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enter, and which is used for the purpose of installing, operating, and/or maintaining equipment and/or cable which need not be of submersible design.

(43) *Vented vault.* An enclosure as described in paragraph(s) (42) of this section, with provision for air changes using exhaust flue stack(s) and low level air intake(s), operating on differentials of pressure and temperature providing for air flow.

(44) *Voltage of an effectively grounded circuit.* The voltage between any conductor and ground unless otherwise indicated.

(45) *Voltage of a circuit not effectively grounded.* The voltage between any two conductors. If one circuit is directly connected to and supplied from another circuit of higher voltage (as in the case of an autotransformer), both are considered as of the higher voltage, unless the circuit of lower voltage is effectively grounded, in which case its voltage is not determined by the circuit of higher voltage. Direct connection implies electric connection as distinguished from connection merely through electromagnetic or electrostatic induction.

[40 FR 13441, Mar. 26, 1975, as amended at 43 FR 49751, Oct. 24, 1978; 47 FR 14706, Apr. 6, 1982; 52 FR 36387, Sept. 28, 1987; 54 FR 24334, June 7, 1989; 61 FR 9242, Mar. 7, 1996; 63 FR 33467, June 18, 1998; 67 FR 67965, Nov. 7, 2002; 69 FR 31882, June 8, 2004; 70 FR 1141, Jan. 5, 2005]

§ 1910.269 Electric power generation, transmission, and distribution.

NOTE: OSHA is staying the enforcement of the following paragraphs of §1910.269 until November 1, 1994: (b)(1)(ii), (d) except for (d)(2)(i) and (d)(2)(iii), (e)(2), (e)(3), (j)(2)(iii), (l)(6)(iii), (m), (n)(3), (n)(4)(ii), (n)(8), (o) except for (o)(2)(i), (r)(1)(vi), (u)(1), (u)(4), (u)(5). OSHA is also staying the enforcement of paragraphs (n)(6) and (n)(7) of §1910.269 until November 1, 1994, but only insofar as they apply to lines and equipment operated at 600 volts or less. Further, OSHA is staying the enforcement of paragraph (v)(11)(xii) of §1910.269 until February 1, 1996.

(a) *General*—(1) *Application.* (i) This section covers the operation and maintenance of electric power generation, control, transformation, transmission, and distribution lines and equipment. These provisions apply to:

(A) Power generation, transmission, and distribution installations, including related equipment for the purpose of communication or metering, which are accessible only to qualified employees;

NOTE: The types of installations covered by this paragraph include the generation, transmission, and distribution installations of electric utilities, as well as equivalent installations of industrial establishments. Supplementary electric generating equipment that is used to supply a workplace for emergency, standby, or similar purposes only is covered under subpart S of this part. (See paragraph (a)(1)(ii)(B) of this section.)

(B) Other installations at an electric power generating station, as follows:

(1) Fuel and ash handling and processing installations, such as coal conveyors,

(2) Water and steam installations, such as penstocks, pipelines, and tanks, providing a source of energy for electric generators, and

(3) Chlorine and hydrogen systems;

(C) Test sites where electrical testing involving temporary measurements associated with electric power generation, transmission, and distribution is performed in laboratories, in the field, in substations, and on lines, as opposed to metering, relaying, and routine line work;

(D) Work on or directly associated with the installations covered in paragraphs (a)(1)(i)(A) through (a)(1)(i)(C) of this section; and

(E) Line-clearance tree-trimming operations, as follows:

(1) Entire §1910.269 of this part, except paragraph (r)(1) of this section, applies to line-clearance tree-trimming operations performed by qualified employees (those who are knowledgeable in the construction and operation of electric power generation, transmission, or distribution equipment involved, along with the associated hazards).

(2) Paragraphs (a)(2), (b), (c), (g), (k), (p), and (r) of this section apply to line-clearance tree-trimming operations performed by line-clearance tree trimmers who are not qualified employees.

(ii) Notwithstanding paragraph (a)(1)(i) of this section, §1910.269 of this part does not apply:

(A) To construction work, as defined in § 1910.12 of this part; or

(B) To electrical installations, electrical safety-related work practices, or electrical maintenance considerations covered by subpart S of this part.

NOTE 1: Work practices conforming to §§ 1910.332 through 1910.335 of this part are considered as complying with the electrical safety-related work practice requirements of this section identified in Table 1 of appendix A-2 to this section, provided the work is being performed on a generation or distribution installation meeting §§ 1910.303 through 1910.308 of this part. This table also identifies provisions in this section that apply to work by qualified persons directly on or associated with installations of electric power generation, transmission, and distribution lines or equipment, regardless of compliance with §§ 1910.332 through 1910.335 of this part.

NOTE 2: Work practices performed by qualified persons and conforming to § 1910.269 of this part are considered as complying with §§ 1910.333(c) and 1910.335 of this part.

(iii) This section applies in addition to all other applicable standards contained in this part 1910. Specific references in this section to other sections of part 1910 are provided for emphasis only.

(2) *Training.* (i) Employees shall be trained in and familiar with the safety-related work practices, safety procedures, and other safety requirements in this section that pertain to their respective job assignments. Employees shall also be trained in and familiar with any other safety practices, including applicable emergency procedures (such as pole top and manhole rescue), that are not specifically addressed by this section but that are related to their work and are necessary for their safety.

(ii) Qualified employees shall also be trained and competent in:

(A) The skills and techniques necessary to distinguish exposed live parts from other parts of electric equipment,

(B) The skills and techniques necessary to determine the nominal voltage of exposed live parts,

(C) The minimum approach distances specified in this section corresponding to the voltages to which the qualified employee will be exposed, and

(D) The proper use of the special precautionary techniques, personal protective equipment, insulating and

shielding materials, and insulated tools for working on or near exposed energized parts of electric equipment.

NOTE: For the purposes of this section, a person must have this training in order to be considered a qualified person.

(iii) The employer shall determine, through regular supervision and through inspections conducted on at least an annual basis, that each employee is complying with the safety-related work practices required by this section.

(iv) An employee shall receive additional training (or retraining) under any of the following conditions:

(A) If the supervision and annual inspections required by paragraph (a)(2)(iii) of this section indicate that the employee is not complying with the safety-related work practices required by this section, or

(B) If new technology, new types of equipment, or changes in procedures necessitate the use of safety-related work practices that are different from those which the employee would normally use, or

(C) If he or she must employ safety-related work practices that are not normally used during his or her regular job duties.

NOTE: OSHA would consider tasks that are performed less often than once per year to necessitate retraining before the performance of the work practices involved.

(v) The training required by paragraph (a)(2) of this section shall be of the classroom or on-the-job type.

(vi) The training shall establish employee proficiency in the work practices required by this section and shall introduce the procedures necessary for compliance with this section.

(vii) The employer shall certify that each employee has received the training required by paragraph (a)(2) of this section. This certification shall be made when the employee demonstrates proficiency in the work practices involved and shall be maintained for the duration of the employee's employment.

NOTE: Employment records that indicate that an employee has received the required training are an acceptable means of meeting this requirement.

(3) *Existing conditions.* Existing conditions related to the safety of the work to be performed shall be determined before work on or near electric lines or equipment is started. Such conditions include, but are not limited to, the nominal voltages of lines and equipment, the maximum switching transient voltages, the presence of hazardous induced voltages, the presence and condition of protective grounds and equipment grounding conductors, the condition of poles, environmental conditions relative to safety, and the locations of circuits and equipment, including power and communication lines and fire protective signaling circuits.

(b) *Medical services and first aid.* The employer shall provide medical services and first aid as required in § 1910.151 of this part. In addition to the requirements of § 1910.151 of this part, the following requirements also apply:

(1) *Cardiopulmonary resuscitation and first aid training.* When employees are performing work on or associated with exposed lines or equipment energized at 50 volts or more, persons trained in first aid including cardiopulmonary resuscitation (CPR) shall be available as follows:

(i) For field work involving two or more employees at a work location, at least two trained persons shall be available. However, only one trained person need be available if all new employees are trained in first aid, including CPR, within 3 months of their hiring dates.

(ii) For fixed work locations such as generating stations, the number of trained persons available shall be sufficient to ensure that each employee exposed to electric shock can be reached within 4 minutes by a trained person. However, where the existing number of employees is insufficient to meet this requirement (at a remote substation, for example), all employees at the work location shall be trained.

(2) *First aid supplies.* First aid supplies required by § 1910.151(b) of this part shall be placed in weatherproof containers if the supplies could be exposed to the weather.

(3) *First aid kits.* Each first aid kit shall be maintained, shall be readily available for use, and shall be in-

spected frequently enough to ensure that expended items are replaced but at least once per year.

(c) *Job briefing.* The employer shall ensure that the employee in charge conducts a job briefing with the employees involved before they start each job. The briefing shall cover at least the following subjects: hazards associated with the job, work procedures involved, special precautions, energy source controls, and personal protective equipment requirements.

(1) *Number of briefings.* If the work or operations to be performed during the work day or shift are repetitive and similar, at least one job briefing shall be conducted before the start of the first job of each day or shift. Additional job briefings shall be held if significant changes, which might affect the safety of the employees, occur during the course of the work.

(2) *Extent of briefing.* A brief discussion is satisfactory if the work involved is routine and if the employee, by virtue of training and experience, can reasonably be expected to recognize and avoid the hazards involved in the job. A more extensive discussion shall be conducted:

(i) If the work is complicated or particularly hazardous, or

(ii) If the employee cannot be expected to recognize and avoid the hazards involved in the job.

NOTE: The briefing is always required to touch on all the subjects listed in the introductory text to paragraph (c) of this section.

(3) *Working alone.* An employee working alone need not conduct a job briefing. However, the employer shall ensure that the tasks to be performed are planned as if a briefing were required.

(d) *Hazardous energy control (lockout/tagout) procedures—(1) Application.* The provisions of paragraph (d) of this section apply to the use of lockout/tagout procedures for the control of energy sources in installations for the purpose of electric power generation, including related equipment for communication or metering. Locking and tagging procedures for the deenergizing of electric energy sources which are used exclusively for purposes of transmission and distribution are addressed by paragraph (m) of this section.

NOTE 1: Installations in electric power generation facilities that are not an integral part of, or inextricably commingled with, power generation processes or equipment are covered under §1910.147 and subpart S of this part.

NOTE 2: Lockout and tagging procedures that comply with paragraphs (c) through (f) of §1910.147 of this part will also be deemed to comply with paragraph (d) of this section if the procedures address the hazards covered by paragraph (d) of this section.

(2) *General.* (i) The employer shall establish a program consisting of energy control procedures, employee training, and periodic inspections to ensure that, before any employee performs any servicing or maintenance on a machine or equipment where the unexpected energizing, start up, or release of stored energy could occur and cause injury, the machine or equipment is isolated from the energy source and rendered inoperative.

(ii) The employer's energy control program under paragraph (d)(2) of this section shall meet the following requirements:

(A) If an energy isolating device is not capable of being locked out, the employer's program shall use a tagout system.

(B) If an energy isolating device is capable of being locked out, the employer's program shall use lockout, unless the employer can demonstrate that the use of a tagout system will provide full employee protection as follows:

(1) When a tagout device is used on an energy isolating device which is capable of being locked out, the tagout device shall be attached at the same location that the lockout device would have been attached, and the employer shall demonstrate that the tagout program will provide a level of safety equivalent to that obtained by the use of a lockout program.

(2) In demonstrating that a level of safety is achieved in the tagout program equivalent to the level of safety obtained by the use of a lockout program, the employer shall demonstrate full compliance with all tagout-related provisions of this standard together with such additional elements as are necessary to provide the equivalent safety available from the use of a lockout device. Additional means to be con-

sidered as part of the demonstration of full employee protection shall include the implementation of additional safety measures such as the removal of an isolating circuit element, blocking of a controlling switch, opening of an extra disconnecting device, or the removal of a valve handle to reduce the likelihood of inadvertent energizing.

(C) After November 1, 1994, whenever replacement or major repair, renovation, or modification of a machine or equipment is performed, and whenever new machines or equipment are installed, energy isolating devices for such machines or equipment shall be designed to accept a lockout device.

(iii) Procedures shall be developed, documented, and used for the control of potentially hazardous energy covered by paragraph (d) of this section.

(iv) The procedure shall clearly and specifically outline the scope, purpose, responsibility, authorization, rules, and techniques to be applied to the control of hazardous energy, and the measures to enforce compliance including, but not limited to, the following:

(A) A specific statement of the intended use of this procedure;

(B) Specific procedural steps for shutting down, isolating, blocking and securing machines or equipment to control hazardous energy;

(C) Specific procedural steps for the placement, removal, and transfer of lockout devices or tagout devices and the responsibility for them; and

(D) Specific requirements for testing a machine or equipment to determine and verify the effectiveness of lockout devices, tagout devices, and other energy control measures.

(v) The employer shall conduct a periodic inspection of the energy control procedure at least annually to ensure that the procedure and the provisions of paragraph (d) of this section are being followed.

(A) The periodic inspection shall be performed by an authorized employee who is not using the energy control procedure being inspected.

(B) The periodic inspection shall be designed to identify and correct any deviations or inadequacies.

(C) If lockout is used for energy control, the periodic inspection shall include a review, between the inspector

and each authorized employee, of that employee's responsibilities under the energy control procedure being inspected.

(D) Where tagout is used for energy control, the periodic inspection shall include a review, between the inspector and each authorized and affected employee, of that employee's responsibilities under the energy control procedure being inspected, and the elements set forth in paragraph (d)(2)(vii) of this section.

(E) The employer shall certify that the inspections required by paragraph (d)(2)(v) of this section have been accomplished. The certification shall identify the machine or equipment on which the energy control procedure was being used, the date of the inspection, the employees included in the inspection, and the person performing the inspection.

NOTE: If normal work schedule and operation records demonstrate adequate inspection activity and contain the required information, no additional certification is required.

(vi) The employer shall provide training to ensure that the purpose and function of the energy control program are understood by employees and that the knowledge and skills required for the safe application, usage, and removal of energy controls are acquired by employees. The training shall include the following:

(A) Each authorized employee shall receive training in the recognition of applicable hazardous energy sources, the type and magnitude of energy available in the workplace, and in the methods and means necessary for energy isolation and control.

(B) Each affected employee shall be instructed in the purpose and use of the energy control procedure.

(C) All other employees whose work operations are or may be in an area where energy control procedures may be used shall be instructed about the procedures and about the prohibition relating to attempts to restart or reenergize machines or equipment that are locked out or tagged out.

(vii) When tagout systems are used, employees shall also be trained in the following limitations of tags:

(A) Tags are essentially warning devices affixed to energy isolating devices and do not provide the physical restraint on those devices that is provided by a lock.

(B) When a tag is attached to an energy isolating means, it is not to be removed without authorization of the authorized person responsible for it, and it is never to be bypassed, ignored, or otherwise defeated.

(C) Tags must be legible and understandable by all authorized employees, affected employees, and all other employees whose work operations are or may be in the area, in order to be effective.

(D) Tags and their means of attachment must be made of materials which will withstand the environmental conditions encountered in the workplace.

(E) Tags may evoke a false sense of security, and their meaning needs to be understood as part of the overall energy control program.

(F) Tags must be securely attached to energy isolating devices so that they cannot be inadvertently or accidentally detached during use.

(viii) Retraining shall be provided by the employer as follows:

(A) Retraining shall be provided for all authorized and affected employees whenever there is a change in their job assignments, a change in machines, equipment, or processes that present a new hazard or whenever there is a change in the energy control procedures.

(B) Retraining shall also be conducted whenever a periodic inspection under paragraph (d)(2)(v) of this section reveals, or whenever the employer has reason to believe, that there are deviations from or inadequacies in an employee's knowledge or use of the energy control procedures.

(C) The retraining shall reestablish employee proficiency and shall introduce new or revised control methods and procedures, as necessary.

(ix) The employer shall certify that employee training has been accomplished and is being kept up to date. The certification shall contain each employee's name and dates of training.

(3) *Protective materials and hardware.*

(i) Locks, tags, chains, wedges, key

blocks, adapter pins, self-locking fasteners, or other hardware shall be provided by the employer for isolating, securing, or blocking of machines or equipment from energy sources.

(ii) Lockout devices and tagout devices shall be singularly identified; shall be the only devices used for controlling energy; may not be used for other purposes; and shall meet the following requirements:

(A) Lockout devices and tagout devices shall be capable of withstanding the environment to which they are exposed for the maximum period of time that exposure is expected.

(1) Tagout devices shall be constructed and printed so that exposure to weather conditions or wet and damp locations will not cause the tag to deteriorate or the message on the tag to become illegible.

(2) Tagout devices shall be so constructed as not to deteriorate when used in corrosive environments.

(B) Lockout devices and tagout devices shall be standardized within the facility in at least one of the following criteria: color, shape, size. Additionally, in the case of tagout devices, print and format shall be standardized.

(C) Lockout devices shall be substantial enough to prevent removal without the use of excessive force or unusual techniques, such as with the use of bolt cutters or metal cutting tools.

(D) Tagout devices, including their means of attachment, shall be substantial enough to prevent inadvertent or accidental removal. Tagout device attachment means shall be of a non-reusable type, attachable by hand, self-locking, and non-releasable with a minimum unlocking strength of no less than 50 pounds and shall have the general design and basic characteristics of being at least equivalent to a one-piece, all-environment-tolerant nylon cable tie.

(E) Each lockout device or tagout device shall include provisions for the identification of the employee applying the device.

(F) Tagout devices shall warn against hazardous conditions if the machine or equipment is energized and shall include a legend such as the following: Do Not Start, Do Not Open, Do Not

Close, Do Not Energize, Do Not Operate.

NOTE: For specific provisions covering accident prevention tags, see §1910.145 of this part.

(4) *Energy isolation.* Lockout and tagout device application and removal may only be performed by the authorized employees who are performing the servicing or maintenance.

(5) *Notification.* Affected employees shall be notified by the employer or authorized employee of the application and removal of lockout or tagout devices. Notification shall be given before the controls are applied and after they are removed from the machine or equipment.

NOTE: See also paragraph (d)(7) of this section, which requires that the second notification take place before the machine or equipment is reenergized.

(6) *Lockout/tagout application.* The established procedures for the application of energy control (the lockout or tagout procedures) shall include the following elements and actions, and these procedures shall be performed in the following sequence:

(i) Before an authorized or affected employee turns off a machine or equipment, the authorized employee shall have knowledge of the type and magnitude of the energy, the hazards of the energy to be controlled, and the method or means to control the energy.

(ii) The machine or equipment shall be turned off or shut down using the procedures established for the machine or equipment. An orderly shutdown shall be used to avoid any additional or increased hazards to employees as a result of the equipment stoppage.

(iii) All energy isolating devices that are needed to control the energy to the machine or equipment shall be physically located and operated in such a manner as to isolate the machine or equipment from energy sources.

(iv) Lockout or tagout devices shall be affixed to each energy isolating device by authorized employees.

(A) Lockout devices shall be attached in a manner that will hold the energy isolating devices in a "safe" or "off" position.

(B) Tagout devices shall be affixed in such a manner as will clearly indicate

that the operation or movement of energy isolating devices from the "safe" or "off" position is prohibited.

(1) Where tagout devices are used with energy isolating devices designed with the capability of being locked out, the tag attachment shall be fastened at the same point at which the lock would have been attached.

(2) Where a tag cannot be affixed directly to the energy isolating device, the tag shall be located as close as safely possible to the device, in a position that will be immediately obvious to anyone attempting to operate the device.

(v) Following the application of lockout or tagout devices to energy isolating devices, all potentially hazardous stored or residual energy shall be relieved, disconnected, restrained, or otherwise rendered safe.

(vi) If there is a possibility of reaccumulation of stored energy to a hazardous level, verification of isolation shall be continued until the servicing or maintenance is completed or until the possibility of such accumulation no longer exists.

(vii) Before starting work on machines or equipment that have been locked out or tagged out, the authorized employee shall verify that isolation and deenergizing of the machine or equipment have been accomplished. If normally energized parts will be exposed to contact by an employee while the machine or equipment is deenergized, a test shall be performed to ensure that these parts are deenergized.

(7) *Release from lockout/tagout.* Before lockout or tagout devices are removed and energy is restored to the machine or equipment, procedures shall be followed and actions taken by the authorized employees to ensure the following:

(i) The work area shall be inspected to ensure that nonessential items have been removed and that machine or equipment components are operationally intact.

(ii) The work area shall be checked to ensure that all employees have been safely positioned or removed.

(iii) After lockout or tagout devices have been removed and before a machine or equipment is started, affected employees shall be notified that the

lockout or tagout devices have been removed.

(iv) Each lockout or tagout device shall be removed from each energy isolating device by the authorized employee who applied the lockout or tagout device. However, if that employee is not available to remove it, the device may be removed under the direction of the employer, provided that specific procedures and training for such removal have been developed, documented, and incorporated into the employer's energy control program. The employer shall demonstrate that the specific procedure provides a degree of safety equivalent to that provided by the removal of the device by the authorized employee who applied it. The specific procedure shall include at least the following elements:

(A) Verification by the employer that the authorized employee who applied the device is not at the facility;

(B) Making all reasonable efforts to contact the authorized employee to inform him or her that his or her lockout or tagout device has been removed; and

(C) Ensuring that the authorized employee has this knowledge before he or she resumes work at that facility.

(8) *Additional requirements.* (i) If the lockout or tagout devices must be temporarily removed from energy isolating devices and the machine or equipment must be energized to test or position the machine, equipment, or component thereof, the following sequence of actions shall be followed:

(A) Clear the machine or equipment of tools and materials in accordance with paragraph (d)(7)(i) of this section;

(B) Remove employees from the machine or equipment area in accordance with paragraphs (d)(7)(ii) and (d)(7)(iii) of this section;

(C) Remove the lockout or tagout devices as specified in paragraph (d)(7)(iv) of this section;

(D) Energize and proceed with the testing or positioning; and

(E) Deenergize all systems and reapply energy control measures in accordance with paragraph (d)(6) of this section to continue the servicing or maintenance.

(ii) When servicing or maintenance is performed by a crew, craft, department, or other group, they shall use a

procedure which affords the employees a level of protection equivalent to that provided by the implementation of a personal lockout or tagout device. Group lockout or tagout devices shall be used in accordance with the procedures required by paragraphs (d)(2)(iii) and (d)(2)(iv) of this section including, but not limited to, the following specific requirements:

(A) Primary responsibility shall be vested in an authorized employee for a set number of employees working under the protection of a group lockout or tagout device (such as an operations lock);

(B) Provision shall be made for the authorized employee to ascertain the exposure status of all individual group members with regard to the lockout or tagout of the machine or equipment;

(C) When more than one crew, craft, department, or other group is involved, assignment of overall job-associated lockout or tagout control responsibility shall be given to an authorized employee designated to coordinate affected work forces and ensure continuity of protection; and

(D) Each authorized employee shall affix a personal lockout or tagout device to the group lockout device, group lockbox, or comparable mechanism when he or she begins work and shall remove those devices when he or she stops working on the machine or equipment being serviced or maintained.

(iii) Procedures shall be used during shift or personnel changes to ensure the continuity of lockout or tagout protection, including provision for the orderly transfer of lockout or tagout device protection between off-going and on-coming employees, to minimize their exposure to hazards from the unexpected energizing or start-up of the machine or equipment or from the release of stored energy.

(iv) Whenever outside servicing personnel are to be engaged in activities covered by paragraph (d) of this section, the on-site employer and the outside employer shall inform each other of their respective lockout or tagout procedures, and each employer shall ensure that his or her personnel understand and comply with restrictions and prohibitions of the energy control procedures being used.

(v) If energy isolating devices are installed in a central location and are under the exclusive control of a system operator, the following requirements apply:

(A) The employer shall use a procedure that affords employees a level of protection equivalent to that provided by the implementation of a personal lockout or tagout device.

(B) The system operator shall place and remove lockout and tagout devices in place of the authorized employee under paragraphs (d)(4), (d)(6)(iv), and (d)(7)(iv) of this section.

(C) Provisions shall be made to identify the authorized employee who is responsible for (that is, being protected by) the lockout or tagout device, to transfer responsibility for lockout and tagout devices, and to ensure that an authorized employee requesting removal or transfer of a lockout or tagout device is the one responsible for it before the device is removed or transferred.

(e) *Enclosed spaces.* This paragraph covers enclosed spaces that may be entered by employees. It does not apply to vented vaults if a determination is made that the ventilation system is operating to protect employees before they enter the space. This paragraph applies to routine entry into enclosed spaces in lieu of the permit-space entry requirements contained in paragraphs (d) through (k) of §1910.146 of this part. If, after the precautions given in paragraphs (e) and (t) of this section are taken, the hazards remaining in the enclosed space endanger the life of an entrant or could interfere with escape from the space, then entry into the enclosed space shall meet the permit-space entry requirements of paragraphs (d) through (k) of §1910.146 of this part.

NOTE: Entries into enclosed spaces conducted in accordance with the permit-space entry requirements of paragraphs (d) through (k) of §1910.146 of this part are considered as complying with paragraph (e) of this section.

(1) *Safe work practices.* The employer shall ensure the use of safe work practices for entry into and work in enclosed spaces and for rescue of employees from such spaces.



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(2) *Training.* Employees who enter enclosed spaces or who serve as attendants shall be trained in the hazards of enclosed space entry, in enclosed space entry procedures, and in enclosed space rescue procedures.

(3) *Rescue equipment.* Employers shall provide equipment to ensure the prompt and safe rescue of employees from the enclosed space.

(4) *Evaluation of potential hazards.* Before any entrance cover to an enclosed space is removed, the employer shall determine whether it is safe to do so by checking for the presence of any atmospheric pressure or temperature differences and by evaluating whether there might be a hazardous atmosphere in the space. Any conditions making it unsafe to remove the cover shall be eliminated before the cover is removed.

NOTE: The evaluation called for in this paragraph may take the form of a check of the conditions expected to be in the enclosed space. For example, the cover could be checked to see if it is hot and, if it is fastened in place, could be loosened gradually to release any residual pressure. A determination must also be made of whether conditions at the site could cause a hazardous atmosphere, such as an oxygen deficient or flammable atmosphere, to develop within the space.

(5) *Removal of covers.* When covers are removed from enclosed spaces, the opening shall be promptly guarded by a railing, temporary cover, or other barrier intended to prevent an accidental fall through the opening and to protect employees working in the space from objects entering the space.

(6) *Hazardous atmosphere.* Employees may not enter any enclosed space while it contains a hazardous atmosphere, unless the entry conforms to the generic permit-required confined spaces standard in § 1910.146 of this part.

NOTE: The term "entry" is defined in § 1910.146(b) of this part.

(7) *Attendants.* While work is being performed in the enclosed space, a person with first aid training meeting paragraph (b) of this section shall be immediately available outside the enclosed space to render emergency assistance if there is reason to believe that a hazard may exist in the space or if a hazard exists because of traffic patterns in the area of the opening used

for entry. That person is not precluded from performing other duties outside the enclosed space if these duties do not distract the attendant from monitoring employees within the space.

NOTE: See paragraph (t)(3) of this section for additional requirements on attendants for work in manholes.

(8) *Calibration of test instruments.* Test instruments used to monitor atmospheres in enclosed spaces shall be kept in calibration, with a minimum accuracy of  $\pm 10$  percent.

(9) *Testing for oxygen deficiency.* Before an employee enters an enclosed space, the internal atmosphere shall be tested for oxygen deficiency with a direct-reading meter or similar instrument, capable of collection and immediate analysis of data samples without the need for off-site evaluation. If continuous forced air ventilation is provided, testing is not required provided that the procedures used ensure that employees are not exposed to the hazards posed by oxygen deficiency.

(10) *Testing for flammable gases and vapors.* Before an employee enters an enclosed space, the internal atmosphere shall be tested for flammable gases and vapors with a direct-reading meter or similar instrument capable of collection and immediate analysis of data samples without the need for off-site evaluation. This test shall be performed after the oxygen testing and ventilation required by paragraph (e)(9) of this section demonstrate that there is sufficient oxygen to ensure the accuracy of the test for flammability.

(11) *Ventilation and monitoring.* If flammable gases or vapors are detected or if an oxygen deficiency is found, forced air ventilation shall be used to maintain oxygen at a safe level and to prevent a hazardous concentration of flammable gases and vapors from accumulating. A continuous monitoring program to ensure that no increase in flammable gas or vapor concentration occurs may be followed in lieu of ventilation, if flammable gases or vapors are detected at safe levels.

NOTE: See the definition of hazardous atmosphere for guidance in determining whether or not a given concentration of a substance is considered to be hazardous.

(12) *Specific ventilation requirements.* If continuous forced air ventilation is used, it shall begin before entry is made and shall be maintained long enough to ensure that a safe atmosphere exists before employees are allowed to enter the work area. The forced air ventilation shall be so directed as to ventilate the immediate area where employees are present within the enclosed space and shall continue until all employees leave the enclosed space.

(13) *Air supply.* The air supply for the continuous forced air ventilation shall be from a clean source and may not increase the hazards in the enclosed space.

(14) *Open flames.* If open flames are used in enclosed spaces, a test for flammable gases and vapors shall be made immediately before the open flame device is used and at least once per hour while the device is used in the space. Testing shall be conducted more frequently if conditions present in the enclosed space indicate that once per hour is insufficient to detect hazardous accumulations of flammable gases or vapors.

NOTE: See the definition of hazardous atmosphere for guidance in determining whether or not a given concentration of a substance is considered to be hazardous.

(f) *Excavations.* Excavation operations shall comply with subpart P of part 1926 of this chapter.

(g) *Personal protective equipment—(1) General.* Personal protective equipment shall meet the requirements of subpart I of this part.

(2) *Fall protection.* (i) Personal fall arrest equipment shall meet the requirements of subpart M of part 1926 of this chapter.

(ii) Body belts and safety straps for work positioning shall meet the requirements of §1926.959 of this chapter.

(iii) Body belts, safety straps, lanyards, lifelines, and body harnesses shall be inspected before use each day to determine that the equipment is in safe working condition. Defective equipment may not be used.

(iv) Lifelines shall be protected against being cut or abraded.

(v) Fall arrest equipment, work positioning equipment, or travel restricting equipment shall be used by employ-

ees working at elevated locations more than 4 feet (1.2 m) above the ground on poles, towers, or similar structures if other fall protection has not been provided. Fall protection equipment is not required to be used by a qualified employee climbing or changing location on poles, towers, or similar structures, unless conditions, such as, but not limited to, ice, high winds, the design of the structure (for example, no provision for holding on with hands), or the presence of contaminants on the structure, could cause the employee to lose his or her grip or footing.

NOTE 1: This paragraph applies to structures that support overhead electric power generation, transmission, and distribution lines and equipment. It does not apply to portions of buildings, such as loading docks, to electric equipment, such as transformers and capacitors, nor to aerial lifts. Requirements for fall protection associated with walking and working surfaces are contained in subpart D of this part; requirements for fall protection associated with aerial lifts are contained in §1910.67 of this part.

NOTE 2: Employees undergoing training are not considered "qualified employees" for the purposes of this provision. Unqualified employees (including trainees) are required to use fall protection any time they are more than 4 feet (1.2 m) above the ground.

(vi) The following requirements apply to personal fall arrest systems:

(A) When stopping or arresting a fall, personal fall arrest systems shall limit the maximum arresting force on an employee to 900 pounds (4 kN) if used with a body belt.

(B) When stopping or arresting a fall, personal fall arrest systems shall limit the maximum arresting force on an employee to 1800 pounds (8 kN) if used with a body harness.

(C) Personal fall arrest systems shall be rigged such that an employee can neither free fall more than 6 feet (1.8 m) nor contact any lower level.

(vii) If vertical lifelines or droplines are used, not more than one employee may be attached to any one lifeline.

(viii) Snaphooks may not be connected to loops made in webbing-type lanyards.

(ix) Snaphooks may not be connected to each other.

(h) *Ladders, platforms, step bolts, and manhole steps—(1) General.* Requirements for ladders contained in subpart

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D of this part apply, except as specifically noted in paragraph (h)(2) of this section.

(2) *Special ladders and platforms.* Portable ladders and platforms used on structures or conductors in conjunction with overhead line work need not meet paragraphs (d)(2)(i) and (d)(2)(iii) of §1910.25 of this part or paragraph (c)(3)(iii) of §1910.26 of this part. However, these ladders and platforms shall meet the following requirements:

(i) Ladders and platforms shall be secured to prevent their becoming accidentally dislodged.

(ii) Ladders and platforms may not be loaded in excess of the working loads for which they are designed.

(iii) Ladders and platforms may be used only in applications for which they were designed.

(iv) In the configurations in which they are used, ladders and platforms shall be capable of supporting without failure at least 2.5 times the maximum intended load.

(3) *Conductive ladders.* Portable metal ladders and other portable conductive ladders may not be used near exposed energized lines or equipment. However, in specialized high-voltage work, conductive ladders shall be used where the employer can demonstrate that non-conductive ladders would present a greater hazard than conductive ladders.

(i) *Hand and portable power tools—(1) General.* Paragraph (i)(2) of this section applies to electric equipment connected by cord and plug. Paragraph (i)(3) of this section applies to portable and vehicle-mounted generators used to supply cord-and plug-connected equipment. Paragraph (i)(4) of this section applies to hydraulic and pneumatic tools.

(2) *Cord- and plug-connected equipment.* (i) Cord-and plug-connected equipment supplied by premises wiring is covered by subpart S of this part.

(ii) Any cord- and plug-connected equipment supplied by other than premises wiring shall comply with one of the following in lieu of §1910.243(a)(5) of this part:

(A) It shall be equipped with a cord containing an equipment grounding conductor connected to the tool frame and to a means for grounding the other

end (however, this option may not be used where the introduction of the ground into the work environment increases the hazard to an employee); or

(B) It shall be of the double-insulated type conforming to subpart S of this part; or

(C) It shall be connected to the power supply through an isolating transformer with an ungrounded secondary.

(3) *Portable and vehicle-mounted generators.* Portable and vehicle-mounted generators used to supply cord- and plug-connected equipment shall meet the following requirements:

(i) The generator may only supply equipment located on the generator or the vehicle and cord- and plug-connected equipment through receptacles mounted on the generator or the vehicle.

(ii) The non-current-carrying metal parts of equipment and the equipment grounding conductor terminals of the receptacles shall be bonded to the generator frame.

(iii) In the case of vehicle-mounted generators, the frame of the generator shall be bonded to the vehicle frame.

(iv) Any neutral conductor shall be bonded to the generator frame.

(4) *Hydraulic and pneumatic tools.* (i) Safe operating pressures for hydraulic and pneumatic tools, hoses, valves, pipes, filters, and fittings may not be exceeded.

NOTE: If any hazardous defects are present, no operating pressure would be safe, and the hydraulic or pneumatic equipment involved may not be used. In the absence of defects, the maximum rated operating pressure is the maximum safe pressure.

(ii) A hydraulic or pneumatic tool used where it may contact exposed live parts shall be designed and maintained for such use.

(iii) The hydraulic system supplying a hydraulic tool used where it may contact exposed live parts shall provide protection against loss of insulating value for the voltage involved due to the formation of a partial vacuum in the hydraulic line.

NOTE: Hydraulic lines without check valves having a separation of more than 35 feet (10.7 m) between the oil reservoir and the upper end of the hydraulic system promote the formation of a partial vacuum.

(iv) A pneumatic tool used on energized electric lines or equipment or used where it may contact exposed live parts shall provide protection against the accumulation of moisture in the air supply.

(v) Pressure shall be released before connections are broken, unless quick acting, self-closing connectors are used. Hoses may not be kinked.

(vi) Employees may not use any part of their bodies to locate or attempt to stop a hydraulic leak.

(j) *Live-line tools*—(1) *Design of tools.* Live-line tool rods, tubes, and poles shall be designed and constructed to withstand the following minimum tests:

(i) 100,000 volts per foot (3281 volts per centimeter) of length for 5 minutes if the tool is made of fiberglass-reinforced plastic (FRP), or

(ii) 75,000 volts per foot (2461 volts per centimeter) of length for 3 minutes if the tool is made of wood, or

(iii) Other tests that the employer can demonstrate are equivalent.

NOTE: Live-line tools using rod and tube that meet ASTM F711-89, Standard Specification for Fiberglass-Reinforced Plastic (FRP) Rod and Tube Used in Live-Line Tools, conform to paragraph (j)(1)(i) of this section.

(2) *Condition of tools.* (i) Each live-line tool shall be wiped clean and visually inspected for defects before use each day.

(ii) If any defect or contamination that could adversely affect the insulating qualities or mechanical integrity of the live-line tool is present after wiping, the tool shall be removed from service and examined and tested according to paragraph (j)(2)(iii) of this section before being returned to service.

(iii) Live-line tools used for primary employee protection shall be removed from service every 2 years and whenever required under paragraph (j)(2)(ii) of this section for examination, cleaning, repair, and testing as follows:

(A) Each tool shall be thoroughly examined for defects.

(B) If a defect or contamination that could adversely affect the insulating qualities or mechanical integrity of the live-line tool is found, the tool shall be repaired and refinished or shall

be permanently removed from service. If no such defect or contamination is found, the tool shall be cleaned and waxed.

(C) The tool shall be tested in accordance with paragraphs (j)(2)(iii)(D) and (j)(2)(iii)(E) of this section under the following conditions:

(1) After the tool has been repaired or refinished; and

(2) After the examination if repair or refinishing is not performed, unless the tool is made of FRP rod or foam-filled FRP tube and the employer can demonstrate that the tool has no defects that could cause it to fail in use.

(D) The test method used shall be designed to verify the tool's integrity along its entire working length and, if the tool is made of fiberglass-reinforced plastic, its integrity under wet conditions.

(E) The voltage applied during the tests shall be as follows:

(1) 75,000 volts per foot (2461 volts per centimeter) of length for 1 minute if the tool is made of fiberglass, or

(2) 50,000 volts per foot (1640 volts per centimeter) of length for 1 minute if the tool is made of wood, or

(3) Other tests that the employer can demonstrate are equivalent.

NOTE: Guidelines for the examination, cleaning, repairing, and in-service testing of live-line tools are contained in the Institute of Electrical and Electronics Engineers Guide for In-Service Maintenance and Electrical Testing of Live-Line Tools, IEEE Std. 978-1984.

(k) *Materials handling and storage*—(1) *General.* Material handling and storage shall conform to the requirements of subpart N of this part.

(2) *Materials storage near energized lines or equipment.* (i) In areas not restricted to qualified persons only, materials or equipment may not be stored closer to energized lines or exposed energized parts of equipment than the following distances plus an amount providing for the maximum sag and side swing of all conductors and providing for the height and movement of material handling equipment:

(A) For lines and equipment energized at 50 kV or less, the distance is 10 feet (305 cm).

(B) For lines and equipment energized at more than 50 kV, the distance

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is 10 feet (305 cm) plus 4 inches (10 cm) for every 10 kV over 50 kV.

(ii) In areas restricted to qualified employees, material may not be stored within the working space about energized lines or equipment.

NOTE: Requirements for the size of the working space are contained in paragraphs (u)(1) and (v)(3) of this section.

(1) *Working on or near exposed energized parts.* This paragraph applies to work on exposed live parts, or near enough to them, to expose the employee to any hazard they present.

(1) *General.* Only qualified employees may work on or with exposed energized lines or parts of equipment. Only qualified employees may work in areas containing unguarded, uninsulated energized lines or parts of equipment operating at 50 volts or more. Electric lines and equipment shall be considered and treated as energized unless the provisions of paragraph (d) or paragraph (m) of this section have been followed.

(i) Except as provided in paragraph (1)(1)(ii) of this section, at least two employees shall be present while the following types of work are being performed:

(A) Installation, removal, or repair of lines that are energized at more than 600 volts,

(B) Installation, removal, or repair of deenergized lines if an employee is exposed to contact with other parts energized at more than 600 volts,

(C) Installation, removal, or repair of equipment, such as transformers, capacitors, and regulators, if an employee is exposed to contact with parts energized at more than 600 volts,

(D) Work involving the use of mechanical equipment, other than insulated aerial lifts, near parts energized at more than 600 volts, and

(E) Other work that exposes an employee to electrical hazards greater than or equal to those posed by operations that are specifically listed in paragraphs (1)(1)(i)(A) through (1)(1)(i)(D) of this section.

(ii) Paragraph (1)(1)(i) of this section does not apply to the following operations:

(A) Routine switching of circuits, if the employer can demonstrate that conditions at the site allow this work to be performed safely,

(B) Work performed with live-line tools if the employee is positioned so that he or she is neither within reach of nor otherwise exposed to contact with energized parts, and

(C) Emergency repairs to the extent necessary to safeguard the general public.

(2) *Minimum approach distances.* The employer shall ensure that no employee approaches or takes any conductive object closer to exposed energized parts than set forth in Table R-6 through Table R-10, unless:

(i) The employee is insulated from the energized part (insulating gloves or insulating sleeves worn in accordance with paragraph (1)(3) of this section are considered insulation of the employee only with regard to the energized part upon which work is being performed), or

(ii) The energized part is insulated from the employee and from any other conductive object at a different potential, or

(iii) The employee is insulated from any other exposed conductive object, as during live-line bare-hand work.

NOTE: Paragraphs (u)(5)(i) and (v)(5)(i) of this section contain requirements for the guarding and isolation of live parts. Parts of electric circuits that meet these two provisions are not considered as "exposed" unless a guard is removed or an employee enters the space intended to provide isolation from the live parts.

(3) *Type of insulation.* If the employee is to be insulated from energized parts by the use of insulating gloves (under paragraph (1)(2)(i) of this section), insulating sleeves shall also be used. However, insulating sleeves need not be used under the following conditions:

(i) If exposed energized parts on which work is not being performed are insulated from the employee and

(ii) If such insulation is placed from a position not exposing the employee's upper arm to contact with other energized parts.

(4) *Working position.* The employer shall ensure that each employee, to the extent that other safety-related conditions at the worksite permit, works in a position from which a slip or shock will not bring the employee's body into contact with exposed, uninsulated

parts energized at a potential different from the employee.

(5) *Making connections.* The employer shall ensure that connections are made as follows:

(i) In connecting deenergized equipment or lines to an energized circuit by means of a conducting wire or device, an employee shall first attach the wire to the deenergized part;

(ii) When disconnecting equipment or lines from an energized circuit by means of a conducting wire or device, an employee shall remove the source end first; and

(iii) When lines or equipment are connected to or disconnected from energized circuits, loose conductors shall be kept away from exposed energized parts.

(6) *Apparel.* (i) When work is performed within reaching distance of exposed energized parts of equipment, the employer shall ensure that each employee removes or renders nonconductive all exposed conductive articles, such as key or watch chains, rings, or wrist watches or bands, unless such articles do not increase the hazards associated with contact with the energized parts.

(ii) The employer shall train each employee who is exposed to the hazards of flames or electric arcs in the hazards involved.

(iii) The employer shall ensure that each employee who is exposed to the hazards of flames or electric arcs does not wear clothing that, when exposed to flames or electric arcs, could increase the extent of injury that would be sustained by the employee.

NOTE: Clothing made from the following types of fabrics, either alone or in blends, is prohibited by this paragraph, unless the employer can demonstrate that the fabric has been treated to withstand the conditions that may be encountered or that the clothing is worn in such a manner as to eliminate the hazard involved: acetate, nylon, polyester, rayon.

(7) *Fuse handling.* When fuses must be installed or removed with one or both terminals energized at more than 300 volts or with exposed parts energized at more than 50 volts, the employer

shall ensure that tools or gloves rated for the voltage are used. When expulsion-type fuses are installed with one or both terminals energized at more than 300 volts, the employer shall ensure that each employee wears eye protection meeting the requirements of subpart I of this part, uses a tool rated for the voltage, and is clear of the exhaust path of the fuse barrel.

(8) *Covered (noninsulated) conductors.* The requirements of this section which pertain to the hazards of exposed live parts also apply when work is performed in the proximity of covered (noninsulated) wires.

(9) *Noncurrent-carrying metal parts.* Noncurrent-carrying metal parts of equipment or devices, such as transformer cases and circuit breaker housings, shall be treated as energized at the highest voltage to which they are exposed, unless the employer inspects the installation and determines that these parts are grounded before work is performed.

(10) *Opening circuits under load.* Devices used to open circuits under load conditions shall be designed to interrupt the current involved.

TABLE R-6—AC LIVE-LINE WORK MINIMUM APPROACH DISTANCE

Nominal voltage in kilovolts phase to phase	Distance			
	Phase to ground expo- sure		Phase to phase expo- sure	
	(ft-in)	(m)	(ft-in)	(m)
0.05 to 1.0 .....	( <sup>4</sup> )	( <sup>4</sup> )	( <sup>4</sup> )	( <sup>4</sup> )
1.1 to 15.0 .....	2-1	0.64	2-2	0.66
15.1 to 36.0 .....	2-4	0.72	2-7	0.77
36.1 to 46.0 .....	2-7	0.77	2-10	0.85
46.1 to 72.5 .....	3-0	0.90	3-6	1.05
72.6 to 121 .....	3-2	0.95	4-3	1.29
138 to 145 .....	3-7	1.09	4-11	1.50
161 to 169 .....	4-0	1.22	5-8	1.71
230 to 242 .....	5-3	1.59	7-6	2.27
345 to 362 .....	8-6	2.59	12-6	3.80
500 to 550 .....	11-3	3.42	18-1	5.50
765 to 800 .....	14-11	4.53	26-0	7.91

NOTE 1: These distances take into consideration the highest switching surge an employee will be exposed to on any system with air as the insulating medium and the maximum voltages shown.

NOTE 2: The clear live-line tool distance shall equal or exceed the values for the indicated voltage ranges.

NOTE 3: See appendix B to this section for information on how the minimum approach distances listed in the tables were derived.

<sup>4</sup>Avoid contact.

TABLE R-7—AC LIVE-LINE WORK MINIMUM APPROACH DISTANCE WITH OVERVOLTAGE FACTOR PHASE-TO-GROUND EXPOSURE

Maximum anticipated per-unit transient overvoltage	Distance in feet-inches						
	Maximum phase-to-phase voltage in kilovolts						
	121	145	169	242	362	552	800
1.5	.....	.....	.....	.....	.....	6-0	9-8
1.6	.....	.....	.....	.....	.....	6-6	10-8
1.7	.....	.....	.....	.....	.....	7-0	11-8
1.8	.....	.....	.....	.....	.....	7-7	12-8
1.9	.....	.....	.....	.....	.....	8-1	13-9
2.0	2-5	2-9	3-0	3-10	5-3	8-9	14-11
2.1	2-6	2-10	3-2	4-0	5-5	9-4	.....
2.2	2-7	2-11	3-3	4-1	5-9	9-11	.....
2.3	2-8	3-0	3-4	4-3	6-1	10-6	.....
2.4	2-9	3-1	3-5	4-5	6-4	11-3	.....
2.5	2-9	3-2	3-6	4-6	6-8	.....	.....
2.6	2-10	3-3	3-8	4-8	7-1	.....	.....
2.7	2-11	3-4	3-9	4-10	7-5	.....	.....
2.8	3-0	3-5	3-10	4-11	7-9	.....	.....
2.9	3-1	3-6	3-11	5-1	8-2	.....	.....
3.0	3-2	3-7	4-0	5-3	8-6	.....	.....

NOTE 1: The distance specified in this table may be applied only where the maximum anticipated per-unit transient overvoltage has been determined by engineering analysis and has been supplied by the employer. Table R-6 applies otherwise.  
 NOTE 2: The distances specified in this table are the air, bare-hand, and live-line tool distances.  
 NOTE 3: See appendix B to this section for information on how the minimum approach distances listed in the tables were derived and on how to calculate revised minimum approach distances based on the control of transient overvoltages.

TABLE R-8—AC LIVE-LINE WORK MINIMUM APPROACH DISTANCE WITH OVERVOLTAGE FACTOR PHASE-TO-PHASE EXPOSURE

Maximum anticipated per-unit transient overvoltage	Distance in feet-inches						
	Maximum phase-to-phase voltage in kilovolts						
	121	145	169	242	362	552	800
1.5	.....	.....	.....	.....	.....	7-4	12-1
1.6	.....	.....	.....	.....	.....	8-9	14-6
1.7	.....	.....	.....	.....	.....	10-2	17-2
1.8	.....	.....	.....	.....	.....	11-7	19-11
1.9	.....	.....	.....	.....	.....	13-2	22-11
2.0	3-7	4-1	4-8	6-1	8-7	14-10	26-0
2.1	3-7	4-2	4-9	6-3	8-10	15-7	.....
2.2	3-8	4-3	4-10	6-4	9-2	16-4	.....
2.3	3-9	4-4	4-11	6-6	9-6	17-2	.....
2.4	3-10	4-5	5-0	6-7	9-11	18-1	.....
2.5	3-11	4-6	5-2	6-9	10-4	.....	.....
2.6	4-0	4-7	5-3	6-11	10-9	.....	.....
2.7	4-1	4-8	5-4	7-0	11-2	.....	.....
2.8	4-1	4-9	5-5	7-2	11-7	.....	.....
2.9	4-2	4-10	5-6	7-4	12-1	.....	.....
3.0	4-3	4-11	5-8	7-6	12-6	.....	.....

NOTE 1: The distance specified in this table may be applied only where the maximum anticipated per-unit transient overvoltage has been determined by engineering analysis and has been supplied by the employer. Table R-6 applies otherwise.  
 NOTE 2: The distances specified in this table are the air, bare-hand, and live-line tool distances.  
 NOTE 3: See appendix B to this section for information on how the minimum approach distances listed in the tables were derived and on how to calculate revised minimum approach distances based on the control of transient overvoltages.

TABLE R-9—DC LIVE-LINE WORK MINIMUM APPROACH DISTANCE WITH OVERVOLTAGE FACTOR

Maximum anticipated per-unit transient overvoltage	Distance in feet-inches				
	Maximum line-to-ground voltage in kilovolts				
	250	400	500	600	750
1.5 or lower	3-8	5-3	6-9	8-7	11-10
1.6	3-10	5-7	7-4	9-5	13-1
1.7	4-1	6-0	7-11	10-3	14-4
1.8	4-3	6-5	8-7	11-2	15-9

NOTE 1: The distances specified in this table may be applied only where the maximum anticipated per-unit transient overvoltage has been determined by engineering analysis and has been supplied by the employer. However, if the transient overvoltage factor is not known, a factor of 1.8 shall be assumed.

NOTE 2: The distances specified in this table are the air, bare-hand, and live-line tool distances.

TABLE R-10—ALTITUDE CORRECTION FACTOR

Altitude		Correction factor
ft	m	
3000	900	1.00
4000	1200	1.02
5000	1500	1.05
6000	1800	1.08
7000	2100	1.11
8000	2400	1.14
9000	2700	1.17
10000	3000	1.20
12000	3600	1.25
14000	4200	1.30
16000	4800	1.35
18000	5400	1.39
20000	6000	1.44

NOTE: If the work is performed at elevations greater than 3000 ft (900 m) above mean sea level, the minimum approach distance shall be determined by multiplying the distances in Table R-6 through Table R-9 by the correction factor corresponding to the altitude at which work is performed.

(m) *Deenergizing lines and equipment for employee protection*—(1) *Application.* Paragraph (m) of this section applies to the deenergizing of transmission and distribution lines and equipment for the purpose of protecting employees. Control of hazardous energy sources used in the generation of electric energy is covered in paragraph (d) of this section. Conductors and parts of electric equipment that have been deenergized under procedures other than those required by paragraph (d) or (m) of this section, as applicable, shall be treated as energized.

(2) *General.* (i) If a system operator is in charge of the lines or equipment and their means of disconnection, all of the requirements of paragraph (m)(3) of this section shall be observed, in the order given.

(ii) If no system operator is in charge of the lines or equipment and their means of disconnection, one employee in the crew shall be designated as being in charge of the clearance. All of the requirements of paragraph (m)(3) of this section apply, in the order given, except as provided in paragraph (m)(2)(iii) of this section. The employee in charge of the clearance shall take the place of the system operator, as necessary.

(iii) If only one crew will be working on the lines or equipment and if the means of disconnection is accessible and visible to and under the sole control of the employee in charge of the clearance, paragraphs (m)(3)(i),

(m)(3)(iii), (m)(3)(iv), (m)(3)(viii), and (m)(3)(xii) of this section do not apply. Additionally, tags required by the remaining provisions of paragraph (m)(3) of this section need not be used.

(iv) Any disconnecting means that are accessible to persons outside the employer's control (for example, the general public) shall be rendered inoperable while they are open for the purpose of protecting employees.

(3) *Deenergizing lines and equipment.* (i) A designated employee shall make a request of the system operator to have the particular section of line or equipment deenergized. The designated employee becomes the employee in charge (as this term is used in paragraph (m)(3) of this section) and is responsible for the clearance.

(ii) All switches, disconnectors, jumpers, taps, and other means through which known sources of electric energy may be supplied to the particular lines and equipment to be deenergized shall be opened. Such means shall be rendered inoperable, unless its design does not so permit, and tagged to indicate that employees are at work.

(iii) Automatically and remotely controlled switches that could cause the opened disconnecting means to close shall also be tagged at the point of control. The automatic or remote control feature shall be rendered inoperable, unless its design does not so permit.

(iv) Tags shall prohibit operation of the disconnecting means and shall indicate that employees are at work.

(v) After the applicable requirements in paragraphs (m)(3)(i) through (m)(3)(iv) of this section have been followed and the employee in charge of the work has been given a clearance by the system operator, the lines and equipment to be worked shall be tested to ensure that they are deenergized.

(vi) Protective grounds shall be installed as required by paragraph (n) of this section.

(vii) After the applicable requirements of paragraphs (m)(3)(i) through (m)(3)(vi) of this section have been followed, the lines and equipment involved may be worked as deenergized.

(viii) If two or more independent crews will be working on the same



lines or equipment, each crew shall independently comply with the requirements in paragraph (m)(3) of this section.

(ix) To transfer the clearance, the employee in charge (or, if the employee in charge is forced to leave the worksite due to illness or other emergency, the employee's supervisor) shall inform the system operator; employees in the crew shall be informed of the transfer; and the new employee in charge shall be responsible for the clearance.

(x) To release a clearance, the employee in charge shall:

(A) Notify employees under his or her direction that the clearance is to be released;

(B) Determine that all employees in the crew are clear of the lines and equipment;

(C) Determine that all protective grounds installed by the crew have been removed; and

(D) Report this information to the system operator and release the clearance.

(xi) The person releasing a clearance shall be the same person that requested the clearance, unless responsibility has been transferred under paragraph (m)(3)(ix) of this section.

(xii) Tags may not be removed unless the associated clearance has been released under paragraph (m)(3)(x) of this section.

(xiii) Only after all protective grounds have been removed, after all crews working on the lines or equipment have released their clearances, after all employees are clear of the lines and equipment, and after all protective tags have been removed from a given point of disconnection, may action be initiated to reenergize the lines or equipment at that point of disconnection.

(n) *Grounding for the protection of employees—(1) Application.* Paragraph (n) of this section applies to the grounding of transmission and distribution lines and equipment for the purpose of protecting employees. Paragraph (n)(4) of this section also applies to the protective grounding of other equipment as required elsewhere in this section.

(2) *General.* For the employee to work lines or equipment as deenergized, the lines or equipment shall be deenergized

under the provisions of paragraph (m) of this section and shall be grounded as specified in paragraphs (n)(3) through (n)(9) of this section. However, if the employer can demonstrate that installation of a ground is impracticable or that the conditions resulting from the installation of a ground would present greater hazards than working without grounds, the lines and equipment may be treated as deenergized provided all of the following conditions are met:

(i) The lines and equipment have been deenergized under the provisions of paragraph (m) of this section.

(ii) There is no possibility of contact with another energized source.

(iii) The hazard of induced voltage is not present.

(3) *Equipotential zone.* Temporary protective grounds shall be placed at such locations and arranged in such a manner as to prevent each employee from being exposed to hazardous differences in electrical potential.

(4) *Protective grounding equipment.* (i) Protective grounding equipment shall be capable of conducting the maximum fault current that could flow at the point of grounding for the time necessary to clear the fault. This equipment shall have an ampacity greater than or equal to that of No. 2 AWG copper.

NOTE: Guidelines for protective grounding equipment are contained in American Society for Testing and Materials Standard Specifications for Temporary Grounding Systems to be Used on De-Energized Electric Power Lines and Equipment, ASTM F855–1990.

(ii) Protective grounds shall have an impedance low enough to cause immediate operation of protective devices in case of accidental energizing of the lines or equipment.

(5) *Testing.* Before any ground is installed, lines and equipment shall be tested and found absent of nominal voltage, unless a previously installed ground is present.

(6) *Order of connection.* When a ground is to be attached to a line or to equipment, the ground-end connection shall be attached first, and then the other end shall be attached by means of a live-line tool.

(7) *Order of removal.* When a ground is to be removed, the grounding device shall be removed from the line or

equipment using a live-line tool before the ground-end connection is removed.

(8) *Additional precautions.* When work is performed on a cable at a location remote from the cable terminal, the cable may not be grounded at the cable terminal if there is a possibility of hazardous transfer of potential should a fault occur.

(9) *Removal of grounds for test.* Grounds may be removed temporarily during tests. During the test procedure, the employer shall ensure that each employee uses insulating equipment and is isolated from any hazards involved, and the employer shall institute any additional measures as may be necessary to protect each exposed employee in case the previously grounded lines and equipment become energized.

(o) *Testing and test facilities—(1) Application.* Paragraph (o) of this section provides for safe work practices for high-voltage and high-power testing performed in laboratories, shops, and substations, and in the field and on electric transmission and distribution lines and equipment. It applies only to testing involving interim measurements utilizing high voltage, high power, or combinations of both, and not to testing involving continuous measurements as in routine metering, relaying, and normal line work.

NOTE: Routine inspection and maintenance measurements made by qualified employees are considered to be routine line work and are not included in the scope of paragraph (o) of this section, as long as the hazards related to the use of intrinsic high-voltage or high-power sources require only the normal precautions associated with routine operation and maintenance work required in the other paragraphs of this section. Two typical examples of such excluded test work procedures are "phasing-out" testing and testing for a "no-voltage" condition.

(2) *General requirements.* (i) The employer shall establish and enforce work practices for the protection of each worker from the hazards of high-voltage or high-power testing at all test areas, temporary and permanent. Such work practices shall include, as a minimum, test area guarding, grounding, and the safe use of measuring and control circuits. A means providing for periodic safety checks of field test

areas shall also be included. (See paragraph (o)(6) of this section.)

(ii) Employees shall be trained in safe work practices upon their initial assignment to the test area, with periodic reviews and updates provided as required by paragraph (a)(2) of this section.

(3) *Guarding of test areas.* (i) Permanent test areas shall be guarded by walls, fences, or barriers designed to keep employees out of the test areas.

(ii) In field testing, or at a temporary test site where permanent fences and gates are not provided, one of the following means shall be used to prevent unauthorized employees from entering:

(A) The test area shall be guarded by the use of distinctively colored safety tape that is supported approximately waist high and to which safety signs are attached,

(B) The test area shall be guarded by a barrier or barricade that limits access to the test area to a degree equivalent, physically and visually, to the barricade specified in paragraph (o)(3)(ii)(A) of this section, or

(C) The test area shall be guarded by one or more test observers stationed so that the entire area can be monitored.

(iii) The barriers required by paragraph (o)(3)(ii) of this section shall be removed when the protection they provide is no longer needed.

(iv) Guarding shall be provided within test areas to control access to test equipment or to apparatus under test that may become energized as part of the testing by either direct or inductive coupling, in order to prevent accidental employee contact with energized parts.

(4) *Grounding practices.* (i) The employer shall establish and implement safe grounding practices for the test facility.

(A) All conductive parts accessible to the test operator during the time the equipment is operating at high voltage shall be maintained at ground potential except for portions of the equipment that are isolated from the test operator by guarding.

(B) Wherever ungrounded terminals of test equipment or apparatus under test may be present, they shall be treated as energized until determined by tests to be deenergized.

(ii) Visible grounds shall be applied, either automatically or manually with properly insulated tools, to the high-voltage circuits after they are deenergized and before work is performed on the circuit or item or apparatus under test. Common ground connections shall be solidly connected to the test equipment and the apparatus under test.

(iii) In high-power testing, an isolated ground-return conductor system shall be provided so that no intentional passage of current, with its attendant voltage rise, can occur in the ground grid or in the earth. However, an isolated ground-return conductor need not be provided if the employer can demonstrate that both the following conditions are met:

(A) An isolated ground-return conductor cannot be provided due to the distance of the test site from the electric energy source, and

(B) Employees are protected from any hazardous step and touch potentials that may develop during the test.

NOTE: See appendix C to this section for information on measures that can be taken to protect employees from hazardous step and touch potentials.

(iv) In tests in which grounding of test equipment by means of the equipment grounding conductor located in the equipment power cord cannot be used due to increased hazards to test personnel or the prevention of satisfactory measurements, a ground that the employer can demonstrate affords equivalent safety shall be provided, and the safety ground shall be clearly indicated in the test set-up.

(v) When the test area is entered after equipment is deenergized, a ground shall be placed on the high-voltage terminal and any other exposed terminals.

(A) High capacitance equipment or apparatus shall be discharged through a resistor rated for the available energy.

(B) A direct ground shall be applied to the exposed terminals when the stored energy drops to a level at which it is safe to do so.

(vi) If a test trailer or test vehicle is used in field testing, its chassis shall be grounded. Protection against hazardous touch potentials with respect to the vehicle, instrument panels, and

other conductive parts accessible to employees shall be provided by bonding, insulation, or isolation.

(5) *Control and measuring circuits.* (i) Control wiring, meter connections, test leads and cables may not be run from a test area unless they are contained in a grounded metallic sheath and terminated in a grounded metallic enclosure or unless other precautions are taken that the employer can demonstrate as ensuring equivalent safety.

(ii) Meters and other instruments with accessible terminals or parts shall be isolated from test personnel to protect against hazards arising from such terminals and parts becoming energized during testing. If this isolation is provided by locating test equipment in metal compartments with viewing windows, interlocks shall be provided to interrupt the power supply if the compartment cover is opened.

(iii) The routing and connections of temporary wiring shall be made secure against damage, accidental interruptions and other hazards. To the maximum extent possible, signal, control, ground, and power cables shall be kept separate.

(iv) If employees will be present in the test area during testing, a test observer shall be present. The test observer shall be capable of implementing the immediate deenergizing of test circuits for safety purposes.

(6) *Safety check.* (i) Safety practices governing employee work at temporary or field test areas shall provide for a routine check of such test areas for safety at the beginning of each series of tests.

(ii) The test operator in charge shall conduct these routine safety checks before each series of tests and shall verify at least the following conditions:

(A) That barriers and guards are in workable condition and are properly placed to isolate hazardous areas;

(B) That system test status signals, if used, are in operable condition;

(C) That test power disconnects are clearly marked and readily available in an emergency;

(D) That ground connections are clearly identifiable;

(E) That personal protective equipment is provided and used as required

by subpart I of this part and by this section; and

(F) That signal, ground, and power cables are properly separated.

(p) *Mechanical equipment*—(1) *General requirements.* (i) The critical safety components of mechanical elevating and rotating equipment shall receive a thorough visual inspection before use on each shift.

NOTE: Critical safety components of mechanical elevating and rotating equipment are components whose failure would result in a free fall or free rotation of the boom.

(ii) No vehicular equipment having an obstructed view to the rear may be operated on off-highway jobsites where any employee is exposed to the hazards created by the moving vehicle, unless:

(A) The vehicle has a reverse signal alarm audible above the surrounding noise level, or

(B) The vehicle is backed up only when a designated employee signals that it is safe to do so.

(iii) The operator of an electric line truck may not leave his or her position at the controls while a load is suspended, unless the employer can demonstrate that no employee (including the operator) might be endangered.

(iv) Rubber-tired, self-propelled scrapers, rubber-tired front-end loaders, rubber-tired dozers, wheel-type agricultural and industrial tractors, crawler-type tractors, crawler-type loaders, and motor graders, with or without attachments, shall have roll-over protective structures that meet the requirements of subpart W of part 1926 of this chapter.

(2) *Outriggers.* (i) Vehicular equipment, if provided with outriggers, shall be operated with the outriggers extended and firmly set as necessary for the stability of the specific configuration of the equipment. Outriggers may not be extended or retracted outside of clear view of the operator unless all employees are outside the range of possible equipment motion.

(ii) If the work area or the terrain precludes the use of outriggers, the equipment may be operated only within its maximum load ratings for the particular configuration of the equipment without outriggers.

(3) *Applied loads.* Mechanical equipment used to lift or move lines or other

material shall be used within its maximum load rating and other design limitations for the conditions under which the work is being performed.

(4) *Operations near energized lines or equipment.* (i) Mechanical equipment shall be operated so that the minimum approach distances of Table R-6 through Table R-10 are maintained from exposed energized lines and equipment. However, the insulated portion of an aerial lift operated by a qualified employee in the lift is exempt from this requirement.

(ii) A designated employee other than the equipment operator shall observe the approach distance to exposed lines and equipment and give timely warnings before the minimum approach distance required by paragraph (p)(4)(i) is reached, unless the employer can demonstrate that the operator can accurately determine that the minimum approach distance is being maintained.

(iii) If, during operation of the mechanical equipment, the equipment could become energized, the operation shall also comply with at least one of paragraphs (p)(4)(iii)(A) through (p)(4)(iii)(C) of this section.

(A) The energized lines exposed to contact shall be covered with insulating protective material that will withstand the type of contact that might be made during the operation.

(B) The equipment shall be insulated for the voltage involved. The equipment shall be positioned so that its uninsulated portions cannot approach the lines or equipment any closer than the minimum approach distances specified in Table R-6 through Table R-10.

(C) Each employee shall be protected from hazards that might arise from equipment contact with the energized lines. The measures used shall ensure that employees will not be exposed to hazardous differences in potential. Unless the employer can demonstrate that the methods in use protect each employee from the hazards that might arise if the equipment contacts the energized line, the measures used shall include all of the following techniques:

(1) Using the best available ground to minimize the time the lines remain energized,

(2) Bonding equipment together to minimize potential differences,

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(3) Providing ground mats to extend areas of equipotential, and

(4) Employing insulating protective equipment or barricades to guard against any remaining hazardous potential differences.

NOTE: Appendix C to this section contains information on hazardous step and touch potentials and on methods of protecting employees from hazards resulting from such potentials.

(q) *Overhead lines.* This paragraph provides additional requirements for work performed on or near overhead lines and equipment.

(1) *General.* (i) Before elevated structures, such as poles or towers, are subjected to such stresses as climbing or the installation or removal of equipment may impose, the employer shall ascertain that the structures are capable of sustaining the additional or unbalanced stresses. If the pole or other structure cannot withstand the loads which will be imposed, it shall be braced or otherwise supported so as to prevent failure.

NOTE: Appendix D to this section contains test methods that can be used in ascertaining whether a wood pole is capable of sustaining the forces that would be imposed by an employee climbing the pole. This paragraph also requires the employer to ascertain that the pole can sustain all other forces that will be imposed by the work to be performed.

(ii) When poles are set, moved, or removed near exposed energized overhead conductors, the pole may not contact the conductors.

(iii) When a pole is set, moved, or removed near an exposed energized overhead conductor, the employer shall ensure that each employee wears electrical protective equipment or uses insulated devices when handling the pole and that no employee contacts the pole with uninsulated parts of his or her body.

(iv) To protect employees from falling into holes into which poles are to be placed, the holes shall be attended by employees or physically guarded whenever anyone is working nearby.

(2) *Installing and removing overhead lines.* The following provisions apply to the installation and removal of overhead conductors or cable.

(i) The employer shall use the tension stringing method, barriers, or other equivalent measures to minimize the possibility that conductors and cables being installed or removed will contact energized power lines or equipment.

(ii) The protective measures required by paragraph (p)(4)(iii) of this section for mechanical equipment shall also be provided for conductors, cables, and pulling and tensioning equipment when the conductor or cable is being installed or removed close enough to energized conductors that any of the following failures could energize the pulling or tensioning equipment or the wire or cable being installed or removed:

(A) Failure of the pulling or tensioning equipment,

(B) Failure of the wire or cable being pulled, or

(C) Failure of the previously installed lines or equipment.

(iii) If the conductors being installed or removed cross over energized conductors in excess of 600 volts and if the design of the circuit-interrupting devices protecting the lines so permits, the automatic-reclosing feature of these devices shall be made inoperative.

(iv) Before lines are installed parallel to existing energized lines, the employer shall make a determination of the approximate voltage to be induced in the new lines, or work shall proceed on the assumption that the induced voltage is hazardous. Unless the employer can demonstrate that the lines being installed are not subject to the induction of a hazardous voltage or unless the lines are treated as energized, the following requirements also apply:

(A) Each bare conductor shall be grounded in increments so that no point along the conductor is more than 2 miles (3.22 km) from a ground.

(B) The grounds required in paragraph (q)(2)(iv)(A) of this section shall be left in place until the conductor installation is completed between dead ends.

(C) The grounds required in paragraph (q)(2)(iv)(A) of this section shall be removed as the last phase of aerial cleanup.

(D) If employees are working on bare conductors, grounds shall also be installed at each location where these employees are working, and grounds shall be installed at all open dead-end or catch-off points or the next adjacent structure.

(E) If two bare conductors are to be spliced, the conductors shall be bonded and grounded before being spliced.

(v) Reel handling equipment, including pulling and tensioning devices, shall be in safe operating condition and shall be leveled and aligned.

(vi) Load ratings of stringing lines, pulling lines, conductor grips, load-bearing hardware and accessories, rigging, and hoists may not be exceeded.

(vii) Pulling lines and accessories shall be repaired or replaced when defective.

(viii) Conductor grips may not be used on wire rope, unless the grip is specifically designed for this application.

(ix) Reliable communications, through two-way radios or other equivalent means, shall be maintained between the reel tender and the pulling rig operator.

(x) The pulling rig may only be operated when it is safe to do so.

NOTE: Examples of unsafe conditions include employees in locations prohibited by paragraph (q)(2)(xi) of this section, conductor and pulling line hang-ups, and slipping of the conductor grip.

(xi) While the conductor or pulling line is being pulled (in motion) with a power-driven device, employees are not permitted directly under overhead operations or on the cross arm, except as necessary to guide the stringing sock or board over or through the stringing sheave.

(3) *Live-line bare-hand work.* In addition to other applicable provisions contained in this section, the following requirements apply to live-line bare-hand work:

(i) Before using or supervising the use of the live-line bare-hand technique on energized circuits, employees shall be trained in the technique and in the safety requirements of paragraph (q)(3) of this section. Employees shall receive refresher training as required by paragraph (a)(2) of this section.

(ii) Before any employee uses the live-line bare-hand technique on energized high-voltage conductors or parts, the following information shall be ascertained:

(A) The nominal voltage rating of the circuit on which the work is to be performed.

(B) The minimum approach distances to ground of lines and other energized parts on which work is to be performed, and

(C) The voltage limitations of equipment to be used.

(iii) The insulated equipment, insulated tools, and aerial devices and platforms used shall be designed, tested, and intended for live-line bare-hand work. Tools and equipment shall be kept clean and dry while they are in use.

(iv) The automatic-reclosing feature of circuit-interrupting devices protecting the lines shall be made inoperative, if the design of the devices permits.

(v) Work may not be performed when adverse weather conditions would make the work hazardous even after the work practices required by this section are employed. Additionally, work may not be performed when winds reduce the phase-to-phase or phase-to-ground minimum approach distances at the work location below that specified in paragraph (q)(3)(xiii) of this section, unless the grounded objects and other lines and equipment are covered by insulating guards.

NOTE: Thunderstorms in the immediate vicinity, high winds, snow storms, and ice storms are examples of adverse weather conditions that are presumed to make live-line bare-hand work too hazardous to perform safely.

(vi) A conductive bucket liner or other conductive device shall be provided for bonding the insulated aerial device to the energized line or equipment.

(A) The employee shall be connected to the bucket liner or other conductive device by the use of conductive shoes, leg clips, or other means.

(B) Where differences in potentials at the worksite pose a hazard to employees, electrostatic shielding designed for the voltage being worked shall be provided.

(vii) Before the employee contacts the energized part, the conductive bucket liner or other conductive device shall be bonded to the energized conductor by means of a positive connection. This connection shall remain attached to the energized conductor until the work on the energized circuit is completed.

(viii) Aerial lifts to be used for live-line bare-hand work shall have dual controls (lower and upper) as follows:

(A) The upper controls shall be within easy reach of the employee in the bucket. On a two-bucket-type lift, access to the controls shall be within easy reach from either bucket.

(B) The lower set of controls shall be located near the base of the boom, and they shall be so designed that they can override operation of the equipment at any time.

(ix) Lower (ground-level) lift controls may not be operated with an employee in the lift, except in case of emergency.

(x) Before employees are elevated into the work position, all controls (ground level and bucket) shall be checked to determine that they are in proper working condition.

(xi) Before the boom of an aerial lift is elevated, the body of the truck shall be grounded, or the body of the truck shall be barricaded and treated as energized.

(xii) A boom-current test shall be made before work is started each day, each time during the day when higher voltage is encountered, and when changed conditions indicate a need for an additional test. This test shall consist of placing the bucket in contact with an energized source equal to the voltage to be encountered for a minimum of 3 minutes. The leakage current may not exceed 1 microampere per kilovolt of nominal phase-to-ground voltage. Work from the aerial lift shall be immediately suspended upon indication of a malfunction in the equipment.

(xiii) The minimum approach distances specified in Table R-6 through Table R-10 shall be maintained from all grounded objects and from lines and equipment at a potential different from that to which the live-line bare-hand equipment is bonded, unless such grounded objects and other lines and

equipment are covered by insulating guards.

(xiv) While an employee is approaching, leaving, or bonding to an energized circuit, the minimum approach distances in Table R-6 through Table R-10 shall be maintained between the employee and any grounded parts, including the lower boom and portions of the truck.

(xv) While the bucket is positioned alongside an energized bushing or insulator string, the phase-to-ground minimum approach distances of Table R-6 through Table R-10 shall be maintained between all parts of the bucket and the grounded end of the bushing or insulator string or any other grounded surface.

(xvi) Hand lines may not be used between the bucket and the boom or between the bucket and the ground. However, non-conductive-type hand lines may be used from conductor to ground if not supported from the bucket. Ropes used for live-line bare-hand work may not be used for other purposes.

(xvii) Uninsulated equipment or material may not be passed between a pole or structure and an aerial lift while an employee working from the bucket is bonded to an energized part.

(xviii) A minimum approach distance table reflecting the minimum approach distances listed in Table R-6 through Table R-10 shall be printed on a plate of durable non-conductive material. This table shall be mounted so as to be visible to the operator of the boom.

(xix) A non-conductive measuring device shall be readily accessible to assist employees in maintaining the required minimum approach distance.

(4) *Towers and structures.* The following requirements apply to work performed on towers or other structures which support overhead lines.

(i) The employer shall ensure that no employee is under a tower or structure while work is in progress, except where the employer can demonstrate that such a working position is necessary to assist employees working above.

(ii) Tag lines or other similar devices shall be used to maintain control of tower sections being raised or positioned, unless the employer can demonstrate that the use of such devices would create a greater hazard.

(iii) The loadline may not be detached from a member or section until the load is safely secured.

(iv) Except during emergency restoration procedures, work shall be discontinued when adverse weather conditions would make the work hazardous in spite of the work practices required by this section.

NOTE: Thunderstorms in the immediate vicinity, high winds, snow storms, and ice storms are examples of adverse weather conditions that are presumed to make this work too hazardous to perform, except under emergency conditions.

(r) *Line-clearance tree trimming operations.* This paragraph provides additional requirements for line-clearance tree-trimming operations and for equipment used in these operations.

(1) *Electrical hazards.* This paragraph does not apply to qualified employees.

(i) Before an employee climbs, enters, or works around any tree, a determination shall be made of the nominal voltage of electric power lines posing a hazard to employees. However, a determination of the maximum nominal voltage to which an employee will be exposed may be made instead, if all lines are considered as energized at this maximum voltage.

(ii) There shall be a second line-clearance tree trimmer within normal (that is, unassisted) voice communication under any of the following conditions:

(A) If a line-clearance tree trimmer is to approach more closely than 10 feet (305 cm) any conductor or electric apparatus energized at more than 750 volts or

(B) If branches or limbs being removed are closer to lines energized at more than 750 volts than the distances listed in Table R-6, Table R-9, and Table R-10 or

(C) If roping is necessary to remove branches or limbs from such conductors or apparatus.

(iii) Line-clearance tree trimmers shall maintain the minimum approach distances from energized conductors given in Table R-6, Table R-9, and Table R-10.

(iv) Branches that are contacting exposed energized conductors or equipment or that are within the distances specified in Table R-6, Table R-9, and Table R-10 may be removed only

through the use of insulating equipment.

NOTE: A tool constructed of a material that the employer can demonstrate has insulating qualities meeting paragraph (j)(1) of this section is considered as insulated under this paragraph if the tool is clean and dry.

(v) Ladders, platforms, and aerial devices may not be brought closer to an energized part than the distances listed in Table R-6, Table R-9, and Table R-10.

(vi) Line-clearance tree-trimming work may not be performed when adverse weather conditions make the work hazardous in spite of the work practices required by this section. Each employee performing line-clearance tree trimming work in the aftermath of a storm or under similar emergency conditions shall be trained in the special hazards related to this type of work.

NOTE: Thunderstorms in the immediate vicinity, high winds, snow storms, and ice storms are examples of adverse weather conditions that are presumed to make line-clearance tree trimming work too hazardous to perform safely.

(2) *Brush chippers.* (i) Brush chippers shall be equipped with a locking device in the ignition system.

(ii) Access panels for maintenance and adjustment of the chipper blades and associated drive train shall be in place and secure during operation of the equipment.

(iii) Brush chippers not equipped with a mechanical infeed system shall be equipped with an infeed hopper of length sufficient to prevent employees from contacting the blades or knives of the machine during operation.

(iv) Trailer chippers detached from trucks shall be chocked or otherwise secured.

(v) Each employee in the immediate area of an operating chipper feed table shall wear personal protective equipment as required by subpart I of this part.

(3) *Sprayers and related equipment.* (i) Walking and working surfaces of sprayers and related equipment shall be covered with slip-resistant material. If slipping hazards cannot be eliminated, slip-resistant footwear or handrails and stair rails meeting the requirements of



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subpart D may be used instead of slip-resistant material.

(ii) Equipment on which employees stand to spray while the vehicle is in motion shall be equipped with guardrails around the working area. The guardrail shall be constructed in accordance with subpart D of this part.

(4) *Stump cutters.* (i) Stump cutters shall be equipped with enclosures or guards to protect employees.

(ii) Each employee in the immediate area of stump grinding operations (including the stump cutter operator) shall wear personal protective equipment as required by subpart I of this part.

(5) *Gasoline-engine power saws.* Gasoline-engine power saw operations shall meet the requirements of §1910.266(e) and the following:

(i) Each power saw weighing more than 15 pounds (6.8 kilograms, service weight) that is used in trees shall be supported by a separate line, except when work is performed from an aerial lift and except during topping or removing operations where no supporting limb will be available.

(ii) Each power saw shall be equipped with a control that will return the saw to idling speed when released.

(iii) Each power saw shall be equipped with a clutch and shall be so adjusted that the clutch will not engage the chain drive at idling speed.

(iv) A power saw shall be started on the ground or where it is otherwise firmly supported. Drop starting of saws over 15 pounds (6.8 kg) is permitted outside of the bucket of an aerial lift only if the area below the lift is clear of personnel.

(v) A power saw engine may be started and operated only when all employees other than the operator are clear of the saw.

(vi) A power saw may not be running when the saw is being carried up into a tree by an employee.

(vii) Power saw engines shall be stopped for all cleaning, refueling, adjustments, and repairs to the saw or motor, except as the manufacturer's servicing procedures require otherwise.

(6) *Backpack power units for use in pruning and clearing.* (i) While a backpack power unit is running, no one other than the operator may be within

10 feet (305 cm) of the cutting head of a brush saw.

(ii) A backpack power unit shall be equipped with a quick shutoff switch readily accessible to the operator.

(iii) Backpack power unit engines shall be stopped for all cleaning, refueling, adjustments, and repairs to the saw or motor, except as the manufacturer's servicing procedures require otherwise.

(7) *Rope.* (i) Climbing ropes shall be used by employees working aloft in trees. These ropes shall have a minimum diameter of 0.5 inch (1.2 cm) with a minimum breaking strength of 2300 pounds (10.2 kN). Synthetic rope shall have elasticity of not more than 7 percent.

(ii) Rope shall be inspected before each use and, if unsafe (for example, because of damage or defect), may not be used.

(iii) Rope shall be stored away from cutting edges and sharp tools. Rope contact with corrosive chemicals, gas, and oil shall be avoided.

(iv) When stored, rope shall be coiled and piled, or shall be suspended, so that air can circulate through the coils.

(v) Rope ends shall be secured to prevent their unraveling.

(vi) Climbing rope may not be spliced to effect repair.

(vii) A rope that is wet, that is contaminated to the extent that its insulating capacity is impaired, or that is otherwise not considered to be insulated for the voltage involved may not be used near exposed energized lines.

(8) *Fall protection.* Each employee shall be tied in with a climbing rope and safety saddle when the employee is working above the ground in a tree, unless he or she is ascending into the tree.

(s) *Communication facilities—(1) Microwave transmission.* (i) The employer shall ensure that no employee looks into an open waveguide or antenna that is connected to an energized microwave source.

(ii) If the electromagnetic radiation level within an accessible area associated with microwave communications systems exceeds the radiation protection guide given in §1910.97(a)(2) of this part, the area shall be posted with the

warning symbol described in §1910.97(a)(3) of this part. The lower half of the warning symbol shall include the following statements or ones that the employer can demonstrate are equivalent:

Radiation in this area may exceed hazard limitations and special precautions are required. Obtain specific instruction before entering.

(iii) When an employee works in an area where the electromagnetic radiation could exceed the radiation protection guide, the employer shall institute measures that ensure that the employee's exposure is not greater than that permitted by that guide. Such measures may include administrative and engineering controls and personal protective equipment.

(2) *Power line carrier.* Power line carrier work, including work on equipment used for coupling carrier current to power line conductors, shall be performed in accordance with the requirements of this section pertaining to work on energized lines.

(t) *Underground electrical installations.* This paragraph provides additional requirements for work on underground electrical installations.

(1) *Access.* A ladder or other climbing device shall be used to enter and exit a manhole or subsurface vault exceeding 4 feet (122 cm) in depth. No employee may climb into or out of a manhole or vault by stepping on cables or hangers.

(2) *Lowering equipment into manholes.* Equipment used to lower materials and tools into manholes or vaults shall be capable of supporting the weight to be lowered and shall be checked for defects before use. Before tools or material are lowered into the opening for a manhole or vault, each employee working in the manhole or vault shall be clear of the area directly under the opening.

(3) *Attendants for manholes.* (i) While work is being performed in a manhole containing energized electric equipment, an employee with first aid and CPR training meeting paragraph (b)(1) of this section shall be available on the surface in the immediate vicinity to render emergency assistance.

(ii) Occasionally, the employee on the surface may briefly enter a man-

hole to provide assistance, other than emergency.

NOTE 1: An attendant may also be required under paragraph (e)(7) of this section. One person may serve to fulfill both requirements. However, attendants required under paragraph (e)(7) of this section are not permitted to enter the manhole.

NOTE 2: Employees entering manholes containing unguarded, uninsulated energized lines or parts of electric equipment operating at 50 volts or more are required to be qualified under paragraph (1)(1) of this section.

(iii) For the purpose of inspection, housekeeping, taking readings, or similar work, an employee working alone may enter, for brief periods of time, a manhole where energized cables or equipment are in service, if the employer can demonstrate that the employee will be protected from all electrical hazards.

(iv) Reliable communications, through two-way radios or other equivalent means, shall be maintained among all employees involved in the job.

(4) *Duct rods.* If duct rods are used, they shall be installed in the direction presenting the least hazard to employees. An employee shall be stationed at the far end of the duct line being rodged to ensure that the required minimum approach distances are maintained.

(5) *Multiple cables.* When multiple cables are present in a work area, the cable to be worked shall be identified by electrical means, unless its identity is obvious by reason of distinctive appearance or location or by other readily apparent means of identification. Cables other than the one being worked shall be protected from damage.

(6) *Moving cables.* Energized cables that are to be moved shall be inspected for defects.

(7) *Defective cables.* Where a cable in a manhole has one or more abnormalities that could lead to or be an indication of an impending fault, the defective cable shall be deenergized before any employee may work in the manhole, except when service load conditions and a lack of feasible alternatives require that the cable remain energized. In that case, employees may enter the manhole provided they are protected from the possible effects of a failure by

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shields or other devices that are capable of containing the adverse effects of a fault in the joint.

NOTE: Abnormalities such as oil or compound leaking from cable or joints, broken cable sheaths or joint sleeves, hot localized surface temperatures of cables or joints, or joints that are swollen beyond normal tolerance are presumed to lead to or be an indication of an impending fault.

(8) *Sheath continuity.* When work is performed on buried cable or on cable in manholes, metallic sheath continuity shall be maintained or the cable sheath shall be treated as energized.

(u) *Substations.* This paragraph provides additional requirements for substations and for work performed in them.

(1) *Access and working space.* Sufficient access and working space shall be provided and maintained about electric equipment to permit ready and safe operation and maintenance of such equipment.

NOTE: Guidelines for the dimensions of access and working space about electric equipment in substations are contained in American National Standard—National Electrical Safety Code, ANSI C2-1987. Installations meeting the ANSI provisions comply with paragraph (u)(1) of this section. An installation that does not conform to this ANSI standard will, nonetheless, be considered as complying with paragraph (u)(1) of this section if the employer can demonstrate that the installation provides ready and safe access based on the following evidence:

(1) That the installation conforms to the edition of ANSI C2 that was in effect at the time the installation was made,

(2) That the configuration of the installation enables employees to maintain the minimum approach distances required by paragraph (1)(2) of this section while they are working on exposed, energized parts, and

(3) That the precautions taken when work is performed on the installation provide protection equivalent to the protection that would be provided by access and working space meeting ANSI C2-1987.

(2) *Draw-out-type circuit breakers.* When draw-out-type circuit breakers are removed or inserted, the breaker shall be in the open position. The control circuit shall also be rendered inoperative, if the design of the equipment permits.

(3) *Substation fences.* Conductive fences around substations shall be

grounded. When a substation fence is expanded or a section is removed, fence grounding continuity shall be maintained, and bonding shall be used to prevent electrical discontinuity.

(4) *Guarding of rooms containing electric supply equipment.* (i) Rooms and spaces in which electric supply lines or equipment are installed shall meet the requirements of paragraphs (u)(4)(ii) through (u)(4)(v) of this section under the following conditions:

(A) If exposed live parts operating at 50 to 150 volts to ground are located within 8 feet of the ground or other working surface inside the room or space,

(B) If live parts operating at 151 to 600 volts and located within 8 feet of the ground or other working surface inside the room or space are guarded only by location, as permitted under paragraph (u)(5)(1) of this section, or

(C) If live parts operating at more than 600 volts are located within the room or space, unless:

(1) The live parts are enclosed within grounded, metal-enclosed equipment whose only openings are designed so that foreign objects inserted in these openings will be deflected from energized parts, or

(2) The live parts are installed at a height above ground and any other working surface that provides protection at the voltage to which they are energized corresponding to the protection provided by an 8-foot height at 50 volts.

(ii) The rooms and spaces shall be so enclosed within fences, screens, partitions, or walls as to minimize the possibility that unqualified persons will enter.

(iii) Signs warning unqualified persons to keep out shall be displayed at entrances to the rooms and spaces.

(iv) Entrances to rooms and spaces that are not under the observation of an attendant shall be kept locked.

(v) Unqualified persons may not enter the rooms or spaces while the electric supply lines or equipment are energized.

(5) *Guarding of energized parts.* (i) Guards shall be provided around all live parts operating at more than 150 volts to ground without an insulating covering, unless the location of the live

parts gives sufficient horizontal or vertical or a combination of these clearances to minimize the possibility of accidental employee contact.

NOTE: Guidelines for the dimensions of clearance distances about electric equipment in substations are contained in American National Standard—National Electrical Safety Code, ANSI C2-1987. Installations meeting the ANSI provisions comply with paragraph (u)(5)(i) of this section. An installation that does not conform to this ANSI standard will, nonetheless, be considered as complying with paragraph (u)(5)(i) of this section if the employer can demonstrate that the installation provides sufficient clearance based on the following evidence:

(1) That the installation conforms to the edition of ANSI C2 that was in effect at the time the installation was made,

(2) That each employee is isolated from energized parts at the point of closest approach, and

(3) That the precautions taken when work is performed on the installation provide protection equivalent to the protection that would be provided by horizontal and vertical clearances meeting ANSI C2-1987.

(ii) Except for fuse replacement and other necessary access by qualified persons, the guarding of energized parts within a compartment shall be maintained during operation and maintenance functions to prevent accidental contact with energized parts and to prevent tools or other equipment from being dropped on energized parts.

(iii) When guards are removed from energized equipment, barriers shall be installed around the work area to prevent employees who are not working on the equipment, but who are in the area, from contacting the exposed live parts.

(6) *Substation entry.* (i) Upon entering an attended substation, each employee other than those regularly working in the station shall report his or her presence to the employee in charge in order to receive information on special system conditions affecting employee safety.

(ii) The job briefing required by paragraph (c) of this section shall cover such additional subjects as the location of energized equipment in or adjacent to the work area and the limits of any deenergized work area.

(v) *Power generation.* This paragraph provides additional requirements and

related work practices for power generating plants.

(1) *Interlocks and other safety devices.* (i) Interlocks and other safety devices shall be maintained in a safe, operable condition.

(ii) No interlock or other safety device may be modified to defeat its function, except for test, repair, or adjustment of the device.

(2) *Changing brushes.* Before exciter or generator brushes are changed while the generator is in service, the exciter or generator field shall be checked to determine whether a ground condition exists. The brushes may not be changed while the generator is energized if a ground condition exists.

(3) *Access and working space.* Sufficient access and working space shall be provided and maintained about electric equipment to permit ready and safe operation and maintenance of such equipment.

NOTE: Guidelines for the dimensions of access and working space about electric equipment in generating stations are contained in American National Standard—National Electrical Safety Code, ANSI C2-1987. Installations meeting the ANSI provisions comply with paragraph (v)(3) of this section. An installation that does not conform to this ANSI standard will, nonetheless, be considered as complying with paragraph (v)(3) of this section if the employer can demonstrate that the installation provides ready and safe access based on the following evidence:

(1) That the installation conforms to the edition of ANSI C2 that was in effect at the time the installation was made,

(2) That the configuration of the installation enables employees to maintain the minimum approach distances required by paragraph (1)(2) of this section while they are working on exposed, energized parts, and

(3) That the precautions taken when working is performed on the installation provide protection equivalent to the protection that would be provided by access and working space meeting ANSI C2-1987.

(4) *Guarding of rooms containing electric supply equipment.* (i) Rooms and spaces in which electric supply lines or equipment are installed shall meet the requirements of paragraphs (v)(4)(ii) through (v)(4)(v) of this section under the following conditions:

(A) If exposed live parts operating at 50 to 150 volts to ground are located within 8 feet of the ground or other

working surface inside the room or space.

(B) If live parts operating at 151 to 600 volts and located within 8 feet of the ground or other working surface inside the room or space are guarded only by location, as permitted under paragraph (v)(5)(i) of this section, or

(C) If live parts operating at more than 600 volts are located within the room or space, unless:

(1) The live parts are enclosed within grounded, metal-enclosed equipment whose only openings are designed so that foreign objects inserted in these openings will be deflected from energized parts, or

(2) The live parts are installed at a height above ground and any other working surface that provides protection at the voltage to which they are energized corresponding to the protection provided by an 8-foot height at 50 volts.

(ii) The rooms and spaces shall be so enclosed within fences, screens, partitions, or walls as to minimize the possibility that unqualified persons will enter.

(iii) Signs warning unqualified persons to keep out shall be displayed at entrances to the rooms and spaces.

(iv) Entrances to rooms and spaces that are not under the observation of an attendant shall be kept locked.

(v) Unqualified persons may not enter the rooms or spaces while the electric supply lines or equipment are energized.

(5) *Guarding of energized parts.* (i) Guards shall be provided around all live parts operating at more than 150 volts to ground without an insulating covering, unless the location of the live parts gives sufficient horizontal or vertical or a combination of these clearances to minimize the possibility of accidental employee contact.

NOTE: Guidelines for the dimensions of clearance distances about electric equipment in generating stations are contained in American National Standard—National Electrical Safety Code, ANSI C2-1987. Installations meeting the ANSI provisions comply with paragraph (v)(5)(i) of this section. An installation that does not conform to this ANSI standard will, nonetheless, be considered as complying with paragraph (v)(5)(i) of this section if the employer can demonstrate

that the installation provides sufficient clearance based on the following evidence:

(1) That the installation conforms to the edition of ANSI C2 that was in effect at the time the installation was made,

(2) That each employee is isolated from energized parts at the point of closest approach, and

(3) That the precautions taken when work is performed on the installation provide protection equivalent to the protection that would be provided by horizontal and vertical clearances meeting ANSI C2-1987.

(ii) Except for fuse replacement or other necessary access by qualified persons, the guarding of energized parts within a compartment shall be maintained during operation and maintenance functions to prevent accidental contact with energized parts and to prevent tools or other equipment from being dropped on energized parts.

(iii) When guards are removed from energized equipment, barriers shall be installed around the work area to prevent employees who are not working on the equipment, but who are in the area, from contacting the exposed live parts.

(6) *Water or steam spaces.* The following requirements apply to work in water and steam spaces associated with boilers:

(i) A designated employee shall inspect conditions before work is permitted and after its completion. Eye protection, or full face protection if necessary, shall be worn at all times when condenser, heater, or boiler tubes are being cleaned.

(ii) Where it is necessary for employees to work near tube ends during cleaning, shielding shall be installed at the tube ends.

(7) *Chemical cleaning of boilers and pressure vessels.* The following requirements apply to chemical cleaning of boilers and pressure vessels:

(i) Areas where chemical cleaning is in progress shall be cordoned off to restrict access during cleaning. If flammable liquids, gases, or vapors or combustible materials will be used or might be produced during the cleaning process, the following requirements also apply:

(A) The area shall be posted with signs restricting entry and warning of the hazards of fire and explosion; and

(B) Smoking, welding, and other possible ignition sources are prohibited in these restricted areas.

(ii) The number of personnel in the restricted area shall be limited to those necessary to accomplish the task safely.

(iii) There shall be ready access to water or showers for emergency use.

NOTE: See § 1910.141 of this part for requirements that apply to the water supply and to washing facilities.

(iv) Employees in restricted areas shall wear protective equipment meeting the requirements of subpart I of this part and including, but not limited to, protective clothing, boots, goggles, and gloves.

(8) *Chlorine systems.* (i) Chlorine system enclosures shall be posted with signs restricting entry and warning of the hazard to health and the hazards of fire and explosion.

NOTE: See subpart Z of this part for requirements necessary to protect the health of employees from the effects of chlorine.

(ii) Only designated employees may enter the restricted area. Additionally, the number of personnel shall be limited to those necessary to accomplish the task safely.

(iii) Emergency repair kits shall be available near the shelter or enclosure to allow for the prompt repair of leaks in chlorine lines, equipment, or containers.

(iv) Before repair procedures are started, chlorine tanks, pipes, and equipment shall be purged with dry air and isolated from other sources of chlorine.

(v) The employer shall ensure that chlorine is not mixed with materials that would react with the chlorine in a dangerously exothermic or other hazardous manner.

(9) *Boilers.* (i) Before internal furnace or ash hopper repair work is started, overhead areas shall be inspected for possible falling objects. If the hazard of falling objects exists, overhead protection such as planking or nets shall be provided.

(ii) When opening an operating boiler door, employees shall stand clear of the opening of the door to avoid the heat blast and gases which may escape from the boiler.

(10) *Turbine generators.* (i) Smoking and other ignition sources are prohibited near hydrogen or hydrogen sealing systems, and signs warning of the danger of explosion and fire shall be posted.

(ii) Excessive hydrogen makeup or abnormal loss of pressure shall be considered as an emergency and shall be corrected immediately.

(iii) A sufficient quantity of inert gas shall be available to purge the hydrogen from the largest generator.

(11) *Coal and ash handling.* (i) Only designated persons may operate railroad equipment.

(ii) Before a locomotive or locomotive crane is moved, a warning shall be given to employees in the area.

(iii) Employees engaged in switching or dumping cars may not use their feet to line up drawheads.

(iv) Drawheads and knuckles may not be shifted while locomotives or cars are in motion.

(v) When a railroad car is stopped for unloading, the car shall be secured from displacement that could endanger employees.

(vi) An emergency means of stopping dump operations shall be provided at railcar dumps.

(vii) The employer shall ensure that employees who work in coal- or ash-handling conveyor areas are trained and knowledgeable in conveyor operation and in the requirements of paragraphs (v)(11)(viii) through (v)(11)(xii) of this section.

(viii) Employees may not ride a coal- or ash-handling conveyor belt at any time. Employees may not cross over the conveyor belt, except at walkways, unless the conveyor's energy source has been deenergized and has been locked out or tagged in accordance with paragraph (d) of this section.

(ix) What could cause injury when started may not be started until personnel in the area are alerted by a signal or by a designated person that the conveyor is about to start.

(x) If a conveyor that could cause injury when started is automatically controlled or is controlled from a remote location, an audible device shall be provided that sounds an alarm that will be recognized by each employee as a warning that the conveyor will start

and that can be clearly heard at all points along the conveyor where personnel may be present. The warning device shall be actuated by the device starting the conveyor and shall continue for a period of time before the conveyor starts that is long enough to allow employees to move clear of the conveyor system. A visual warning may be used in place of the audible device if the employer can demonstrate that it will provide an equally effective warning in the particular circumstances involved.

*Exception:* If the employer can demonstrate that the system's function would be seriously hindered by the required time delay, warning signs may be provided in place of the audible warning device. If the system was installed before January 31, 1995, warning signs may be provided in place of the audible warning device until such time as the conveyor or its control system is rebuilt or rewired. These warning signs shall be clear, concise, and legible and shall indicate that conveyors and allied equipment may be started at any time, that danger exists, and that personnel must keep clear. These warning signs shall be provided along the conveyor at areas not guarded by position or location.

(xi) Remotely and automatically controlled conveyors, and conveyors that have operating stations which are not manned or which are beyond voice and visual contact from drive areas, loading areas, transfer points, and other locations on the conveyor path not guarded by location, position, or guards shall be furnished with emergency stop buttons, pull cords, limit switches, or similar emergency stop devices. However, if the employer can demonstrate that the design, function, and operation of the conveyor do not expose an employee to hazards, an emergency stop device is not required.

(A) Emergency stop devices shall be easily identifiable in the immediate vicinity of such locations.

(B) An emergency stop device shall act directly on the control of the conveyor involved and may not depend on the stopping of any other equipment.

(C) Emergency stop devices shall be installed so that they cannot be overridden from other locations.

(xii) Where coal-handling operations may produce a combustible atmosphere from fuel sources or from flammable gases or dust, sources of ignition shall be eliminated or safely controlled to prevent ignition of the combustible atmosphere.

NOTE: Locations that are hazardous because of the presence of combustible dust are classified as Class II hazardous locations. See §1910.307 of this part.

(xiii) An employee may not work on or beneath overhanging coal in coal bunkers, coal silos, or coal storage areas, unless the employee is protected from all hazards posed by shifting coal.

(xiv) An employee entering a bunker or silo to dislodge the contents shall wear a body harness with lifeline attached. The lifeline shall be secured to a fixed support outside the bunker and shall be attended at all times by an employee located outside the bunker or facility.

(12) *Hydroplants and equipment.* Employees working on or close to water gates, valves, intakes, forebays, flumes, or other locations where increased or decreased water flow or levels may pose a significant hazard shall be warned and shall vacate such dangerous areas before water flow changes are made.

(w) *Special conditions—(1) Capacitors.* The following additional requirements apply to work on capacitors and on lines connected to capacitors.

NOTE: See paragraphs (m) and (n) of this section for requirements pertaining to the deenergizing and grounding of capacitor installations.

(i) Before employees work on capacitors, the capacitors shall be disconnected from energized sources and, after a wait of at least 5 minutes from the time of disconnection, short-circuited.

(ii) Before the units are handled, each unit in series-parallel capacitor banks shall be short-circuited between all terminals and the capacitor case or its rack. If the cases of capacitors are on ungrounded substation racks, the racks shall be bonded to ground.

(iii) Any line to which capacitors are connected shall be short-circuited before it is considered deenergized.

(2) *Current transformer secondaries.* The secondary of a current transformer may not be opened while the transformer is energized. If the primary of the current transformer cannot be deenergized before work is performed on an instrument, a relay, or other section of a current transformer secondary circuit, the circuit shall be bridged so that the current transformer secondary will not be opened.

(3) *Series streetlighting.* (i) If the open-circuit voltage exceeds 600 volts, the series streetlighting circuit shall be worked in accordance with paragraph (q) or (t) of this section, as appropriate.

(ii) A series loop may only be opened after the streetlighting transformer has been deenergized and isolated from the source of supply or after the loop is bridged to avoid an open-circuit condition.

(4) *Illumination.* Sufficient illumination shall be provided to enable the employee to perform the work safely.

(5) *Protection against drowning.* (i) Whenever an employee may be pulled or pushed or may fall into water where the danger of drowning exists, the employee shall be provided with and shall use U.S. Coast Guard approved personal flotation devices.

(ii) Each personal flotation device shall be maintained in safe condition and shall be inspected frequently enough to ensure that it does not have rot, mildew, water saturation, or any other condition that could render the device unsuitable for use.

(iii) An employee may cross streams or other bodies of water only if a safe means of passage, such as a bridge, is provided.

(6) *Employee protection in public work areas.* (i) Traffic control signs and traffic control devices used for the protection of employees shall meet the requirements of §1926.200(g)(2) of this chapter.

(ii) Before work is begun in the vicinity of vehicular or pedestrian traffic that may endanger employees, warning signs or flags and other traffic control devices shall be placed in conspicuous locations to alert and channel approaching traffic.

(iii) Where additional employee protection is necessary, barricades shall be used.

(iv) Excavated areas shall be protected with barricades.

(v) At night, warning lights shall be prominently displayed.

(7) *Backfeed.* If there is a possibility of voltage backfeed from sources of co-generation or from the secondary system (for example, backfeed from more than one energized phase feeding a common load), the requirements of paragraph (1) of this section apply if the lines or equipment are to be worked as energized, and the requirements of paragraphs (m) and (n) of this section apply if the lines or equipment are to be worked as deenergized.

(8) *Lasers.* Laser equipment shall be installed, adjusted, and operated in accordance with §1926.54 of this chapter.

(9) *Hydraulic fluids.* Hydraulic fluids used for the insulated sections of equipment shall provide insulation for the voltage involved.

(x) *Definitions.*

*Affected employee.* An employee whose job requires him or her to operate or use a machine or equipment on which servicing or maintenance is being performed under lockout or tagout, or whose job requires him or her to work in an area in which such servicing or maintenance is being performed.

*Attendant.* An employee assigned to remain immediately outside the entrance to an enclosed or other space to render assistance as needed to employees inside the space.

*Authorized employee.* An employee who locks out or tags out machines or equipment in order to perform servicing or maintenance on that machine or equipment. An affected employee becomes an authorized employee when that employee's duties include performing servicing or maintenance covered under this section.

*Automatic circuit recloser.* A self-controlled device for interrupting and reclosing an alternating current circuit with a predetermined sequence of opening and reclosing followed by resetting, hold-closed, or lockout operation.

*Barricade.* A physical obstruction such as tapes, cones, or A-frame type wood or metal structures intended to



provide a warning about and to limit access to a hazardous area.

*Barrier.* A physical obstruction which is intended to prevent contact with energized lines or equipment or to prevent unauthorized access to a work area.

*Bond.* The electrical interconnection of conductive parts designed to maintain a common electrical potential.

*Bus.* A conductor or a group of conductors that serve as a common connection for two or more circuits.

*Bushing.* An insulating structure, including a through conductor or providing a passageway for such a conductor, with provision for mounting on a barrier, conducting or otherwise, for the purposes of insulating the conductor from the barrier and conducting current from one side of the barrier to the other.

*Cable.* A conductor with insulation, or a stranded conductor with or without insulation and other coverings (single-conductor cable), or a combination of conductors insulated from one another (multiple-conductor cable).

*Cable sheath.* A conductive protective covering applied to cables.

NOTE: A cable sheath may consist of multiple layers of which one or more is conductive.

*Circuit.* A conductor or system of conductors through which an electric current is intended to flow.

*Clearance (between objects).* The clear distance between two objects measured surface to surface.

*Clearance (for work).* Authorization to perform specified work or permission to enter a restricted area.

*Communication lines.* (See *Lines, communication.*)

*Conductor.* A material, usually in the form of a wire, cable, or bus bar, used for carrying an electric current.

*Covered conductor.* A conductor covered with a dielectric having no rated insulating strength or having a rated insulating strength less than the voltage of the circuit in which the conductor is used.

*Current-carrying part.* A conducting part intended to be connected in an electric circuit to a source of voltage. Non-current-carrying parts are those not intended to be so connected.

*Deenergized.* Free from any electrical connection to a source of potential difference and from electric charge; not having a potential different from that of the earth.

NOTE: The term is used only with reference to current-carrying parts, which are sometimes energized (alive).

*Designated employee (designated person).* An employee (or person) who is designated by the employer to perform specific duties under the terms of this section and who is knowledgeable in the construction and operation of the equipment and the hazards involved.

*Electric line truck.* A truck used to transport personnel, tools, and material for electric supply line work.

*Electric supply equipment.* Equipment that produces, modifies, regulates, controls, or safeguards a supply of electric energy.

*Electric supply lines.* (See *Lines, electric supply.*)

*Electric utility.* An organization responsible for the installation, operation, or maintenance of an electric supply system.

*Enclosed space.* A working space, such as a manhole, vault, tunnel, or shaft, that has a limited means of egress or entry, that is designed for periodic employee entry under normal operating conditions, and that under normal conditions does not contain a hazardous atmosphere, but that may contain a hazardous atmosphere under abnormal conditions.

NOTE: Spaces that are enclosed but not designed for employee entry under normal operating conditions are not considered to be enclosed spaces for the purposes of this section. Similarly, spaces that are enclosed and that are expected to contain a hazardous atmosphere are not considered to be enclosed spaces for the purposes of this section. Such spaces meet the definition of permit spaces in §1910.146 of this part, and entry into them must be performed in accordance with that standard.

*Energized (alive, live).* Electrically connected to a source of potential difference, or electrically charged so as to have a potential significantly different from that of earth in the vicinity.

*Energy isolating device.* A physical device that prevents the transmission or release of energy, including, but not limited to, the following: a manually

operated electric circuit breaker, a disconnect switch, a manually operated switch, a slide gate, a slip blind, a line valve, blocks, and any similar device with a visible indication of the position of the device. (Push buttons, selector switches, and other control-circuit-type devices are not energy isolating devices.)

*Energy source.* Any electrical, mechanical, hydraulic, pneumatic, chemical, nuclear, thermal, or other energy source that could cause injury to personnel.

*Equipment (electric).* A general term including material, fittings, devices, appliances, fixtures, apparatus, and the like used as part of or in connection with an electrical installation.

*Exposed.* Not isolated or guarded.

*Ground.* A conducting connection, whether intentional or accidental, between an electric circuit or equipment and the earth, or to some conducting body that serves in place of the earth.

*Grounded.* Connected to earth or to some conducting body that serves in place of the earth.

*Guarded.* Covered, fenced, enclosed, or otherwise protected, by means of suitable covers or casings, barrier rails or screens, mats, or platforms, designed to minimize the possibility, under normal conditions, of dangerous approach or accidental contact by persons or objects.

NOTE: Wires which are insulated, but not otherwise protected, are not considered as guarded.

*Hazardous atmosphere* means an atmosphere that may expose employees to the risk of death, incapacitation, impairment of ability to self-rescue (that is, escape unaided from an enclosed space), injury, or acute illness from one or more of the following causes:

(1) Flammable gas, vapor, or mist in excess of 10 percent of its lower flammable limit (LFL);

(2) Airborne combustible dust at a concentration that meets or exceeds its LFL;

NOTE: This concentration may be approximated as a condition in which the dust obscures vision at a distance of 5 feet (1.52 m) or less.

(3) Atmospheric oxygen concentration below 19.5 percent or above 23.5 percent;

(4) Atmospheric concentration of any substance for which a dose or a permissible exposure limit is published in Subpart G, *Occupational Health and Environmental Control*, or in Subpart Z, *Toxic and Hazardous Substances*, of this part and which could result in employee exposure in excess of its dose or permissible exposure limit;

NOTE: An atmospheric concentration of any substance that is not capable of causing death, incapacitation, impairment of ability to self-rescue, injury, or acute illness due to its health effects is not covered by this provision.

(5) Any other atmospheric condition that is immediately dangerous to life or health.

NOTE: For air contaminants for which OSHA has not determined a dose or permissible exposure limit, other sources of information, such as Material Safety Data Sheets that comply with the Hazard Communication Standard, §1910.1200 of this part, published information, and internal documents can provide guidance in establishing acceptable atmospheric conditions.

*High-power tests.* Tests in which fault currents, load currents, magnetizing currents, and line-dropping currents are used to test equipment, either at the equipment's rated voltage or at lower voltages.

*High-voltage tests.* Tests in which voltages of approximately 1000 volts are used as a practical minimum and in which the voltage source has sufficient energy to cause injury.

*High wind.* A wind of such velocity that the following hazards would be present:

(1) An employee would be exposed to being blown from elevated locations, or

(2) An employee or material handling equipment could lose control of material being handled, or

(3) An employee would be exposed to other hazards not controlled by the standard involved.

NOTE: Winds exceeding 40 miles per hour (64.4 kilometers per hour), or 30 miles per hour (48.3 kilometers per hour) if material handling is involved, are normally considered as meeting this criteria unless precautions are taken to protect employees from the hazardous effects of the wind.

*Immediately dangerous to life or health* (IDLH) means any condition that poses an immediate or delayed threat to life or that would cause irreversible adverse health effects or that would interfere with an individual's ability to escape unaided from a permit space.

NOTE: Some materials—hydrogen fluoride gas and cadmium vapor, for example—may produce immediate transient effects that, even if severe, may pass without medical attention, but are followed by sudden, possibly fatal collapse 12-72 hours after exposure. The victim “feels normal” from recovery from transient effects until collapse. Such materials in hazardous quantities are considered to be “immediately” dangerous to life or health.

*Insulated.* Separated from other conducting surfaces by a dielectric (including air space) offering a high resistance to the passage of current.

NOTE: When any object is said to be insulated, it is understood to be insulated for the conditions to which it is normally subjected. Otherwise, it is, within the purpose of this section, uninsulated.

*Insulation (cable).* That which is relied upon to insulate the conductor from other conductors or conducting parts or from ground.

*Line-clearance tree trimmer.* An employee who, through related training or on-the-job experience or both, is familiar with the special techniques and hazards involved in line-clearance tree trimming.

NOTE 1: An employee who is regularly assigned to a line-clearance tree-trimming crew and who is undergoing on-the-job training and who, in the course of such training, has demonstrated an ability to perform duties safely at his or her level of training and who is under the direct supervision of a line-clearance tree trimmer is considered to be a line-clearance tree trimmer for the performance of those duties.

NOTE 2: A line-clearance tree trimmer is not considered to be a “qualified employee” under this section unless he or she has the training required for a qualified employee under paragraph (a)(2)(ii) of this section. However, under the electrical safety-related work practices standard in subpart S of this part, a line-clearance tree trimmer is considered to be a “qualified employee”. Tree trimming performed by such “qualified employees” is not subject to the electrical safety-related work practice requirements contained in §§ 1910.331 through 1910.335 of this part. (See also the note following

§ 1910.332(b)(3) of this part for information regarding the training an employee must have to be considered a qualified employee under §§ 1910.331 through 1910.335 of this part.)

*Line-clearance tree trimming.* The pruning, trimming, repairing, maintaining, removing, or clearing of trees or the cutting of brush that is within 10 feet (305 cm) of electric supply lines and equipment.

*Lines—(1) Communication lines.* The conductors and their supporting or containing structures which are used for public or private signal or communication service, and which operate at potentials not exceeding 400 volts to ground or 750 volts between any two points of the circuit, and the transmitted power of which does not exceed 150 watts. If the lines are operating at less than 150 volts, no limit is placed on the transmitted power of the system. Under certain conditions, communication cables may include communication circuits exceeding these limitations where such circuits are also used to supply power solely to communication equipment.

NOTE: Telephone, telegraph, railroad signal, data, clock, fire, police alarm, cable television, and other systems conforming to this definition are included. Lines used for signaling purposes, but not included under this definition, are considered as electric supply lines of the same voltage.

(2) *Electric supply lines.* Conductors used to transmit electric energy and their necessary supporting or containing structures. Signal lines of more than 400 volts are always supply lines within this section, and those of less than 400 volts are considered as supply lines, if so run and operated throughout.

*Manhole.* A subsurface enclosure which personnel may enter and which is used for the purpose of installing, operating, and maintaining submersible equipment or cable.

*Manhole steps.* A series of steps individually attached to or set into the walls of a manhole structure.

*Minimum approach distance.* The closest distance an employee is permitted to approach an energized or a grounded object.

*Qualified employee (qualified person).* One knowledgeable in the construction and operation of the electric power

generation, transmission, and distribution equipment involved, along with the associated hazards.

NOTE 1: An employee must have the training required by paragraph (a)(2)(ii) of this section in order to be considered a qualified employee.

NOTE 2: Except under paragraph (g)(2)(v) of this section, an employee who is undergoing on-the-job training and who, in the course of such training, has demonstrated an ability to perform duties safely at his or her level of training and who is under the direct supervision of a qualified person is considered to be a qualified person for the performance of those duties.

*Step bolt.* A bolt or rung attached at intervals along a structural member and used for foot placement during climbing or standing.

*Switch.* A device for opening and closing or for changing the connection of a circuit. In this section, a switch is understood to be manually operable, unless otherwise stated.

*System operator.* A qualified person designated to operate the system or its parts.

*Vault.* An enclosure, above or below ground, which personnel may enter and which is used for the purpose of installing, operating, or maintaining equipment or cable.

*Vented vault.* A vault that has provision for air changes using exhaust flue stacks and low level air intakes operating on differentials of pressure and temperature providing for airflow which precludes a hazardous atmosphere from developing.

*Voltage.* The effective (rms) potential difference between any two conductors or between a conductor and ground. Voltages are expressed in nominal values unless otherwise indicated. The nominal voltage of a system or circuit is the value assigned to a system or circuit of a given voltage class for the purpose of convenient designation. The operating voltage of the system may vary above or below this value.

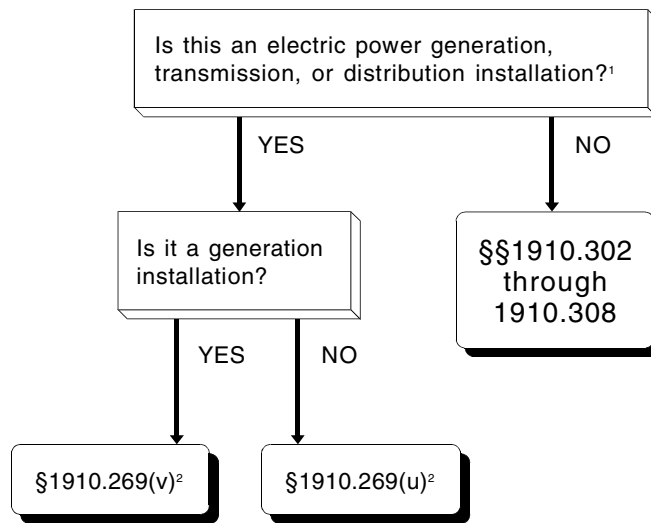
#### APPENDIX A TO § 1910.269—FLOW CHARTS

This appendix presents information, in the form of flow charts, that illustrates the scope and application of § 1910.269. This appendix addresses the interface between § 1910.269 and subpart S of this part (*Electrical*), between § 1910.269 and § 1910.146 of this part (*Permit-required confined spaces*), and between § 1910.269 and § 1910.147 of this part (*The control of hazardous energy (lockout/tagout)*). These flow charts provide guidance for employers trying to implement the requirements of § 1910.269 in combination with other General Industry Standards contained in part 1910.

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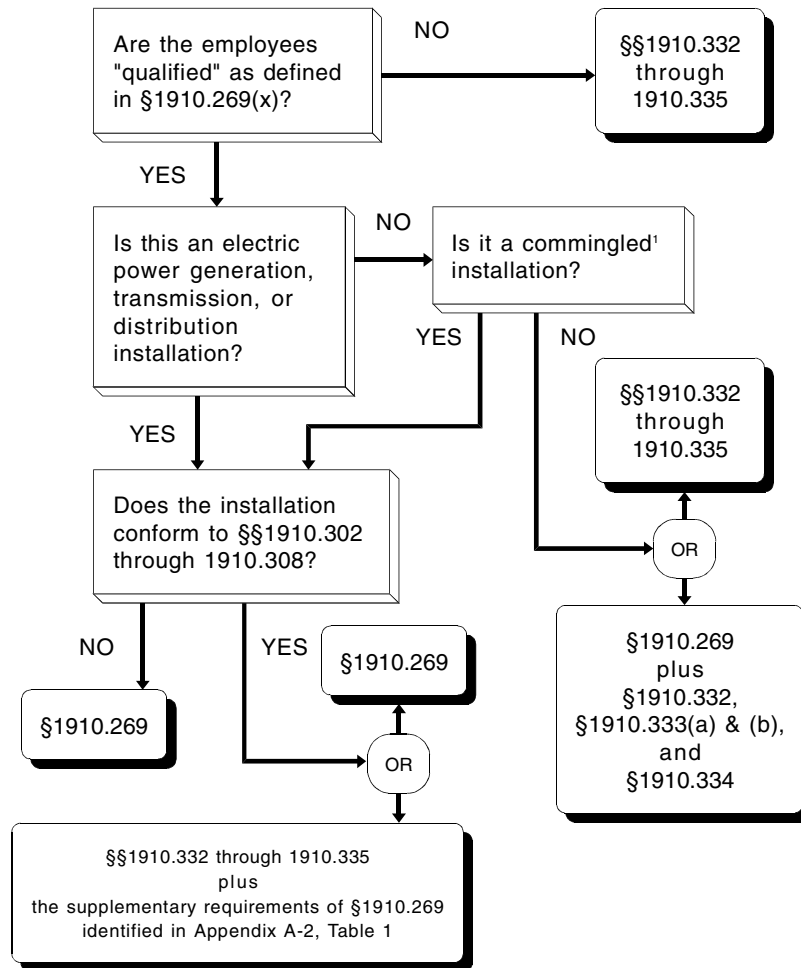
APPENDIX A-1 TO § 1910.269—APPLICATION OF § 1910.269 AND SUBPART S OF THIS PART TO ELECTRICAL INSTALLATIONS



<sup>1</sup> Electrical installation design requirements only. See Appendix 1B for electrical safety-related work practices. Supplementary electric generating equipment that is used to supply a workplace for emergency, standby, or similar purposes only is not considered to be an electric power generation installation.

<sup>2</sup> See Table 1 of Appendix A-2 for requirements that can be met through compliance with Subpart S.

APPENDIX A-2 TO § 1910.269—APPLICATION OF § 1910.269 AND SUBPART S OF THIS PART TO ELECTRICAL SAFETY-RELATED WORK PRACTICES



<sup>1</sup> Commingled to the extent that the electric power generation, transmission, or distribution installation poses the greater hazard.

TABLE 1—ELECTRICAL SAFETY-RELATED WORK PRACTICES IN § 1910.269

Compliance with subpart S is considered as compliance with § 1910.269 <sup>1</sup>	Paragraphs that apply regardless of compliance with subpart S
(d), electric shock hazards only .....	(a)(2) <sup>2</sup> and (a)(3) <sup>2</sup> .

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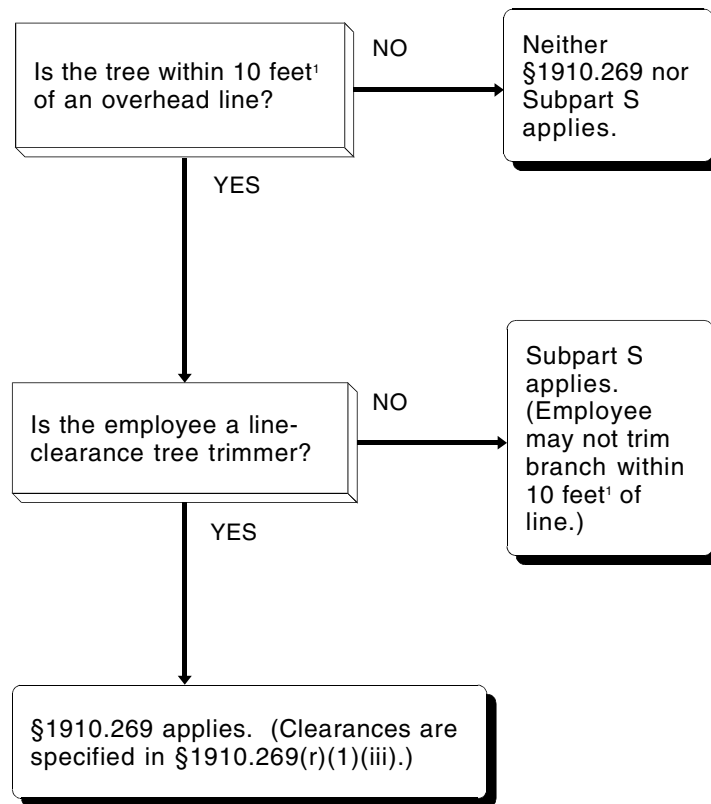
TABLE 1—ELECTRICAL SAFETY-RELATED WORK PRACTICES IN § 1910.269—Continued

Compliance with subpart S is considered as compliance with § 1910.269 <sup>1</sup>	Paragraphs that apply regardless of compliance with subpart S
(h)(3) .....	(b) <sup>2</sup> .
(i)(2) .....	(c) <sup>2</sup> .
(k) .....	(d), other than electric shock hazards.
(l)(1) through (l)(4), (l)(6)(i), and (l)(8) through (l)(10) .....	(e).
(m) .....	(f).
(p)(4) .....	(g).
(s)(2) .....	(h)(1) and (h)(2).
(u)(1) and (u)(3) through (u)(5) .....	(i)(3) <sup>2</sup> and (i)(4) <sup>2</sup> .
(v)(3) through (v)(5) .....	(j) <sup>2</sup> .
(w)(1) and (w)(7) .....	(l)(5) <sup>2</sup> , (l)(6)(ii) <sup>2</sup> , (l)(6)(iii) <sup>2</sup> , and (l)(7) <sup>2</sup> .
	(n) <sup>2</sup> .
	(o) <sup>2</sup> .
	(p)(1) through (p)(3).
	(q) <sup>2</sup> .
	(r) <sup>2</sup> .
	(s)(1).
	(t) <sup>2</sup> .
	(u)(2) <sup>2</sup> and (u)(6) <sup>2</sup> .
	(v)(1), (v)(2) <sup>2</sup> , and (v)(6) through (v)(12).
	(w)(2) through (w)(6) <sup>2</sup> , (w)(8), and (w)(9) <sup>2</sup> .

<sup>1</sup> If the electrical installation meets the requirements of §§ 1910.303 through 1910.308 of this part, then the electrical installation and any associated electrical safety-related work practices conforming to §§ 1910.332 through 1910.335 of this part are considered to comply with these provisions of § 1910.269 of this part.

<sup>2</sup> These provisions include electrical safety requirements that must be met regardless of compliance with subpart S of this part.

APPENDIX A-3 TO § 1910.269—APPLICATION OF § 1910.269 AND SUBPART S OF THIS PART TO TREE-TRIMMING OPERATIONS



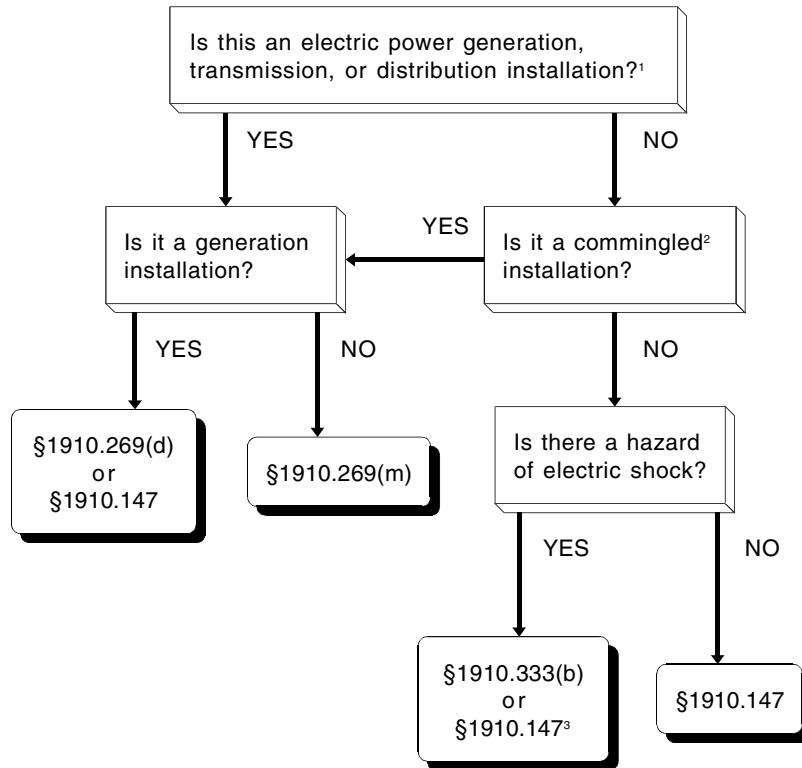
<sup>1</sup> 10 feet plus 4 inches for every 10 kilovolts over 50 kilovolts.



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APPENDIX A–4 TO § 1910.269—APPLICATION OF §§ 1910.147, 1910.269 AND 1910.333 TO HAZARDOUS ENERGY CONTROL PROCEDURES (LOCKOUT/TAGOUT)

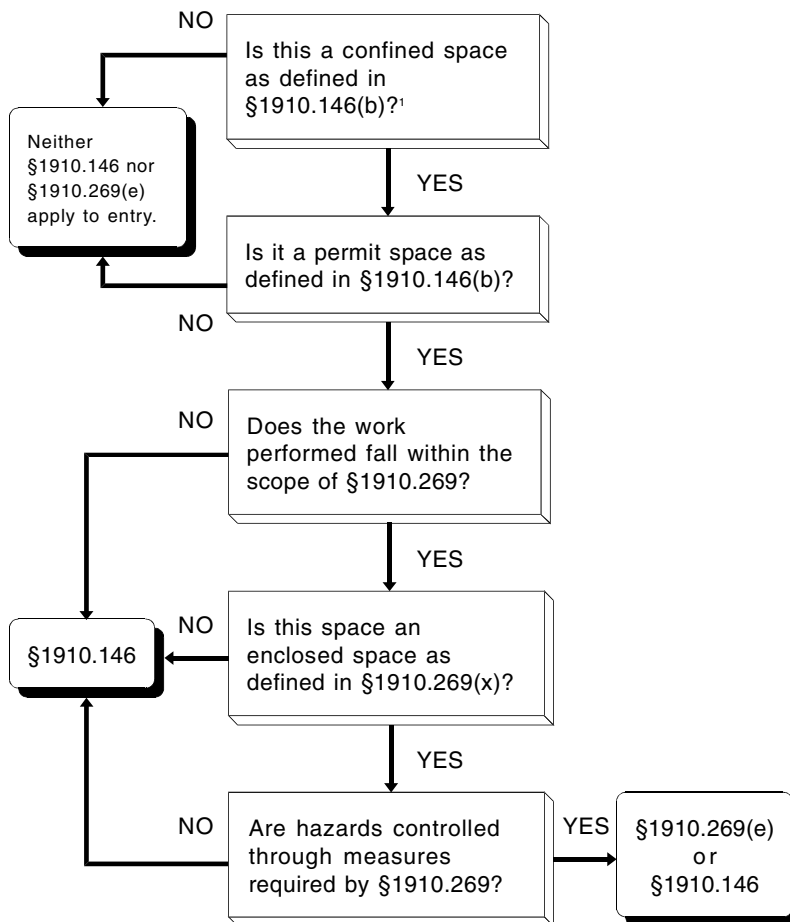


<sup>1</sup> If the installation conforms to §§1910.303 through 1910.308, the lockout and tagging procedures of 1910.333(b) may be followed for electric shock hazards.

<sup>2</sup> Commingled to the extent that the electric power generation, transmission, or distribution installation poses the greater hazard.

<sup>3</sup> §1910.333(b)(2)(iii)(D) and (b)(2)(iv)(B) still apply.

APPENDIX A-5 TO § 1910.269—APPLICATION OF §§ 1910.146 AND 1910.269 TO PERMIT-REQUIRED CONFINED SPACES



<sup>1</sup> See § 1910.146(c) for general non-entry requirements that apply to all confined spaces.

## § 1910.269

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### APPENDIX B TO § 1910.269—WORKING ON EXPOSED ENERGIZED PARTS

#### I. Introduction

Electric transmission and distribution line installations have been designed to meet National Electrical Safety Code (NESC), ANSI C2, requirements and to provide the level of line outage performance required by system reliability criteria. Transmission and distribution lines are also designed to withstand the maximum overvoltages expected to be impressed on the system. Such overvoltages can be caused by such conditions as switching surges, faults, or lightning. Insulator design and lengths and the clearances to structural parts (which, for low voltage through extra-high voltage, or EHV, facilities, are generally based on the performance of the line as a result of contamination of the insulation or during storms) have, over the years, come closer to the minimum approach distances used by workers (which are generally based on non-storm conditions). Thus, as minimum approach (working) distances and structural distances (clearances) converge, it is increasingly important that basic considerations for establishing safe approach distances for performing work be understood by the designers and the operating and maintenance personnel involved.

The information in this appendix will assist employers in complying with the minimum approach distance requirements contained in paragraphs (l)(2) and (q)(3) of this section. The technical criteria and methodology presented herein is mandatory for employers using reduced minimum approach distances as permitted in Table R-7 and Table R-8. This appendix is intended to provide essential background information and technical criteria for the development or modification, if possible, of the safe minimum approach distances for electric transmission and distribution live-line work. The development of these safe distances must be undertaken by persons knowledgeable in the techniques discussed in this appendix and competent in the field of electric transmission and distribution system design.

#### II. General

##### A. Definitions

The following definitions from § 1910.269(x) relate to work on or near transmission and distribution lines and equipment and the electrical hazards they present.

*Exposed.* Not isolated or guarded.

*Guarded.* Covered, fenced, enclosed, or otherwise protected, by means of suitable covers or casings, barrier rails or screens, mats, or platforms, designed to minimize the possibility, under normal conditions, of dangerous approach or accidental contact by persons or objects.

*NOTE:* Wires which are insulated, but not otherwise protected, are not considered as guarded.

*Insulated.* Separated from other conducting surfaces by a dielectric (including air space) offering a high resistance to the passage of current.

*NOTE:* When any object is said to be insulated, it is understood to be insulated for the conditions to which it is normally subjected. Otherwise, it is, within the purpose of this section, uninsulated.

##### B. Installations Energized at 50 to 300 Volts

The hazards posed by installations energized at 50 to 300 volts are the same as those found in many other workplaces. That is not to say that there is no hazard, but the complexity of electrical protection required does not compare to that required for high voltage systems. The employee must avoid contact with the exposed parts, and the protective equipment used (such as rubber insulating gloves) must provide insulation for the voltages involved.

##### C. Exposed Energized Parts Over 300 Volts AC

Table R-6, Table R-7, and Table R-8 of § 1910.269 provide safe approach and working distances in the vicinity of energized electric apparatus so that work can be done safely without risk of electrical flashover.

The working distances must withstand the maximum transient overvoltage that can reach the work site under the working conditions and practices in use. Normal system design may provide or include a means to control transient overvoltages, or temporary devices may be employed to achieve the same result. The use of technically correct practices or procedures to control overvoltages (for example, portable gaps or preventing the automatic control from initiating breaker reclosing) enables line design and operation to be based on reduced transient overvoltage values. Technical information for U.S. electrical systems indicates that current design provides for the following maximum transient overvoltage values (usually produced by switching surges): 362 kV and less—3.0 per unit; 552 kV—2.4 per unit; 800 kV—2.0 per unit.

Additional discussion of maximum transient overvoltages can be found in paragraph IV.A.2, later in this appendix.

#### III. Determination of the Electrical Component of Minimum Approach Distances

##### A. Voltages of 1.1 kV to 72.5 kV

For voltages of 1.1 kV to 72.5 kV, the electrical component of minimum approach distances is based on American National Standards Institute (ANSI)/American Institute of Electrical Engineers (AIEE) Standard No.4,

March 1943, Tables III and IV. (AIEE is the predecessor technical society to the Institute of Electrical and Electronic Engineers (IEEE).) These distances are calculated by the following formula:

Equation (1)—For voltages of 1.1 kV to 72.5 kV

$$D = \left( \frac{V_{\max} \times pu}{124} \right)^{1.63}$$

Where:

D = Electrical component of the minimum approach distance in air in feet

V<sub>max</sub> = Maximum rated line-to-ground rms voltage in kV

pu = Maximum transient overvoltage factor in per unit

SOURCE: AIEE Standard No. 4, 1943.

This formula has been used to generate Table 1.

TABLE 1—AC ENERGIZED LINE-WORK PHASE-TO-GROUND ELECTRICAL COMPONENT OF THE MINIMUM APPROACH DISTANCE—1.1 TO 72.5 kV

Maximum anticipated per-unit transient overvoltage	Phase to phase voltage			
	15,000	36,000	46,000	72,500
3.0 .....	0.08	0.33	0.49	1.03

NOTE: The distances given (in feet) are for *air* as the insulating medium and provide *no* additional clearance for inadvertent movement.

B. Voltages of 72.6 kV to 800 kV

For voltages of 72.6 kV to 800 kV, the electrical component of minimum approach distances is based on ANSI/IEEE Standard 516-1987, "IEEE Guide for Maintenance Methods on Energized Power Lines." This standard gives the electrical component of the minimum approach distance based on power frequency rod-gap data, supplemented with transient overvoltage information and a saturation factor for high voltages. The distances listed in ANSI/IEEE Standard 516 have been calculated according to the following formula:

Equation (2)—For voltages of 72.6 kV to 800 kV

$$D=(C+a)puV_{\max}$$

Where:

D=Electrical component of the minimum approach distance in air in feet

C=0.01 to take care of correction factors associated with the variation of gap sparkover with voltage

a=A factor relating to the saturation of air at voltages of 345 kV or higher

pu=Maximum anticipated transient overvoltage, in per unit (p.u.)

V<sub>max</sub>=Maximum rms system line-to-ground voltage in kilovolts—it should be the "actual" maximum, or the normal highest voltage for the range (for example, 10 percent above the nominal voltage)

SOURCE: Formula developed from ANSI/IEEE Standard No. 516, 1987.

This formula is used to calculate the electrical component of the minimum approach distances in air and is used in the development of Table 2 and Table 3.

TABLE 2—AC ENERGIZED LINE-WORK PHASE-TO-GROUND ELECTRICAL COMPONENT OF THE MINIMUM APPROACH DISTANCE—121 TO 242 kV

Maximum anticipated per-unit transient overvoltage	Phase to phase voltage			
	121,000	145,000	169,000	242,000
2.0 .....	1.40	1.70	2.00	2.80
2.1 .....	1.47	1.79	2.10	2.94
2.2 .....	1.54	1.87	2.20	3.08
2.3 .....	1.61	1.96	2.30	3.22
2.4 .....	1.68	2.04	2.40	3.35
2.5 .....	1.75	2.13	2.50	3.50
2.6 .....	1.82	2.21	2.60	3.64
2.7 .....	1.89	2.30	2.70	3.76
2.8 .....	1.96	2.38	2.80	3.92
2.9 .....	2.03	2.47	2.90	4.05
3.0 .....	2.10	2.55	3.00	4.29

NOTE: The distances given (in feet) are for *air* as the insulating medium and provide *no* additional clearance for inadvertent movement.

TABLE 3—AC ENERGIZED LINE-WORK PHASE-TO-GROUND ELECTRICAL COMPONENT OF THE MINIMUM APPROACH DISTANCE—362 TO 800 KV

Maximum anticipated per-unit transient overvoltage	Phase to phase voltage		
	362,000	552,000	800,000
1.5		4.97	8.66
1.6		5.46	9.60
1.7		5.98	10.60
1.8		6.51	11.64
1.9		7.08	12.73
2.0		7.68	13.86
2.1	4.20	7.68	
2.2	4.41	8.27	
2.3	4.70	8.87	
2.4	5.01	9.49	
2.5	5.34	10.21	
2.6	5.67		
2.7	6.01		
2.8	6.36		
2.9	6.73		
3.0	7.10		
	7.48		

NOTE: The distances given (in feet) are for *air* as the insulating medium and provide *no* additional clearance for inadvertent movement.

C. Provisions for Inadvertent Movement

The minimum approach distances (working distances) must include an “adder” to compensate for the inadvertent movement of the worker relative to an energized part or the movement of the part relative to the worker. A certain allowance must be made to account for this possible inadvertent movement and to provide the worker with a comfortable and safe zone in which to work. A distance for inadvertent movement (called the “ergonomic component of the minimum approach distance”) must be added to the electrical component to determine the total safe minimum approach distances used in live-line work.

One approach that can be used to estimate the ergonomic component of the minimum approach distance is response time-distance analysis. When this technique is used, the total response time to a hazardous incident is estimated and converted to distance travelled. For example, the driver of a car takes a given amount of time to respond to a “stimulus” and stop the vehicle. The elapsed time involved results in a distance being travelled before the car comes to a complete stop. This distance is dependent on the speed of the car at the time the stimulus appears.

In the case of live-line work, the employee must first perceive that he or she is approaching the danger zone. Then, the worker responds to the danger and must decelerate and stop all motion toward the energized part. During the time it takes to stop, a distance will have been traversed. It is this distance that must be added to the electrical component of the minimum approach distance to obtain the total safe minimum approach distance.

At voltages below 72.5 kV, the electrical component of the minimum approach distance is smaller than the ergonomic component. At 72.5 kV the electrical component is only a little more than 1 foot. An ergonomic component of the minimum approach distance is needed that will provide for all the worker’s unexpected movements. The usual live-line work method for these voltages is the use of rubber insulating equipment, frequently rubber gloves. The energized object needs to be far enough away to provide the worker’s face with a safe approach distance, as his or her hands and arms are insulated. In this case, 2 feet has been accepted as a sufficient and practical value.

For voltages between 72.6 and 800 kV, there is a change in the work practices employed during energized line work. Generally, live-line tools (hot sticks) are employed to perform work while equipment is energized. These tools, by design, keep the energized part at a constant distance from the employee and thus maintain the appropriate minimum approach distance automatically.

The length of the ergonomic component of the minimum approach distance is also influenced by the location of the worker and by the nature of the work. In these higher voltage ranges, the employees use work methods that more tightly control their movements than when the workers perform rubber glove work. The worker is farther from energized line or equipment and needs to be more precise in his or her movements just to perform the work.

For these reasons, a smaller ergonomic component of the minimum approach distance is needed, and a distance of 1 foot has been selected for voltages between 72.6 and 800 kV.

Table 4 summarizes the ergonomic component of the minimum approach distance for the two voltage ranges.

TABLE 4—ERGONOMIC COMPONENT OF MINIMUM APPROACH DISTANCE

Voltage range (kV)	Distance (feet)
1.1 to 72.5 .....	2.0
72.6 to 800 .....	1.0

NOTE: This distance must be added to the electrical component of the minimum approach distance to obtain the full minimum approach distance.

#### D. Bare-Hand Live-Line Minimum Approach Distances

Calculating the strength of phase-to-phase transient overvoltages is complicated by the varying time displacement between overvoltages on parallel conductors (electrodes) and by the varying ratio between the positive and negative voltages on the two electrodes. The time displacement causes the maximum voltage between phases to be less than the sum of the phase-to-ground voltages. The International Electrotechnical Commission (IEC) Technical Committee 28, Working Group 2, has developed the following formula for determining the phase-to-phase maximum transient overvoltage, based on the per unit (p.u.) of the system nominal voltage phase-to-ground crest:

$$pu_p = pu_g + 1.6.$$

Where:

$pu_g$  = p.u. phase-to-ground maximum transient overvoltage

$pu_p$  = p.u. phase-to-phase maximum transient overvoltage

This value of maximum anticipated transient overvoltage must be used in Equation (2) to calculate the phase-to-phase minimum approach distances for live-line bare-hand work.

#### E. Compiling the Minimum Approach Distance Tables

For each voltage involved, the distance in Table 4 in this appendix has been added to the distance in Table 1, Table 2 or Table 3 in this appendix to determine the resulting minimum approach distances in Table R-6, Table R-7, and Table R-8 in § 1910.269.

#### F. Miscellaneous Correction Factors

The strength of an air gap is influenced by the changes in the air medium that forms the insulation. A brief discussion of each factor follows, with a summary at the end.

1. *Dielectric strength of air.* The dielectric strength of air in a uniform electric field at standard atmospheric conditions is approximately 31 kV (crest) per cm at 60 Hz. The disruptive gradient is affected by the air pressure, temperature, and humidity, by the

shape, dimensions, and separation of the electrodes, and by the characteristics of the applied voltage (wave shape).

2. *Atmospheric effect.* Flashover for a given air gap is inhibited by an increase in the density (humidity) of the air. The empirically determined electrical strength of a given gap is normally applicable at standard atmospheric conditions (20 °C, 101.3 kPa, 11 g/cm<sup>3</sup> humidity).

The combination of temperature and air pressure that gives the lowest gap flashover voltage is high temperature and low pressure. These are conditions not likely to occur simultaneously. Low air pressure is generally associated with high humidity, and this causes increased electrical strength. An average air pressure is more likely to be associated with low humidity. Hot and dry working conditions are thus normally associated with reduced electrical strength.

The electrical component of the minimum approach distances in Table 1, Table 2, and Table 3 has been calculated using the maximum transient overvoltages to determine withstand voltages at standard atmospheric conditions.

3. *Altitude.* The electrical strength of an air gap is reduced at high altitude, due principally to the reduced air pressure. An increase of about 3 percent per 300 meters in the minimum approach distance for altitudes above 900 meters is required. Table R-10 of § 1910.269 presents this information in tabular form.

*Summary.* After taking all these correction factors into account and after considering their interrelationships relative to the air gap insulation strength and the conditions under which live work is performed, one finds that only a correction for altitude need be made. An elevation of 900 meters is established as the base elevation, and the values of the electrical component of the minimum approach distances has been derived with this correction factor in mind. Thus, the values used for elevations below 900 meters are conservative without any change; corrections have to be made only above this base elevation.

#### IV. Determination of Reduced Minimum Approach Distances

##### A. Factors Affecting Voltage Stress at the Work Site

1. *System voltage (nominal).* The nominal system voltage range sets the absolute lower limit for the minimum approach distance. The highest value within the range, as given in the relevant table, is selected and used as a reference for per unit calculations.

2. *Transient overvoltages.* Transient overvoltages may be generated on an electrical system by the operation of switches or breakers, by the occurrence of a fault on the

line or circuit being worked or on an adjacent circuit, and by similar activities. Most of the overvoltages are caused by switching, and the term “switching surge” is often used to refer generically to all types of overvoltages. However, each overvoltage has an associated transient voltage wave shape. The wave shape arriving at the site and its magnitude vary considerably.

The information used in the development of the minimum approach distances takes into consideration the most common wave shapes; thus, the required minimum approach distances are appropriate for any transient overvoltage level usually found on electric power generation, transmission, and distribution systems. The values of the per unit (p.u.) voltage relative to the nominal maximum voltage are used in the calculation of these distances.

3. *Typical magnitude of overvoltages.* The magnitude of typical transient overvoltages is given in Table 5.

4. *Standard deviation—air-gap withstand.* For each air gap length, and under the same atmospheric conditions, there is a statistical variation in the breakdown voltage. The probability of the breakdown voltage is assumed to have a normal (Gaussian) distribution. The standard deviation of this distribution varies with the wave shape, gap geometry, and atmospheric conditions. The withstand voltage of the air gap used in calculating the electrical component of the minimum approach distance has been set at three standard deviations ( $3\sigma^1$ ) below the critical flashover voltage. (The critical flashover voltage is the crest value of the impulse wave that, under specified conditions, causes flashover on 50 percent of the applications. An impulse wave of three standard deviations below this value, that is, the withstand voltage, has a probability of flashover of approximately 1 in 1000.)

TABLE 5—MAGNITUDE OF TYPICAL TRANSIENT OVERVOLTAGES

Cause	Magnitude (per unit)
Energized 200 mile line without closing resistors ...	3.5
Energized 200 mile line with one step closing resistor .....	2.1
Energized 200 mile line with multi-step resistor .....	2.5
Reclosed with trapped charge one step resistor .....	2.2
Opening surge with single restrike .....	3.0
Fault initiation unfaulted phase .....	2.1
Fault initiation adjacent circuit .....	2.5
Fault clearing .....	1.7-1.9

Source: ANSI/IEEE Standard No. 516, 1987.

5. *Broken Insulators.* Tests have shown that the insulation strength of an insulator string

<sup>1</sup>Sigma,  $\sigma$ , is the symbol for standard deviation.

with broken skirts is reduced. Broken units may have lost up to 70% of their withstand capacity. Because the insulating capability of a broken unit cannot be determined without testing it, damaged units in an insulator are usually considered to have no insulating value. Additionally, the overall insulating strength of a string with broken units may be further reduced in the presence of a live-line tool alongside it. The number of good units that must be present in a string is based on the maximum overvoltage possible at the worksite.

B. Minimum Approach Distances Based on Known Maximum Anticipated Per-Unit Transient Overvoltages

1. *Reduction of the minimum approach distance for AC systems.* When the transient overvoltage values are known and supplied by the employer, Table R-7 and Table R-8 of §1910.269 allow the minimum approach distances from energized parts to be reduced. In order to determine what this maximum overvoltage is, the employer must undertake an engineering analysis of the system. As a result of this engineering study, the employer must provide new live work procedures, reflecting the new minimum approach distances, the conditions and limitations of application of the new minimum approach distances, and the specific practices to be used when these procedures are implemented.

2. *Calculation of reduced approach distance values.* The following method of calculating reduced minimum approach distances is based on ANSI/IEEE Standard 516:

*Step 1.* Determine the maximum voltage (with respect to a given nominal voltage range) for the energized part.

*Step 2.* Determine the maximum transient overvoltage (normally a switching surge) that can be present at the work site during work operation.

*Step 3.* Determine the technique to be used to control the maximum transient overvoltage. (See paragraphs IV.C and IV.D of this appendix.) Determine the maximum voltage that can exist at the work site with that form of control in place and with a confidence level of  $3\sigma$ . This voltage is considered to be the withstand voltage for the purpose of calculating the appropriate minimum approach distance.

*Step 4.* Specify in detail the control technique to be used, and direct its implementation during the course of the work.

*Step 5.* Using the new value of transient overvoltage in per unit (p.u.), determine the required phase-to-ground minimum approach distance from Table R-7 or Table R-8 of §1910.269.

### C. Methods of Controlling Possible Transient Overvoltage Stress Found on a System

1. *Introduction.* There are several means of controlling overvoltages that occur on transmission systems. First, the operation of circuit breakers or other switching devices may be modified to reduce switching transient overvoltages. Second, the overvoltage itself may be forcibly held to an acceptable level by means of installation of surge arresters at the specific location to be protected. Third, the transmission system may be changed to minimize the effect of switching operations.

2. *Operation of circuit breakers.*<sup>2</sup> The maximum transient overvoltage that can reach the work site is often due to switching on the line on which work is being performed. If the automatic-reclosing is removed during energized line work so that the line will not be re-energized after being opened for any reason, the maximum switching surge overvoltage is then limited to the larger of the opening surge or the greatest possible fault-generated surge, provided that the devices (for example, insertion resistors) are operable and will function to limit the transient overvoltage. It is essential that the operating ability of such devices be assured when they are employed to limit the overvoltage level. If it is prudent not to remove the reclosing feature (because of system operating conditions), other methods of controlling the switching surge level may be necessary.

Transient surges on an adjacent line, particularly for double circuit construction, may cause a significant overvoltage on the line on which work is being performed. The coupling to adjacent lines must be accounted for when minimum approach distances are calculated based on the maximum transient overvoltage.

3. *Surge arresters.* The use of modern surge arresters has permitted a reduction in the basic impulse-insulation levels of much transmission system equipment. The primary function of early arresters was to protect the system insulation from the effects of lightning. Modern arresters not only dissipate lightning-caused transients, but may also control many other system transients that may be caused by switching or faults.

It is possible to use properly designed arresters to control transient overvoltages along a transmission line and thereby reduce the requisite length of the insulator string. On the other hand, if the installation of ar-

resters has not been used to reduce the length of the insulator string, it may be used to reduce the minimum approach distance instead.<sup>3</sup>

4. *Switching Restrictions.* Another form of overvoltage control is the establishment of switching restrictions, under which breakers are not permitted to be operated until certain system conditions are satisfied. Restriction of switching is achieved by the use of a tagging system, similar to that used for a "permit", except that the common term used for this activity is a "hold-off" or "restriction". These terms are used to indicate that operation is not prevented, but only modified during the live-work activity.

### D. Minimum Approach Distance Based on Control of Voltage Stress (Overvoltages) at the Work Site.

Reduced minimum approach distances can be calculated as follows:

1. *First Method—Determining the reduced minimum approach distance from a given withstand voltage.*<sup>4</sup>

*Step 1.* Select the appropriate withstand voltage for the protective gap based on system requirements and an acceptable probability of actual gap flashover.

*Step 2.* Determine a gap distance that provides a withstand voltage<sup>5</sup> greater than or equal to the one selected in the first step.<sup>6</sup>

*Step 3.* Using 110 percent of the gap's critical flashover voltage, determine the electrical component of the minimum approach distance from Equation (2) or Table 6, which is a tabulation of distance vs. withstand voltage based on Equation (2).

*Step 4.* Add the 1-foot ergonomic component to obtain the total minimum approach distance to be maintained by the employee.

2. *Second Method—Determining the necessary protective gap length from a desired (reduced) minimum approach distance.*

<sup>3</sup>Surge arrester application is beyond the scope of this appendix. However, if the arrester is installed near the work site, the application would be similar to protective gaps as discussed in paragraph IV.D. of this appendix.

<sup>4</sup>Since a given rod gap of a given configuration corresponds to a certain withstand voltage, this method can also be used to determine the minimum approach distance for a known gap.

<sup>5</sup>The withstand voltage for the gap is equal to 85 percent of its critical flashover voltage.

<sup>6</sup>Switch steps 1 and 2 if the length of the protective gap is known. The withstand voltage must then be checked to ensure that it provides an acceptable probability of gap flashover. In general, it should be at least 1.25 times the maximum crest operating voltage.

<sup>2</sup>The detailed design of a circuit interrupter, such as the design of the contacts, of resistor insertion, and of breaker timing control, are beyond the scope of this appendix. These features are routinely provided as part of the design for the system. Only features that can limit the maximum switching transient overvoltage on a system are discussed in this appendix.



*Step 1.* Determine the desired minimum approach distance for the employee. Subtract the 1-foot ergonomic component of the minimum approach distance.

*Step 2.* Using this distance, calculate the air gap withstand voltage from Equation (2). Alternatively, find the voltage corresponding to the distance in Table 6.<sup>7</sup>

*Step 3.* Select a protective gap distance corresponding to a critical flashover voltage that, when multiplied by 110 percent, is less than or equal to the withstand voltage from Step 2.

*Step 4.* Calculate the withstand voltage of the protective gap (85 percent of the critical flashover voltage) to ensure that it provides an acceptable risk of flashover during the time the gap is installed.

TABLE 6—WITHSTAND DISTANCES FOR TRANSIENT OVERVOLTAGES

Crest voltage (kV)	Withstand distance (in feet) air gap
100	0.71
150	1.06
200	1.41
250	1.77
300	2.12
350	2.47
400	2.83
450	3.18
500	3.54
550	3.89
600	4.24
650	4.60
700	5.17
750	5.73
800	6.31
850	6.91
900	7.57
950	8.23
1000	8.94
1050	9.65
1100	10.42
1150	11.18
1200	12.05
1250	12.90
1300	13.79
1350	14.70
1400	15.64
1450	16.61
1500	17.61
1550	18.63

Source: Calculations are based on Equation (2).

Note: The air gap is based on the 60-Hz rod-gap withstand distance.

<sup>7</sup>Since the value of the saturation factor, *a*, in Equation (2) is dependent on the maximum voltage, several iterative computations may be necessary to determine the correct withstand voltage using the equation. A graph of withstand voltage vs. distance is given in ANSI/IEEE Std. 516, 1987. This graph could also be used to determine the appropriate withstand voltage for the minimum approach distance involved.

3. Sample protective gap calculations.

*Problem 1:* Work is to be performed on a 500-kV transmission line that is subject to transient overvoltages of 2.4 p.u. The maximum operating voltage of the line is 552 kV. Determine the length of the protective gap that will provide the minimum practical safe approach distance. Also, determine what that minimum approach distance is.

*Step 1.* Calculate the smallest practical maximum transient overvoltage (1.25 times the crest line-to-ground voltage):<sup>8</sup>

$$552 \text{ kV} \times \frac{\sqrt{2}}{\sqrt{3}} \times 1.25 = 563 \text{ kV.}$$

This will be the withstand voltage of the protective gap.

*Step 2.* Using test data for a particular protective gap, select a gap that has a critical flashover voltage greater than or equal to:

$$563 \text{ kV} \div 0.85 = 662 \text{ kV.}$$

For example, if a protective gap with a 4.0-foot spacing tested to a critical flashover voltage of 665 kV, crest, select this gap spacing.

*Step 3.* This protective gap corresponds to a 110 percent of critical flashover voltage value of:

$$665 \text{ kV} \times 1.10 = 732 \text{ kV.}$$

This corresponds to the withstand voltage of the electrical component of the minimum approach distance.

*Step 4.* Using this voltage in Equation (2) results in an electrical component of the minimum approach distance of:

$$D = (0.01 + 0.0006) \times \frac{552 \text{ kV}}{\sqrt{3}} = 5.5 \text{ ft.}$$

*Step 5.* Add 1 foot to the distance calculated in step 4, resulting in a total minimum approach distance of 6.5 feet.

*Problem 2:* For a line operating at a maximum voltage of 552 kV subject to a maximum transient overvoltage of 2.4 p.u., find a protective gap distance that will permit the use of a 9.0-foot minimum approach distance. (A minimum approach distance of 11 feet, 3 inches is normally required.)

*Step 1.* The electrical component of the minimum approach distance is 8.0 feet (9.0-1.0).

*Step 2.* From Table 6, select the withstand voltage corresponding to a distance of 8.0 feet. By interpolation:

<sup>8</sup>To eliminate unwanted flashovers due to minor system disturbances, it is desirable to have the crest withstand voltage no lower than 1.25 p.u.

$$900 \text{ kV} + \left[ 50 \times \frac{(8.00 - 7.57)}{(8.23 - 7.57)} \right] = 933 \text{ kV.}$$

*Step 3.* The voltage calculated in Step 2 corresponds to 110 percent of the critical flashover voltage of the gap that should be employed. Using test data for a particular protective gap, select a gap that has a critical flashover voltage less than or equal to:

$$D = (0.01 + 0.0006) \times 732 \text{ kV} \div \sqrt{2}$$

For example, if a protective gap with a 5.8-foot spacing tested to a critical flashover voltage of 820 kV, crest, select this gap spacing.

*Step 4.* The withstand voltage of this protective gap would be:

$$820 \text{ kV} \times 0.85 = 697 \text{ kV.}$$

The maximum operating crest voltage would be:

$$552 \text{ kV} \times \frac{\sqrt{2}}{\sqrt{3}} = 449 \text{ kV,}$$

The crest withstand voltage of the protective gap in per unit is thus:

$$697 \text{ kV} + 449 \text{ kV} = 1.55 \text{ p.u.}$$

If this is acceptable, the protective gap could be installed with a 5.8-foot spacing, and the minimum approach distance could then be reduced to 9.0 feet.

4. *Comments and variations.* The 1-foot ergonomic component of the minimum approach distance must be added to the electrical component of the minimum approach distance calculated under paragraph IV.D of this appendix. The calculations may be varied by starting with the protective gap distance or by starting with the minimum approach distance.

#### E. Location of Protective Gaps

1. Installation of the protective gap on a structure adjacent to the work site is an acceptable practice, as this does not significantly reduce the protection afforded by the gap.

2. Gaps installed at terminal stations of lines or circuits provide a given level of protection. The level may not, however, extend throughout the length of the line to the worksite. The use of gaps at terminal stations must be studied in depth. The use of substation terminal gaps raises the possibility that separate surges could enter the line at opposite ends, each with low enough magnitude to pass the terminal gaps without flashover. When voltage surges are initiated simultaneously at each end of a line and travel toward each other, the total voltage on the line at the point where they meet is

the arithmetic sum of the two surges. A gap that is installed within 0.5 mile of the work site will protect against such intersecting waves. Engineering studies of a particular line or system may indicate that adequate protection can be provided by even more distant gaps.

3. If protective gaps are used at the work site, the work site impulse insulation strength is established by the gap setting. Lightning strikes as much as 6 miles away from the worksite may cause a voltage surge greater than the insulation withstand voltage, and a gap flashover may occur. The flashover will not occur between the employee and the line, but across the protective gap instead.

4. There are two reasons to disable the automatic-reclosing feature of circuit-interrupting devices while employees are performing live-line maintenance:

- To prevent the reenergizing of a circuit faulted by actions of a worker, which could possibly create a hazard or compound injuries or damage produced by the original fault;
- To prevent any transient overvoltage caused by the switching surge that would occur if the circuit were reenergized.

However, due to system stability considerations, it may not always be feasible to disable the automatic-reclosing feature.

#### APPENDIX C TO § 1910.269—PROTECTION FROM STEP AND TOUCH POTENTIALS

##### I. Introduction

When a ground fault occurs on a power line, voltage is impressed on the "grounded" object faulting the line. The voltage to which this object rises depends largely on the voltage on the line, on the impedance of the faulted conductor, and on the impedance to "true," or "absolute," ground represented by the object. If the object causing the fault represents a relatively large impedance, the voltage impressed on it is essentially the phase-to-ground system voltage. However, even faults to well grounded transmission towers or substation structures can result in hazardous voltages.<sup>1</sup> The degree of the hazard depends upon the magnitude of the fault current and the time of exposure.

<sup>1</sup>This appendix provides information primarily with respect to employee protection from contact between equipment being used and an energized power line. The information presented is also relevant to ground faults to transmission towers and substation structures; however, grounding systems for these structures should be designed to minimize the step and touch potentials involved.

*II. Voltage-Gradient Distribution*

## A. Voltage-Gradient Distribution Curve

The dissipation of voltage from a grounding electrode (or from the grounded end of an energized grounded object) is called the ground potential gradient. Voltage drops associated with this dissipation of voltage are called ground potentials. Figure 1 is a typical voltage-gradient distribution curve (assuming a uniform soil texture). This graph shows that voltage decreases rapidly with increasing distance from the grounding electrode.

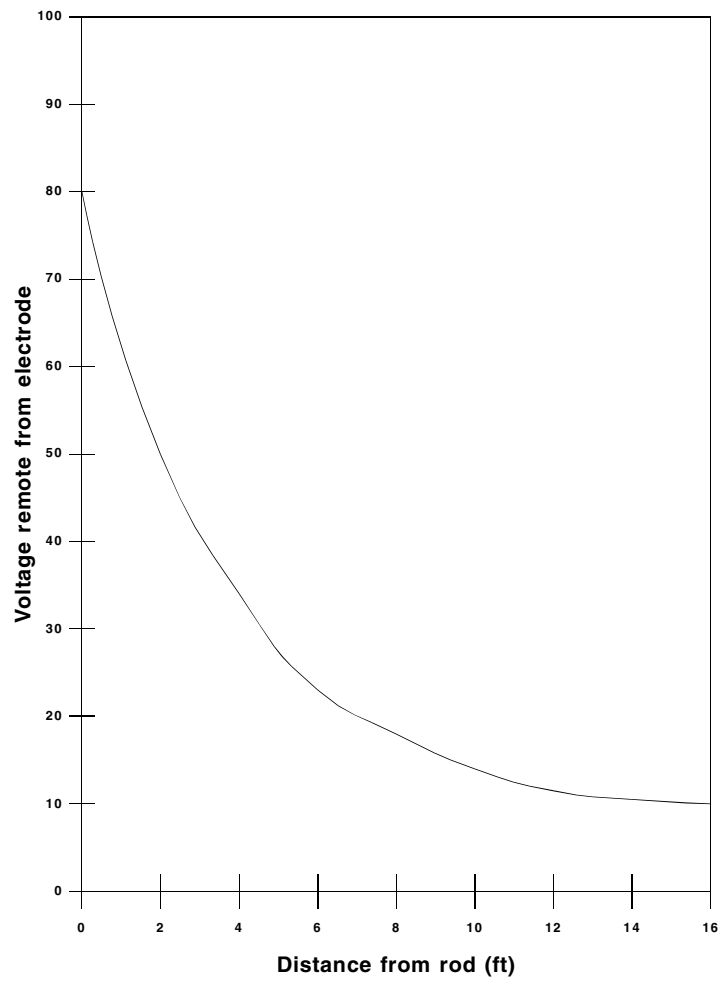
## B. Step and Touch Potentials

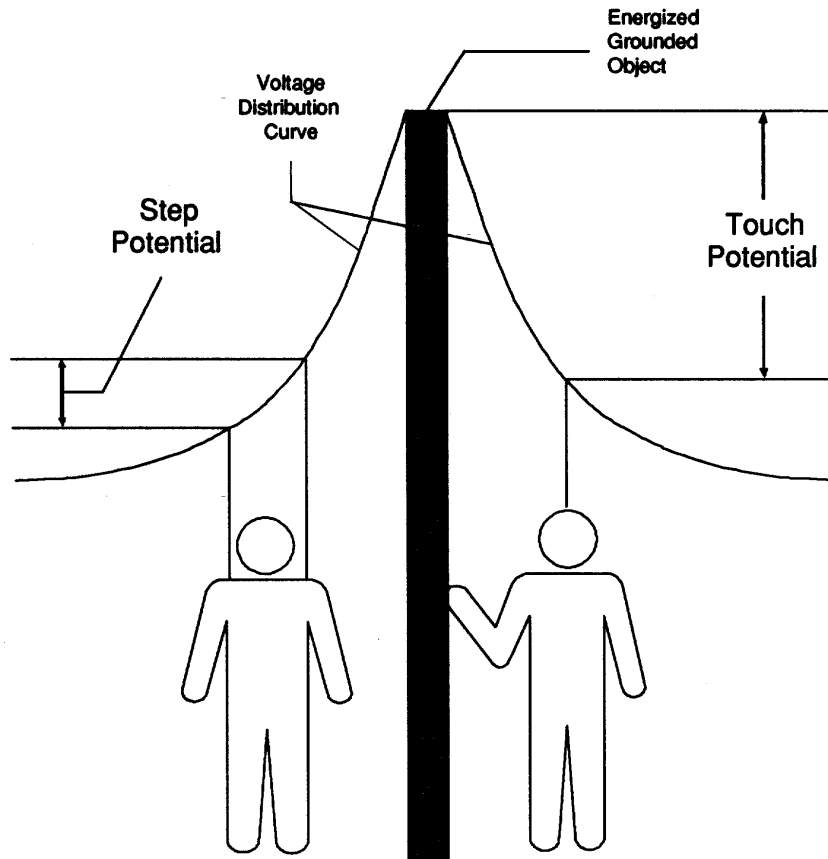
“Step potential” is the voltage between the feet of a person standing near an energized grounded object. It is equal to the difference in voltage, given by the voltage distribution curve, between two points at dif-

ferent distances from the “electrode”. A person could be at risk of injury during a fault simply by standing near the grounding point.

“Touch potential” is the voltage between the energized object and the feet of a person in contact with the object. It is equal to the difference in voltage between the object (which is at a distance of 0 feet) and a point some distance away. It should be noted that the touch potential could be nearly the full voltage across the grounded object if that object is grounded at a point remote from the place where the person is in contact with it. For example, a crane that was grounded to the system neutral and that contacted an energized line would expose any person in contact with the crane or its uninsulated load line to a touch potential nearly equal to the full fault voltage.

Step and touch potentials are illustrated in Figure 2.





**Figure 2 - Step and Touch Potentials**

FIGURE 1—TYPICAL VOLTAGE-GRADIENT DISTRIBUTION CURVE

C. Protection From the Hazards of Ground-Potential Gradients.

An engineering analysis of the power system under fault conditions can be used to determine whether or not hazardous step and

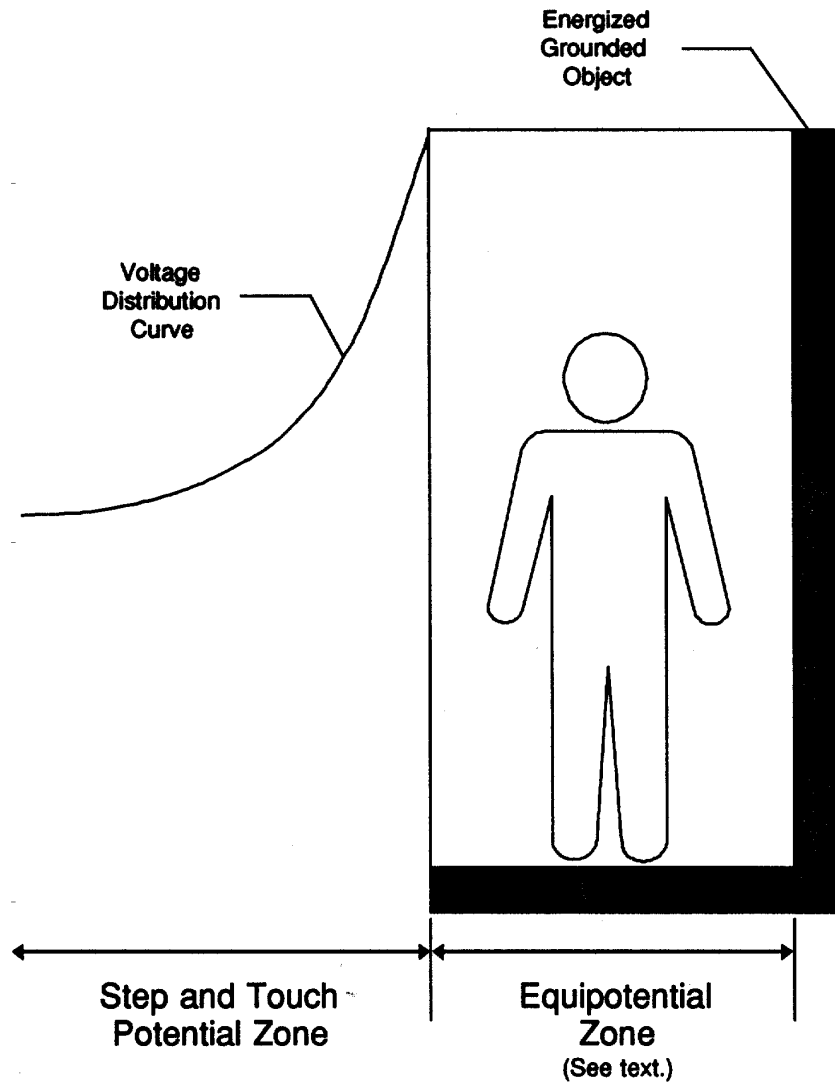
touch voltages will develop. The result of this analysis can ascertain the need for protective measures and can guide the selection of appropriate precautions.

Several methods may be used to protect employees from hazardous ground-potential gradients, including equipotential zones, insulating equipment, and restricted work areas.

1. The creation of an equipotential zone will protect a worker standing within it from hazardous step and touch potentials. (See Figure 3.) Such a zone can be produced through the use of a metal mat connected to the grounded object. In some cases, a grounding grid can be used to equalize the voltage within the grid. Equipotential zones will not, however, protect employees who are either wholly or partially outside the protected area. Bonding conductive objects in the immediate work area can also be used to minimize the potential between the objects and between each object and ground. (Bonding an object outside the work area can increase the touch potential to that object in some cases, however.)

2. The use of insulating equipment, such as rubber gloves, can protect employees handling grounded equipment and conductors from hazardous touch potentials. The insulating equipment must be rated for the highest voltage that can be impressed on the grounded objects under fault conditions (rather than for the full system voltage).

3. Restricting employees from areas where hazardous step or touch potentials could arise can protect employees not directly involved in the operation being performed. Employees on the ground in the vicinity of transmission structures should be kept at a distance where step voltages would be insufficient to cause injury. Employees should not handle grounded conductors or equipment likely to become energized to hazardous voltages unless the employees are within an equipotential zone or are protected by insulating equipment.



**Figure 3 - Protection from Ground-Potential Gradients**

APPENDIX D TO § 1910.269—METHODS OF  
INSPECTING AND TESTING WOOD POLES*I. Introduction*

When work is to be performed on a wood pole, it is important to determine the condition of the pole before it is climbed. The weight of the employee, the weight of equipment being installed, and other working stresses (such as the removal or retensioning of conductors) can lead to the failure of a defective pole or one that is not designed to handle the additional stresses.<sup>1</sup> For these reasons, it is essential that an inspection and test of the condition of a wood pole be performed before it is climbed.

If the pole is found to be unsafe to climb or to work from, it must be secured so that it does not fail while an employee is on it. The pole can be secured by a line truck boom, by ropes or guys, or by lashing a new pole alongside it. If a new one is lashed alongside the defective pole, work should be performed from the new one.

*II. Inspection of Wood Poles*

Wood poles should be inspected by a qualified employee for the following conditions:<sup>2</sup>

*A. General Condition*

The pole should be inspected for buckling at the ground line and for an unusual angle with respect to the ground. Buckling and odd angles may indicate that the pole has rotted or is broken.

*B. Cracks*

The pole should be inspected for cracks. Horizontal cracks perpendicular to the grain of the wood may weaken the pole. Vertical ones, although not considered to be a sign of a defective pole, can pose a hazard to the climber, and the employee should keep his or her gaffs away from them while climbing.

*C. Holes*

Hollow spots and woodpecker holes can reduce the strength of a wood pole.

*D. Shell Rot and Decay*

Rotting and decay are cutout hazards and are possible indications of the age and internal condition of the pole.

<sup>1</sup>A properly guyed pole in good condition should, at a minimum, be able to handle the weight of an employee climbing it.

<sup>2</sup>The presence of any of these conditions is an indication that the pole may not be safe to climb or to work from. The employee performing the inspection must be qualified to make a determination as to whether or not it is safe to perform the work without taking additional precautions.

*E. Knots*

One large knot or several smaller ones at the same height on the pole may be evidence of a weak point on the pole.

*F. Depth of Setting*

Evidence of the existence of a former ground line substantially above the existing ground level may be an indication that the pole is no longer buried to a sufficient extent.

*G. Soil Conditions*

Soft, wet, or loose soil may not support any changes of stress on the pole.

*H. Burn Marks*

Burning from transformer failures or conductor faults could damage the pole so that it cannot withstand mechanical stress changes.

*III. Testing of Wood Poles*

The following tests, which have been taken from § 1910.268(n)(3), are recognized as acceptable methods of testing wood poles:

*A. Hammer Test*

Rap the pole sharply with a hammer weighing about 3 pounds, starting near the ground line and continuing upwards circumferentially around the pole to a height of approximately 6 feet. The hammer will produce a clear sound and rebound sharply when striking sound wood. Decay pockets will be indicated by a dull sound or a less pronounced hammer rebound. Also, prod the pole as near the ground line as possible using a pole prod or a screwdriver with a blade at least 5 inches long. If substantial decay is encountered, the pole is considered unsafe.

*B. Rocking Test*

Apply a horizontal force to the pole and attempt to rock it back and forth in a direction perpendicular to the line. Caution must be exercised to avoid causing power lines to swing together. The force may be applied either by pushing with a pike pole or pulling with a rope. If the pole cracks during the test, it shall be considered unsafe.

APPENDIX E TO § 1910.269—REFERENCE  
DOCUMENTS

The references contained in this appendix provide information that can be helpful in understanding and complying with the requirements contained in § 1910.269. The national consensus standards referenced in this appendix contain detailed specifications that employers may follow in complying with the more performance-oriented requirements of OSHA's final rule. Except as specifically noted in § 1910.269, however, compliance with the national consensus standards is not a



## § 1910.272

substitute for compliance with the provisions of the OSHA standard.

ANSI/SIA A92.2-1990, American National Standard for Vehicle-Mounted Elevating and Rotating Aerial Devices.

ANSI C2-1993, National Electrical Safety Code.

ANSI Z133.1-1988, American National Standard Safety Requirements for Pruning, Trimming, Repairing, Maintaining, and Removing Trees, and for Cutting Brush.

ANSI/ASME B20.1-1990, Safety Standard for Conveyors and Related Equipment.

ANSI/IEEE Std. 4-1978 (Fifth Printing), IEEE Standard Techniques for High-Voltage Testing.

ANSI/IEEE Std. 100-1988, IEEE Standard Dictionary of Electrical and Electronic Terms.

ANSI/IEEE Std. 516-1987, IEEE Guide for Maintenance Methods on Energized Power-Lines.

ANSI/IEEE Std. 935-1989, IEEE Guide on Terminology for Tools and Equipment To Be Used in Live Line Working.

ANSI/IEEE Std. 957-1987, IEEE Guide for Cleaning Insulators.

ANSI/IEEE Std. 978-1984 (R1991), IEEE Guide for In-Service Maintenance and Electrical Testing of Live-Line Tools.

ASTM D 120-87, Specification for Rubber Insulating Gloves.

ASTM D 149-92, Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.

ASTM D 178-93, Specification for Rubber Insulating Matting.

ASTM D 1048-93, Specification for Rubber Insulating Blankets.

ASTM D 1049-93, Specification for Rubber Insulating Covers.

ASTM D 1050-90, Specification for Rubber Insulating Line Hose.

ASTM D 1051-87, Specification for Rubber Insulating Sleeves.

ASTM F 478-92, Specification for In-Service Care of Insulating Line Hose and Covers.

ASTM F 479-93, Specification for In-Service Care of Insulating Blankets.

ASTM F 496-93b, Specification for In-Service Care of Insulating Gloves and Sleeves.

ASTM F 711-89, Specification for Fiberglass-Reinforced Plastic (FRP) Rod and Tube Used in Live Line Tools.

ASTM F 712-88, Test Methods for Electrically Insulating Plastic Guard Equipment for Protection of Workers.

ASTM F 819-83a (1988), Definitions of Terms Relating to Electrical Protective Equipment for Workers.

ASTM F 855-90, Specifications for Temporary Grounding Systems To Be Used on De-Energized Electric Power Lines and Equipment.

ASTM F 887-91a, Specifications for Personal Climbing Equipment.

## 29 CFR Ch. XVII (7-1-06 Edition)

ASTM F 914-91, Test Method for Acoustic Emission for Insulated Aerial Personnel Devices.

ASTM F 968-93, Specification for Electrically Insulating Plastic Guard Equipment for Protection of Workers.

ASTM F 1116-88, Test Method for Determining Dielectric Strength of Overshoe Footwear.

ASTM F 1117-87, Specification for Dielectric Overshoe Footwear.

ASTM F 1236-89, Guide for Visual Inspection of Electrical Protective Rubber Products.

ASTM F 1505-94, Standard Specification for Insulated and Insulating Hand Tools.

ASTM F 1506-94, Standard Performance Specification for Textile Materials for Wearing Apparel for Use by Electrical Workers Exposed to Momentary Electric Arc and Related Thermal Hazards.

IEEE Std. 62-1978, IEEE Guide for Field Testing Power Apparatus Insulation.

IEEE Std. 524-1992, IEEE Guide to the Installation of Overhead Transmission Line Conductors.

IEEE Std. 1048-1990, IEEE Guide for Protective Grounding of Power Lines.

IEEE Std. 1067-1990, IEEE Guide for the In-Service Use, Care, Maintenance, and Testing of Conductive Clothing for Use on Voltages up to 765 kV AC.

[59 FR 4437, Jan. 31, 1994; 59 FR 33658, June 30, 1994, as amended at 59 FR 4458, Jan. 31, 1994; 59 FR 40729, Aug. 9, 1994; 59 FR 51748, Oct. 12, 1994]

### § 1910.272 Grain handling facilities.

(a) *Scope.* This section contains requirements for the control of grain dust fires and explosions, and certain other safety hazards associated with grain handling facilities. It applies in addition to all other relevant provisions of part 1910 (or part 1917 at marine terminals).

(b) *Application.* (1) Paragraphs (a) through (n) of this section apply to grain elevators, feed mills, flour mills, rice mills, dust pelletizing plants, dry corn mills, soybean flaking operations, and the dry grinding operations of soybeans.

(2) Paragraphs (o), (p), and (q) of this section apply only to grain elevators.

#### (c) *Definitions.*

*Choked leg* means a condition of material buildup in the bucket elevator that results in the stoppage of material flow and bucket movement. A bucket elevator is not considered choked that has the up-leg partially or fully loaded