f)(5)(v)(C) of this section, exposed non-current-carrying metal parts of cord- and plug-connected equipment which may become energized shall be grounded.

(A) If in hazardous (classified) locations (see §1910.307).

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

(C) If the equipment is of the following types:

(1) Refrigerators, freezers, and air conditioners;

(2) Clothes-washing, clothes-drying and dishwashing machines, sump pumps, and electrical aquarium equipment;

(3) Hand-held motor-operated tools;

(4) Motor-operated appliances of the following types: hedge clippers, lawn mowers, snow blowers, and wet scrubbers;

(5) Cord- and plug-connected appliances used in damp or wet locations or by employees standing on the ground

or on metal floors or working inside of metal tanks or boilers;

(6) Portable and mobile X-ray and associated equipment;

(7) Tools likely to be used in wet and conductive locations; and

(8) Portable hand lamps.

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

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

(6) *Methods of grounding fixed equipment.* (i) Non-current-carrying metal parts of fixed equipment, if required to be grounded by this subpart, shall be grounded by an equipment grounding conductor which is contained within the same raceway, cable, or cord, or runs with or encloses the circuit conductors. For DC circuits only, the equipment grounding conductor may be run separately from the circuit conductors.

(ii) Electric equipment is considered to be effectively grounded if it is secured to, and in electrical contact with, a metal rack or structure that is provided for its support and the metal rack or structure is grounded by the method specified for the non-current-carrying metal parts of fixed equipment in paragraph (f)(6)(i) of this section. For installations made before April 16, 1981, only, electric equipment is also considered to be effectively grounded if it is secured to, and in metallic contact with, the grounded structural metal frame of a building. Metal

car frames supported by metal hoisting cables attached to or running over metal sheaves or drums of grounded elevator machines are also considered to be effectively grounded.

(7) *Grounding of systems and circuits of 1000 volts and over (high voltage)*—(i) *General.* If high voltage systems are grounded, they shall comply with all applicable provisions of paragraphs (f)(1) through (f)(6) of this section as supplemented and modified by this paragraph (f)(7).

(ii) *Grounding of systems supplying portable or mobile equipment.* (See § 1910.302(b)(3).) Systems supplying portable or mobile high voltage equipment, other than substations installed on a temporary basis, shall comply with the following:

(A) Portable and mobile high voltage 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.

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

(C) Ground-fault detection and relaying shall be provided to automatically de-energize any high voltage system component which has developed a ground fault. The continuity of the equipment grounding conductor shall be continuously monitored so as to de-energize automatically the high voltage feeder to the portable equipment upon loss of continuity of the equipment grounding conductor.

(D) The grounding electrode to which the 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, and there shall be no direct connection between the grounding electrodes, such as buried pipe, fence, etc.

(iii) *Grounding of equipment.* All non-current-carrying metal parts of portable equipment and fixed equipment including their associated fences, housings, enclosures, and supporting

structures shall be grounded. However, equipment which is guarded by location and isolated from ground need not be grounded. Additionally, pole-mounted distribution apparatus at a height exceeding 8 feet above ground or grade level need not be grounded.

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§ 1910.305 Wiring methods, components, and equipment for general use.

(a) *Wiring methods.* The provisions of this section do not apply to the conductors that are an integral part of factory-assembled equipment.

(1) *General requirements—(i) Electrical continuity of metal raceways and enclosures.* Metal raceways, cable armor, and other metal enclosures for conductors shall be metallically joined together into a continuous electric conductor and shall be so connected to all boxes, fittings, and cabinets as to provide effective electrical continuity.

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

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

(i) *Uses permitted, 600 volts, nominal, or less.* Temporary electrical power and lighting installations 600 volts, nominal, or less may be used only:

(A) During and for remodeling, maintenance, repair, or demolition of buildings, structures, or equipment, and similar activities;

(B) For experimental or development work, and

(C) For a period not to exceed 90 days for Christmas decorative lighting, carnivals, and similar purposes.

(ii) *Uses permitted, over 600 volts, nominal.* Temporary wiring over 600 volts,

nominal, may be used only during periods of tests, experiments, or emergencies.

(iii) *General requirements for temporary wiring.* (A) Feeders shall originate in an approved distribution center. The conductors shall be run as multiconductor cord or cable assemblies, or, where not subject to physical damage, they may be run as open conductors on insulators not more than 10 feet apart.

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

(C) Receptacles shall be of the grounding type. Unless installed in a complete metallic raceway, each branch circuit shall contain a separate equipment grounding conductor and all receptacles shall be electrically connected to the grounding conductor.

(D) No bare conductors nor earth returns may be used for the wiring of any temporary circuit.

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

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

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

(3) *Cable trays—(i) Uses permitted.* (a) Only the following may be installed in cable tray systems:

(1) Mineral-insulated metal-sheathed cable (Type MI);

(2) Armored cable (Type AC);

(3) Metal-clad cable (Type MC);