INTRODUCTION:

Electric power generation, transmission, and distribution covers the operation and maintenance of electric power generation, and the control, transformation, transmission, distribution lines, and equipment.

Provisions apply to:

- Power generation, transmission, and distribution installations, including related equipment for the purpose of communication or metering, which are accessible only to qualified employees
- Types of installations covered 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 in the electrical safety appendix.

TRAINING

- Employees must be trained in and familiar with safety-related work practices, safety procedures, and other safety requirements that pertain to their respective job assignments.
- Employees must 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 but that are related to their work and are necessary for their safety.
- Qualified employees must be trained and competent in the skills and techniques necessary to distinguish exposed live parts from other parts of electric equipment, determine the nominal voltage of exposed live parts, the minimum approach distances corresponding to the voltages to which a qualified employee will be exposed, and 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.

Qualified person

The employer must determine, through regular supervision and through inspections conducted on at least an annual basis; that each employee is complying with all safety-related work practices.

An employee is required to receive additional training (or retraining) under the following conditions:

- When supervision and annual inspections indicate that the employee is not complying with the safety-related work practices.
- When 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.
- When he or she must employ safety-related work practices that are not normally used during his or her regular job duties.
- OSHA would consider tasks that are performed less often than once per year to necessitate retraining before the performance of the work practices involved.

Training is required to be in a classroom or on-the-job.

- Training must establish employee proficiency in the work practices and is required to introduce the procedures necessary for compliance.
- Employers must certify that each employee has received the proper training.
- Certification is required to be made when the employee demonstrates proficiency in the work practices involved.
- Certification must be maintained for the duration of the employee's employment.
- Employment records that indicate that an employee has received the required training are an acceptable means of meeting this requirement.

Existing conditions

- Existing conditions related to the safety of the work to be performed must be determined before work on or near electric lines or equipment is started.
- 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.

Job briefing

Employers are required to ensure that the employee in charge conducts a job briefing with the employees involved before they start each job.

Briefings must cover the following:

- Hazards associated with the job
- Work procedures involved
- Special precautions
- Energy source controls
- Personal protective equipment requirements

Number of briefings

- When the work or operations to be performed during the work day or shift are repetitive and similar, at least one job briefing is required to be conducted before the start of the first job of each day or shift. Additional job briefings must be held if significant changes, which might affect the safety of the employees, occur during the course of the work.
- 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 is required to be conducted, when the work is complicated or particularly hazardous, or when the employee cannot be expected to recognize and avoid the hazards involved in the job.
- An employee working alone need not conduct a job briefing. However, the employer must ensure that the tasks to be performed are planned as if a briefing were required.

FIRST AID AND MEDICAL SERVICES

- The employer must ensure the ready availability of medical personnel for advice and consultation on matters of workers health.
- In the absence of an infirmary, clinic, or hospital in near proximity to the workplace which is used for the treatment of all injured employees, a person or persons must be adequately trained to render first aid. Adequate first aid supplies must be readily available.
- Where the eyes or body of any person may be exposed to injurious corrosive materials, suitable facilities for quick drenching or flushing of the eyes and body must be provided within the work area for immediate emergency use.

First aid kits (non-mandatory)

First aid supplies are required to be readily available. An example of the minimal contents of a generic first- aid kit is described in American National Standard (ANSI) Z308.1- 1978 "Minimum Requirements for Industrial Unit-Type First-aid Kits." In the kit are the following items:

- First Aid Guide, Adhesive Bandages, Adhesive Tape, Alcohol Prep Pads, Ammonia Inhalants, Bandage Compress, Burn Ointment, Burn Aid Spray, Cold Pak, Eye Wash Solution, Eye Dressing Pads, Gauze Compress, Sterile Pads, Knuckle Bandages, Latex Gloves, PVP Iodine Wipes, Tweezers, Latex Gloves, Scissors, Sting Kill Swabs, Triangular Bandages, Wire Splint
- The contents should be adequate for small worksites.
- When larger operations or multiple operations are being conducted at the same location, employers should determine the need for additional first-aid kits at the worksite, additional types of first aid equipment and supplies and additional quantities and types of supplies and equipment in the first-aid kits.
- Employers who have unique or changing first-aid needs in their workplace may need to enhance their first-aid kits.

- The employer can use the OSHA 200 log, OSHA 101's or other reports to identify these unique problems. Consultation from the local fire/rescue department, appropriate medical professional or local emergency room may be helpful to employers in these circumstances.
- By assessing the specific needs of their workplace, employers can ensure that reasonably anticipated supplies are available. Employers should assess the specific needs of their worksite periodically and augment the first-aid kit appropriately.
- If it is reasonably anticipated that employees will be exposed to blood or other potentially infectious materials while using first aid supplies, employers are required to provide appropriate personal protective equipment (PPE) in compliance with the provisions of the Occupational Exposure to Bloodborne Pathogens standard. This standard lists appropriate PPE for this type of exposure, such as gloves, gowns, face shields, masks, and eye protection.

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) must be available as follows:

1. For field work involving two or more employees at a work location, at least two trained persons are required to be available.
2. 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.
3. For fixed work locations such as generating stations, the number of trained persons available must 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 must be trained.

First aid supplies: First aid supplies are required to be placed in weatherproof containers if the supplies could be exposed to the weather.

First aid kits: Each first-aid kit must be maintained, must be readily available for use, and is required to be inspected frequently enough to ensure that expended items are replaced at least once per year.

PERSONAL PROTECTIVE EQUIPMENT (PPE)

- Protective equipment, including personal protective equipment for eyes, face, head, and extremities, protective clothing, respiratory devices, and protective shields and barriers, must be provided, used, and maintained in a sanitary and reliable condition wherever it is necessary by reason of hazards of processes or environment, chemical hazards, radiological hazards, or mechanical irritants encountered in a manner capable of causing injury or impairment in the function of any part of the body through absorption, inhalation or physical contact.
- **Employee owned equipment:** Where employees provide their own protective equipment, the employer is responsible to assure its adequacy, including proper maintenance, and sanitation of such equipment.
- **Design:** All personal protective equipment must be of safe design and construction for the work to be performed.

HAZARD ASSESSMENT AND EQUIPMENT SELECTION

- The employer must assess the workplace to determine if hazards are present, or are likely to be present, which necessitate the use of personal protective equipment (PPE).
- If such hazards are present, or likely to be present, the employer must:
  1. Select, and have each affected employee use, the types of PPE that will protect the affected employee from the hazards identified in the hazard assessment
  2. Communicate selection decisions to each affected employee
  3. Select PPE that properly fits each affected employee
- The employer must verify that the required workplace hazard assessment has been performed through a written certification that identifies the workplace evaluated; the person certifying that the evaluation has been performed; the date(s) of the hazard assessment; and, which identifies the document as a certification of hazard assessment.
- **Defective and damaged equipment:** Defective or damaged personal protective equipment must not be used.
- **Training:** The employer is required to provide training to each employee who is required to use PPE.
- Each such employee must be trained to know at least the following:

  1. When PPE is necessary
  2. What PPE is necessary
  3. How to properly don, doff, adjust, and wear PPE
  4. The limitations of the PPE
  5. The proper care, maintenance, useful life and disposal of the PPE

- Each affected employee must demonstrate an understanding of the training, and the ability to use PPE properly, before being allowed to perform work requiring the use of PPE.
- When the employer has reason to believe that any affected employee who has already been trained does not have the understanding and skill required, the employer must retrain each such employee.
  Circumstances where retraining is required include, but are not limited to, situations where:

  1. Changes in the workplace render previous training obsolete
  2. Changes in the types of PPE to be used render previous training obsolete
  3. Inadequacies in an affected employee's knowledge or use of assigned PPE indicate that the employee has not retained the requisite understanding or skill

- The employer is required to verify that each affected employee has received and understood the required training through a written certification that contains the name of each employee trained, the date(s) of training, and that identifies the subject of the certification.
- All hard hats approved for electrical work made since 1997 are marked "Class E." Hard hats made before 1997 are marked "Class B." These markings will be on a label inside the helmet or stamped into the helmet itself.
- Newer hats may also be marked "Type 1" or "Type 2." Type 1 hard hats protect you from impacts on the top of your head. Type 2 hard hats protect you from impacts on the top and sides of your head.
- Wear safety glasses or goggles, and ear muffs or plugs.
- Wear safety shoes or boots, and the proper clothing.

ELECTRICAL PROTECTIVE EQUIPMENT

- Insulating blankets, matting, covers, line hose, gloves, and sleeves made of rubber must meet the following requirements:
- Blankets, gloves, and sleeves must be produced by a seamless process.
- Each item must be clearly marked as follows:
- Class 0 through 4 equipment must be marked with its class number
- Non-ozone-resistant equipment other than matting must be marked Type I.
- Ozone-resistant equipment other than matting must be marked Type II.
- Other relevant markings, such as the manufacturer's identification and the size of the equipment, may also be provided.
- Markings must be non-conducting and are required to be applied in such a manner as not to impair the insulating qualities of the equipment.
- Markings on gloves must be confined to the cuff portion of the glove.

Electrical requirements

All electrical protective gloves must comply with the requirements of OSHA standards 1910.137.

- Equipment must be capable of withstanding the a-c proof-test voltage or the d-c proof-test voltage listed in the standard
- The proof test is required to reliably indicate that the equipment can withstand the voltage involved.
- The test voltage is required to be applied continuously for 3 minutes for equipment other than matting and shall be applied continuously for 1 minute for matting.
- Gloves must also be capable of withstanding the a-c proof-test voltage specified after a 16-hour water soak.
- When the a-c proof test is used on gloves, the 60-hertz proof-test current may not exceed the values specified at any time during the test period.
- If the a-c proof test is made at a frequency other than 60 hertz, the permissible proof-test current is required to be computed from the direct ratio of the frequencies.
- For the test, gloves (right side out) must be filled with tap water and immersed in water to a depth that is in accordance with the OSHA requirements. Water must be added to or removed from the glove, as necessary, so that the water level is the same inside and outside the glove.
- After the 16-hour water soak, the 60-hertz proof-test current may exceed the OSHA limits by not more than 2 milliamperes.
- Equipment that has been subjected to a minimum breakdown voltage test may not be used for electrical protection.
- Material used for Type II insulating equipment must be capable of withstanding an ozone test, with no visible effects.
- The ozone test is required to reliably indicate that the material will resist ozone exposure in actual use.
- Any visible signs of ozone deterioration of the material; such as checking, cracking, breaks, or pitting, is evidence of failure to meet the requirements for ozone-resistant material.

Workmanship and finish

- Equipment must be free of harmful physical irregularities that can be detected by the tests or inspections.
- Surface irregularities that may be present on all rubber goods because of imperfections on forms or molds or because of inherent difficulties in the manufacturing process and that may appear as indentations, protuberances, or imbedded foreign material are acceptable under the following conditions:

    1. The indentation or protuberance blends into a smooth slope when the material is stretched.
    2. Foreign material remains in place when the insulating material is folded and stretches with the insulating material surrounding it.

In-service care and use

- Electrical protective equipment must be maintained in a safe, reliable condition. The following specific requirements apply to insulating blankets, covers, line hose, gloves, and sleeves made of rubber:
  - Maximum use voltages must conform to the OSHA standards in 1910.137
  - Insulating equipment is required to be inspected for damage before each day's use and immediately following any incident that can reasonably be suspected of having caused damage.
  - Insulating gloves must be given an air test, along with the inspection.

  Insulating equipment with any of the following defects may not be used:

  - With a hole, tear, puncture, or cut.
  - Ozone cutting or ozone checking (the cutting action produced by ozone on rubber under mechanical stress into a series of interlacing cracks).
  - An embedded foreign object.
  - Any of the following texture changes: swelling, softening, hardening, or becoming sticky or inelastic.
  - Any other defect that damages the insulating properties.

  Insulating equipment found to have other defects that might affect its insulating properties must be removed from service and returned for testing.

  Insulating equipment must be cleaned as needed to remove foreign substances.

  Insulating equipment must be stored in such a location and in such a manner as to protect it from light, temperature extremes, excessive humidity, ozone, and other injurious substances and conditions.

  Protector gloves must be worn over insulating gloves, except as follows:

  1. Protector gloves need not be used with Class 0 gloves, under limited-use conditions, where small equipment and parts manipulation necessitate unusually high finger dexterity.
  2. Extra care is needed in the visual examination of the glove and in the avoidance of handling sharp objects.
  3. Any other class of glove may be used for similar work without protector gloves if the employer can demonstrate that the possibility of physical damage to the gloves is small and if the class of glove is one class higher than that required for the voltage involved.
  4. Insulating gloves that have been used without protector gloves may not be used at a higher voltage until they have been tested.

- Electrical protective equipment must be subjected to periodic electrical tests. Test voltages and the maximum intervals between tests are required to be in accordance with the tables listed below.
- The test method used under this section must reliably indicate whether the insulating equipment can withstand the voltages involved.
  Insulating equipment failing to pass inspections or electrical tests may not be used by employees, except as follows:

  1. Rubber insulating line hose may be used in shorter lengths with the defective portion cut off.
  2. Rubber insulating blankets may be repaired using a compatible patch that results in physical and electrical properties equal to those of the blanket.
  3. Rubber insulating blankets may be salvaged by severing the defective area from the undamaged portion of the blanket. The resulting undamaged area may not be smaller than 22 inches by 22 inches (560 mm by 560 mm) for Class 1, 2, 3, and 4 blankets.
  4. Rubber insulating gloves and sleeves with minor physical defects, such as small cuts, tears, or punctures, may be repaired by the application of a compatible patch.
  5. Rubber insulating gloves and sleeves with minor surface blemishes may be repaired with a compatible liquid compound. The patched area must have electrical and physical properties equal to those of the surrounding material. Repairs to gloves are permitted only in the area between the wrist and the reinforced edge of the opening.

  - Repaired insulating equipment is required be retested before it may be used by employees.
  - The employer must certify that equipment has been tested in accordance with the requirements.
  - The certification is required to identify the equipment that passed the test and the date it was tested.
  - Marking of equipment and entering the results of the tests and the dates of testing onto logs are two acceptable means of meeting this requirement.

ARC FLASH

Flash Hazard Analysis

A flash hazard analysis involved (in mega volt-amps) must be done in order to protect personnel from the possibility of being injured by an arc flash. The analysis is required to determine the Flash Protection Boundary and the personal protective equipment that workers within the Flash Protection Boundary must use.

Factors in selection of protective clothing (The arc rating for a particular clothing system can be obtained from the FR (flame-resistant) clothing manufacturer.

- Clothing and equipment that provide worker protection from shock and arc flash hazards must be utilized.
- Clothing and equipment required for the degree of exposure must be permitted to be worn alone or integrated with flammable, non-melting apparel.
- If FR clothing is required, it is required to cover associated parts of the body as well as all flammable apparel while allowing movement and visibility.
- All personal protective equipment must be maintained in a sanitary and functionally effective condition.
- Personal protective equipment items will normally be used in conjunction with one another as a system to provide the appropriate level of protection.
- Protective clothing includes shirts, pants, coveralls, jackets, and parkas worn routinely by workers who, under normal working conditions, are exposed to momentary electric arc and related thermal hazards.
- Flame-resistant rainwear worn in inclement weather is included in this category of clothing.

Layering

- Non-melting, flammable fiber garments may be permitted to be used as underlayers in conjunction with FR garments in a layered system for added protection.
- If non-melting, flammable fiber garments are used as underlayers, the system arc rating must be sufficient to prevent break open of the innermost FR layer at the expected arc exposure incident energy level to prevent ignition of flammable underlayers.
- A typical layering system might include cotton underwear, a cotton shirt and trouser, and a FR coverall. Specific tasks might call for additional FR layers to achieve the required protection level.

Outer Layers: Garments worn as outer layers over FR clothing, such as jackets or rainwear, must also be made from FR material.

Underlayers: Meltable fibers such as acetate, nylon, polyester, polypropylene, and spandex will not be permitted in fabric underlayers (underwear) next to the skin.

Exception: An incidental amount of elastic used on non-melting fabric underwear or socks is required to be permitted.

- FR garments (e.g., shirts, trousers, and coveralls) worn as underlayers that neither ignite nor melt and drip in the course of an exposure to electric arc and related thermal hazards generally provide a higher system arc rating than non-melting, flammable fiber underlayers.
- FR underwear or undergarments used as underlayers generally provide a higher system arc rating than non-melting, flammable fiber underwear or undergarments used as underlayers.

Coverage: Clothing is required to cover potentially exposed areas as completely as possible. Shirt sleeves must be fastened at the wrists, and shirts and jackets are required to be closed at the neck.

Fit: Tight-fitting clothing must be avoided. Loose-fitting clothing provides additional thermal insulation because of air spaces. FR apparel must fit properly such that it does not interfere with the work task.

Interference: The garment selected must result in the least interference with the task but still provide the necessary protection. The work method, location, and task could influence the protective equipment selected.

Flash Suits: Flash suit design must permit easy and rapid removal by the wearer. The entire flash suit, including the hood's face shield, is required to have an arc rating that is suitable for the arc flash exposure. When exterior air is supplied into the hood, the air hoses and pump housing must be either covered by FR materials or constructed of non-melting and nonflammable materials.

Face Protection: Face shields must have an arc rating suitable for the arc flash exposure. Face shields without an arc rating must not be used. Eye protection (safety glasses or goggles) are required to always be worn under face shields or hoods.

- Face shields made with energy-absorbing formulations that can provide higher levels of protection from the radiant energy of an arc flash are available, but these shields are tinted and can reduce visual acuity. Additional illumination of the task area might be necessary when these types of arc protective face shields are used.

Hand Protection: Leather or FR gloves must be worn where required for arc flash protection. Where insulating rubber gloves are used for shock protection, leather protectors must be worn over the rubber gloves.

Foot Protection: Heavy-duty leather work shoes provide some arc flash protection to the feet and are required to be used in all tasks in Hazard\Risk Category 2 and higher.

HAZARDOUS ENERGY CONTROL (LOCKOUT/TAGOUT) PROCEDURES

- Employers must 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.

Energy control requirements

If an energy isolating device is not capable of being locked out, use a tagout system. When an energy isolating device is capable of being locked out, use lockout unless it can be demonstrated 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 must be attached at the same location that the lockout device would have been attached.
2. The employer must demonstrate that the tagout program will provide a level of safety equivalent to that obtained by the use of a lockout program.
3. 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 is required to 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.
4. Additional means to be considered as part of the demonstration of full employee protection must 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.

- 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 must be designed to accept a lockout device.
- Procedures must be developed, documented, and used for the control of potentially hazardous energy.

The procedure must 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:

1. A specific statement of the intended use of this procedure.
2. Specific procedural steps for shutting down, isolating, blocking and securing machines or equipment to control hazardous energy.
3. Specific procedural steps for the placement, removal, and transfer of lockout devices or tagout devices and the responsibility for them.
4. Specific requirements for testing a machine or equipment to determine and verify the effectiveness of lockout devices, tagout devices, and other energy control measures.

- Employers must conduct a periodic inspection of the energy control procedure at least annually to ensure that the procedure is being followed.
- The inspection must be performed by an authorized employee who is not using the energy control procedure being inspected. The inspection must be designed to identify and correct any deviations or inadequacies.
- If lockout or tagout is used for energy control, the inspection must include a review, between the inspector and each authorized employee, of that employee's responsibilities under the energy control procedure being inspected.
- The employer is required to certify that the inspections have been accomplished.
- Certification must 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.

Employers are required to 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.

TRAINING:

- 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.
- Purpose and use of the energy control procedure.
- Procedures and prohibition relating to attempts to restart or reenergize machines or equipment that are locked out or tagged out.

Limitations of tags for tagout systems:

1. 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.
2. 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.
3. 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.
4. Tags and their means of attachment must be made of materials which will withstand the environmental conditions encountered in the workplace.
5. Tags may evoke a false sense of security, and their meaning needs to be understood as part of the overall energy control program.
6. Tags must be securely attached to energy isolating devices so that they cannot be inadvertently or accidentally detached during use.

Retraining

Retraining must be provided by 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, and 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.

Protective materials and hardware

- Locks, tags, chains, wedges, key blocks, adapter pins, self-locking fasteners, or other hardware must be provided by the employer for isolating, securing, or blocking of machines or equipment from energy sources.
- Lockout devices and tagout devices must be singularly identified and must be the only devices used for controlling energy.
- Lockout devices and tagout devices may not be used for other purposes.
- Lockout devices and tagout devices are required to be capable of withstanding the environment to which they are exposed for the maximum period of time that exposure is expected.
- Tagout devices must 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, and must not deteriorate when used in corrosive environments.
- Lockout devices and tagout devices are required to be standardized within the facility in at least one of the following criteria: color, shape, size. Tagout devices print and format must be standardized.
- Lockout devices are required to 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.

- Tagout devices, including their means of attachment, must be substantial enough to prevent inadvertent or accidental removal. Tagout device attachment must 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 must have the general design and basic characteristics of being at least equivalent to a one-piece, all-environment-tolerant nylon cable tie.
- Each lockout device or tagout device is required to include provisions for the identification of the employee applying the device.

Tagout devices must warn against hazardous conditions if the machine or equipment is energized and include:

Do Not Start, Do Not Open, Do Not Close, Do Not Energize, Do Not Operate

Energy isolation

Lockout and tagout device application and removal may only be performed by the authorized employees who are performing the servicing or maintenance.

Notification

Affected employees must be notified by the employer or authorized employee of the application and removal of lockout or tagout devices. Notification is required to be given before the controls are applied and after they are removed from the machine or equipment.

Lockout/tagout application

The established procedures for the lockout or tagout procedures must include the following elements and actions and be performed in the following sequence:

1. Before an authorized or affected employee turns off a machine or equipment, the authorized employee is required to 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.
2. The machine or equipment must be turned off or shut down using the procedures established for the machine or equipment. An orderly shutdown is required to be used to avoid any additional or increased hazards to employees as a result of the equipment stoppage.
3. All energy isolating devices that are needed to control the energy to the machine or equipment must be physically located and operated in such a manner as to isolate the machine or equipment from energy sources.
4. Lockout or tagout devices must be affixed to each energy isolating device by authorized employees.

- Lockout devices must be attached in a manner that will hold the energy isolating devices in a "safe" or "off" position.
- Tagout devices are required to 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.

- Where tagout devices are used with energy isolating devices designed with the capability of being locked out, the tag attachment must be fastened at the same point at which the lock would have been attached.
- Where a tag cannot be affixed directly to the energy isolating device, the tag must 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.
- Following the application of lockout or tagout devices to energy isolating devices, all potentially hazardous stored or residual energy is required to be relieved, disconnected, restrained, or otherwise rendered safe.
- If there is a possibility of reaccumulation of stored energy to a hazardous level, verification of isolation must be continued until the servicing or maintenance is completed or until the possibility of such accumulation no longer exists.
- Before starting work on machines or equipment that have been locked out or tagged out, the authorized employee must verify that isolation and de-energizing of the machine or equipment have been accomplished.
- When normally energized parts will be exposed to contact by an employee while the machine or equipment is de-energized, a test is required to be performed to ensure that these parts are de-energized.

Release from lockout/tagout

- Before lockout or tagout devices are removed and energy is restored to the machine or equipment, ensure the following:
  - Inspect to ensure that nonessential items have been removed and that machine or equipment components are operationally intact.
  - Check to ensure that all employees have been safely positioned or removed.
  - After lockout or tagout devices have been removed and before a machine or equipment is started, affected employees must be notified that the lockout or tagout devices have been removed.
  - Each lockout or tagout device must be removed from the energy isolating device by the authorized employee who applied the lockout or tagout device.
  - When 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 is required to 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 must include at least the following elements:

  1. Verification by the employer that the authorized employee who applied the device is not at the facility
  2. 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
  3. Ensuring that the authorized employee has this knowledge before he or she resumes work at that facility

When 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 must be followed:

1. Clear the machine or equipment of tools and materials.
2. Remove employees from the machine or equipment area.
3. Remove the lockout or tagout devices.
4. Energize and proceed with the testing or positioning.
5. De-energize all systems and reapply energy control measures to continue the servicing or maintenance.

When servicing or maintenance is performed by a crew, craft, department, or other group, they are required to 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 must be used in accordance, but not limited to, the following specific requirements:

- Primary responsibility must 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).
- Provision must 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.
- When more than one crew, craft, department, or other group is involved, assignment of overall job-associated lockout or tagout control responsibility must be given to an authorized employee designated to coordinate affected work forces and ensure continuity of protection.
- 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 must remove those devices when he or she stops working on the machine or equipment being serviced or maintained.
- Procedures are required to 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.
- Whenever outside servicing personnel are to be engaged in activities, the on-site employer and the outside employer must inform each other of their respective lockout or tagout procedures, and each employer must ensure that his or her personnel understand and comply with restrictions and prohibitions of the energy control procedures being used.

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

- The employer is required to use a procedure that affords employees a level of protection equivalent to that provided by the implementation of a personal lockout or tagout device.
- The system operator must place and remove lockout and tagout devices in place of the authorized employee.
- Provisions are required to 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.

ENCLOSED SPACES

- This 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.)
- The employer must ensure the use of safe work practices for entry into and work in enclosed spaces and for rescue of employees from such spaces.
- Employees who enter enclosed spaces or who serve as attendants are required to be trained in the hazards of enclosed space entry, in enclosed space entry procedures, and in enclosed space rescue procedures.
- Employers must provide rescue equipment to ensure the prompt and safe rescue of employees from the enclosed space.
- Before any entrance cover to an enclosed space is removed, the employer is required to 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 must be eliminated before the cover is removed.
- The evaluation may take the form of a check of the conditions expected to be in the enclosed space. (E.g. 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 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.
- When covers are removed from enclosed spaces, the opening must 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.

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.
- While work is being performed in the enclosed space, a person with first aid training is required to 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.
- Test instruments used to monitor atmospheres in enclosed spaces must be kept in calibration, with a minimum accuracy of + or - 10 percent.

Testing for oxygen deficiency

Before an employee enters an enclosed space, the internal atmosphere must 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.

Testing for flammable gases and vapors

Before an employee enters an enclosed space, the internal atmosphere is required to 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 must be performed after the oxygen testing and ventilation demonstrate that there is sufficient oxygen to ensure the accuracy of the test for flammability.

Ventilation and monitoring

- If flammable gases or vapors are detected or if an oxygen deficiency is found, forced air ventilation must 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.
- If continuous forced air ventilation is used, it must begin before entry is made and is required to be maintained long enough to ensure that a safe atmosphere exists before employees are allowed to enter the work area. The forced air ventilation must 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.
- The air supply for the continuous forced air ventilation must be from a clean source and may not increase the hazards in the enclosed space.
- If open flames are used in enclosed spaces, a test for flammable gases and vapors is required to 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 must 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.

EXCAVATIONS AND TRENCHING

- Trenching and excavation work presents serious risks to all workers involved.
- An excavation is any man-made cut, cavity, trench, or depression in the earth’s surface formed by earth removal. This can include excavations for anything from cellars to highways.
- A trench is a narrow excavation made below the surface of the ground in which the depth is greater than the width — the width not exceeding 15 feet.
- Find the location of all underground utilities before digging.
- Keep workers away from digging equipment and never allow workers in an excavation when equipment is in use.
- Keep workers from getting between equipment in use and other obstacles and machinery that can cause crushing hazards.
- Keep equipment and the excavated dirt (spoils pile) back 2 feet from the edge of the excavation.
- Have a competent person conduct daily inspections and correct any hazards before workers enter a trench or excavation.
- Provide workers a way to get into and out of a trench or excavation such as ladders and ramps. They must be within 25 feet of the worker.
- For excavations and utility trenches over 4 feet deep, use shoring, shields (trench boxes), benching, or slope back the sides. Unless soil analysis has been completed, the earth's slope must be at least 1½ feet horizontal to 1 vertical.
- Keep water out of trenches with a pump or drainage system, and inspect the area for soil movement and potential cave-ins.
- Keep drivers in the cab and workers away from dump trucks when dirt and other debris are being loaded into them. Do not allow workers under any load and train them to stay clear of the backs of vehicles.

Before starting the job

- Before beginning work, employers must provide employees exposed to vehicular traffic with warning vests or other suitable garments marked with or made of reflectorized or high-visibility material and ensure that they wear them. Workers must also be instructed to remove or neutralize surface obstacles that may create hazards.
- No employee should operate equipment without being properly trained and alert to potential hazards. In training and in the worksite safety and health program, it also is important to include procedures for fast notification and investigation of accidents.

On-the-job evaluation

- The OSHA Standard requires that a competent person inspect excavations and adjacent areas at least daily for possible cave-ins, failures of protective systems and equipment, hazardous atmospheres, or other hazardous conditions. If these conditions are encountered, exposed employees must be removed from the hazardous area until necessary safety precautions have been taken.
- Inspections are also required after heavy rains or man-made events such as blasting that may increase the potential for hazards.
- Larger and more complex operations should have a full-time safety person who makes recommendations to improve implementation of the safety plan. In smaller operations, the safety person may be part-time and will usually be a supervisor.
- Supervisors are the contractor's representatives on the job.
- Supervisors should conduct inspections, investigate accidents, anticipate hazards, and ensure that employees receive on-the-job safety and health training. They must also review and strengthen overall safety and health precautions to guard against potential hazards, get necessary worker cooperation in safety matters, and report frequently to the contractor.
- Employees must also take an active role in job safety. The contractor and supervisor must make certain that workers have been properly trained in the use and fit of protective gear and equipment, that they are wearing and using the equipment correctly, and that they are using safe work practices.

CAVE-INS AND PROTECTIVE SUPPORT SYSTEMS

- Support systems: Excavation workers are exposed to many hazards, but the chief hazard is cave-ins. Employees must be protected by sloping or benching the sides of the excavation, supporting the sides of the excavation, or placing a shield between the side of the excavation and the work area.
- All deep excavations must be protected by a system designed by a registered professional engineer. Before any sloping, benching, or support system is selected, the excavation soil type must be classified by a competent person.
- Designing or selecting a protective system can be complex because of the number of factors involved — soil classification, depth of cut, water content of soil, changes due to weather and climate, or other operations in the vicinity.
- The OSHA Standard provides four methods each for sloping and shoring, including the use of shields to provide the required level of protection against cave-ins.
- One method of ensuring the safety and health of workers in an excavation is to slope the sides to an angle not steeper than 1½ H: 1V (34 degrees measured from the horizontal). These slopes must be excavated to form configurations that are in accordance with those for Type C soil. A slope of this gradation or less is considered safe for any type of soil.
- A second design method, which can be applied for both sloping and shoring, involves using tabulated data such as tables and charts approved by a registered professional engineer. The data, its limitations, and the selection criteria must be in writing.
- At least one copy of the information that includes the identity of the registered professional engineer who approved the data must be kept at the worksite during construction of the protective system. Upon completion of the system, the data may be stored away from the site, but a copy must be made available, upon request, to OSHA.
- Contractors may also use a trench box or shield designed or approved by a registered professional engineer or based on tabulated data prepared or approved by such an engineer. Timber, aluminum, or other suitable materials may also be used. OSHA permits the use of a trench shield as long as the protection it provides is equal to or greater than the protection that would be provided by the appropriate shoring system.
- Employers are free to choose the most practical option for the circumstances. Once an option has been selected, however, that system must meet required performance criteria.
- **Safety precautions:** OSHA requires employers to provide support systems such as shoring, bracing, or underpinning to ensure the stability of nearby structures such as buildings, walls, sidewalks, or pavements.
- The Standard also prohibits excavation below the level of the base or footing of any foundation or retaining wall unless a support system such as underpinning is provided, the excavation is in stable rock, or a registered professional engineer determines that the structure is far enough away from the excavation that the excavation will not pose a hazard to employees.
- Excavations under sidewalks and pavements are also prohibited unless an appropriately designed support system is provided, or another effective method is used.

Installation and removal of protective systems

OSHA requires the following procedures for the protection of employees when installing support systems:

- Connect support system members securely
- Install support systems safely
- Never overload support system members
- Install other structural members to carry loads imposed on the support system when temporary removal of individual members is necessary.

As soon as work is completed, the excavation should be backfilled as the protective system is dismantled. After the excavation has been cleared, workers should slowly remove the protective system from the bottom up, taking care to release members slowly.

Materials and equipment: The employer is responsible for the safe condition of materials and equipment used for protective systems. Defective and damaged materials and equipment can result in the failure of a protective system and cause excavation hazards.

To avoid possible failure of a protective system, the employer must ensure that:

- Materials and equipment are free from damage or defect.
- Manufactured materials and equipment are used and maintained consistent with manufacturers' recommendations and in a way that prevents employee exposure to hazards.
- Materials and equipment damaged while in operation are examined by a competent person.
- When materials and equipment are not safe for use, they must be removed from service.

These materials cannot be returned to service without the evaluation and approval of a registered professional engineer.

Falls and equipment: In addition to cave-in hazards and secondary hazards related to cave-ins, workers must be protected from other hazards during excavation-related work. These include exposure to falls, falling loads, and mobile equipment.

OSHA requires employers to take the following precautions:

- Keep materials or equipment that might fall or roll into an excavation at least two feet from the edge of excavations or use retaining devices, or both.
- Provide warning systems such as mobile equipment, barricades, hand or mechanical signals, or stop logs, to alert operators of the edge of an excavation. If possible, keep the grade away from the excavation.
- Provide scaling to remove loose rock or soil, or install protective barricades and other equivalent protection to protect employees from falling rock, soil, or materials.
- Prohibit employees from working on faces of sloped or benched excavations at levels above other employees unless employees at lower levels are properly protected from falling, rolling, or sliding material or equipment hazards.

- Prohibit employees under loads handled by lifting or digging equipment. To avoid being struck by any spillage or falling materials, require employees to stand away from a vehicle being loaded or unloaded. Operators may remain inside a vehicle if the cab of the vehicle provides adequate protection from falling loads during loading and unloading operation.

Water accumulation: Employees must not be permitted to work in excavations where water has built up or is building. If water removal equipment is used to control or prevent water from accumulating equipment operations must be monitored by a competent person to ensure proper use.

Diversion ditches, dikes, or other suitable means must be used to prevent surface water from entering an excavation and to provide adequate drainage of the area adjacent to the excavation. A competent person must inspect excavations subject to runoffs from heavy rains.

HAZARDOUS ATMOSPHERES

- A competent person must test excavations, or excavations where oxygen deficiency or a hazardous atmosphere exists or could reasonably be expected to exist, before employees may enter. If hazardous conditions exist, proper respiratory protection or ventilation must be provided. Controls used to reduce atmospheric contaminants to acceptable levels must be tested regularly.
- Where adverse atmospheric conditions may exist or develop in an excavation, the employer must provide and ensure that emergency rescue equipment (e.g., breathing apparatus, a safety harness and line, basket stretcher, etc.) is readily available.
- When an employee enters bell-bottom pier holes and similar deep and confined footing excavations, the employee must wear a harness with a lifeline. The lifeline must be securely attached to the harness and must be separate from any line used to handle materials.
- While the employee wearing the lifeline is in the excavation, an observer must ensure that the lifeline is working properly and maintain communication with the employee. Access and egress: Employers must provide safe access and egress to all excavations.

    - When employees are in trench excavations the Standard requires adequate means of entry and exit (ladders, steps, ramps, or other safe means of access and egress) within 25 feet of lateral travel.
    - Structural ramps used for employee access or egress must be designed by a competent person. If the ramps are used by vehicles, they must be designed by a competent person qualified in structural design. Also, structural members used for ramps or runways must be uniform in thickness and joined in a manner to prevent tripping or displacement.

Inspections: Daily inspections of excavations, the adjacent areas, and protective systems shall be made by a competent person for evidence of a situation that could result in possible cave-ins, indications of failure of protective systems, hazardous atmospheres, or other hazardous conditions.

- An inspection shall be conducted by the competent person prior to the start of work and as needed throughout the shift. Inspections shall also be made after every rainstorm or other hazard increasing occurrence. These inspections are only required when employee exposure can be reasonably anticipated.
- Where the competent person finds evidence of a situation that could result in a possible cave-in, indications of failure of protective systems, hazardous atmospheres, or other hazardous conditions, exposed employees shall be removed from the hazardous area until the necessary precautions have been taken to ensure their safety.

SOIL MECHANICS

- Tension Cracks: Tension cracks usually form at a horizontal distance of 0.5 to 0.75 times the depth of the trench, measured from the top of the vertical face of the trench.
- Sliding: Sliding or sluffing may occur as a result of tension cracks.
- Toppling: In addition to sliding, tension cracks can cause toppling. Toppling occurs when the trench's vertical face shears along the tension crack line and topples into the excavation.
- Subsidence and Bulging: An unsupported excavation can create an unbalanced stress in the soil, which, in turn, causes subsidence at the surface and bulging of the vertical face of the trench. If uncorrected, this condition can cause face failure and entrapment of workers in the trench.
- Heaving or Squeezing: Bottom heaving or squeezing is caused by the downward pressure created by the weight of adjoining soil. This pressure causes a bulge in the bottom of the cut. Heaving and squeezing can occur even when shoring or shielding has been properly installed.
- Boiling: Boiling is evidenced by an upward water flow into the bottom of the cut. A high water table is one of the causes of boiling. Boiling produces a "quick" condition in the bottom of the cut, and can occur even when shoring or trench boxes are used.
- Unit Weight of Soils refers to the weight of one unit of a particular soil. The weight of soil varies with type and moisture content. One cubic foot of soil can weigh from 110 pounds to 140 pounds or more, and one cubic meter (35.3 cubic feet) of soil can weigh more than 3000 pounds.

- **Soil Type:** OSHA categorizes soil and rock deposits into four types.
- Visual Test: A visual test is a qualitative evaluation of conditions around the site. In a visual test, the entire excavation site is observed, including the soil adjacent to the site and the soil being excavated. If the soil remains in clumps, it is cohesive; if it appears to be coarse-grained sand or gravel, it is considered granular. The evaluator also checks for any signs of vibration. During a visual test, the evaluator should check for crack-line openings along the failure zone that would indicate tension cracks, look for existing utilities that indicate that the soil has previously been disturbed, and observe the open side of the excavation for indications of layered geologic structuring.
- The evaluator should also look for signs of bulging, boiling, or sluffing, as well as for signs of surface water seeping from the sides of the excavation or from the water table. If there is standing water in the cut, the evaluator should check for "quick" conditions.
- In addition, the area adjacent to the excavation should be checked for signs of foundations or other intrusions into the failure zone, and the evaluator should check for surcharging and the spoil distance from the edge of the excavation.

Shoring Types

- Shoring is the provision of a support system for trench faces used to prevent movement of soil, underground utilities, roadways, and foundations. Shoring or shielding is used when the location or depth of the cut makes sloping back to the maximum allowable slope impractical. There are two basic types of shoring, timber and aluminum hydraulic.
- Shoring systems consist of posts, wales, struts, and sheeting. The trend today is toward the use of hydraulic shoring, a prefabricated strut and/or wale system manufactured of aluminum or steel.
- Hydraulic shoring provides a critical safety advantage over timber shoring because workers do not have to enter the trench to install or remove hydraulic shoring.

Other advantages of most hydraulic systems are that they:

- Are light enough to be installed by one worker.
- Are gauge-regulated to ensure even distribution of pressure along the trench line.
- Can have their trench faces "preloaded," to use the soil's natural cohesion to prevent movement.
- Can be adapted easily to various trench depths and widths.
- All shoring should be installed from the top down and removed from the bottom up.

Hydraulic shoring should be checked at least once per shift for leaking hoses and/or cylinders, broken connections, cracked nipples, bent bases, and any other damaged or defective parts.

Pneumatic Shoring: Pneumatic shoring works in a manner similar to hydraulic shoring. The primary difference is that pneumatic shoring uses air pressure in place of hydraulic pressure. A disadvantage to the use of pneumatic shoring is that an air compressor must be on site.

Screw Jacks: Screw jack systems differ from hydraulic and pneumatic systems in that the struts of a screw jack system must be adjusted manually. This creates a hazard because the worker is required to be in the trench in order to adjust the strut.

In addition, uniform "preloading" cannot be achieved with screw jacks, and their weight creates handling difficulties.

Single-Cylinder Hydraulic Shores: Shores of this type are generally used in a waler system, as an assist to timber shoring systems, and in shallow trenches where face stability is required.

Underpinning: This process involves stabilizing adjacent structures, foundations, and other intrusions that may have an impact on the excavation. As the term indicates, underpinning is a procedure in which the foundation is physically reinforced. Underpinning should be conducted only under the direction and with the approval of a registered professional engineer.

Shielding Types

- Trench boxes are different from shoring because, instead of shoring up or otherwise supporting the trench face, they are intended primarily to protect workers from cave-ins and similar incidents.
- The excavated area between the outside of the trench box and the face of the trench should be as small as possible. The space between the trench boxes and the excavation side are backfilled to prevent lateral movement of the box. Shields may not be subjected to loads exceeding those which the system was designed to withstand.
- Trench boxes are generally used in open areas, but they also may be used in combination with sloping and benching. The box should extend at least 18 inches above the surrounding area if there is sloping toward excavation. This can be accomplished by providing a benched area adjacent to the box.
- Earth excavation to a depth of 2 feet below the shield is permitted, but only if the shield is designed to resist the forces calculated for the full depth of the trench and there are no indications while the trench is open of possible loss of soil from behind or below the bottom of the support system.
- Conditions of this type require observation on the effects of bulging, heaving, and boiling as well as surcharging, vibration, adjacent structures, etc., on excavating below the bottom of a shield.
- Careful visual inspection of the conditions mentioned above is the primary and most prudent approach to hazard identification and control.

SLOPING AND BENCHING

Soil Type	Height to Depth Ratio	Slope Angle
Stable Rock	Vertical	90°
Type A	¾:1	53°
Type B	1:1	45°
Type C	1½:1	34°
Type A (short-term)	½:1	63°

- Sloping: Maximum allowable slopes for excavations less than 20 feet based on soil type and angle to the horizontal are on this table:
- Benching: There are two basic types of benching, simple and multiple. The type of soil determines the horizontal to vertical ratio of the benched side.

(For a maximum excavation depth of 12 feet)

- As a general rule, the bottom vertical height of the trench must not exceed 4 feet for the first bench.
- Subsequent benches may be up to a maximum of 5 feet vertical in Type A soil and 4 feet in Type B soil to a total trench depth of 20 feet.
- All subsequent benches must be below the maximum allowable slope for that soil type.
- For Type B soil the trench excavation is permitted in cohesive soil only.

SPOIL

- **Temporary Spoil:** Temporary spoil must be placed no closer than 2 feet from the surface edge of the excavation, measured from the nearest base of the spoil to the cut. This distance should not be measured from the crown of the spoil deposit.
- This distance requirement ensures that loose rock or soil from the temporary spoil will not fall on employees in the trench.
- Spoil should be placed so that it channels rainwater and other run-off water away from the excavation. Spoil should be placed so that it cannot accidentally run, slide, or fall back into the excavation.

- **Permanent Spoil:** Permanent spoil should be placed some distance from the excavation. Permanent spoil is often created where underpasses are built or utilities are buried. The improper placement of permanent spoil, i.e., insufficient distance from the working excavation, can cause an excavation to be out of compliance with the horizontal to vertical ratio requirement for a particular excavation. This can usually be determined through visual observation. Permanent spoil can change undisturbed soil to disturbed soil and dramatically alter slope requirements.

- **Surface Crossing of Trenches:** Surface crossing of trenches should be discouraged; however, if trenches must be crossed, such crossings are permitted only under the following conditions:

- Vehicle crossings must be designed by and installed under the supervision of a registered professional engineer.
- Walkways or bridges must be provided for foot traffic. These structures shall:
  1. Have a safety factor of 4
  2. Have a minimum clear width of 20 inches
  3. Be fitted with standard rails
  4. Extend a minimum of 24 inches past the surface edge of the trench
- Ingress and Egress: Access to and exit from the trench require:
- Trenches 4 feet or more in depth should be provided with a fixed means of egress.
- Spacing between ladders or other means of egress must be such that a worker will not have to travel more than 25 feet laterally to the nearest means of egress.
- Ladders must be secured and extend a minimum of 36 inches above the landing.
- Metal ladders should be used with caution, particularly when electric utilities are present.
- **Emergency Rescue Equipment:** Emergency rescue equipment is required when a hazardous atmosphere exists or can reasonably be expected to exist.
- Requirements are as follows:
- Respirators must be of the type suitable for the exposure. Employees must be trained in their use and a respirator program must be instituted.
- Attended (at all times) lifelines must be provided when employees enter bell-bottom pier holes, deep confined spaces, or other similar hazards.
- Employees who enter confined spaces must be trained.

FALL PROTECTION

- Body belts, safety straps, lanyards, lifelines, and body harnesses must be inspected before use each day to determine that the equipment is in safe working condition. Defective equipment may not be used.
- Lifelines are required to be protected against being cut or abraded.
- Fall arrest equipment, work positioning equipment, or travel restricting equipment must be used by employees 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.

Personal fall arrest systems:

- When stopping or arresting a fall, personal fall arrest systems must limit the maximum arresting force on an employee to 900 pounds (4 kN) if used with a body belt.
- When stopping or arresting a fall, personal fall arrest systems must limit the maximum arresting force on an employee to 1800 pounds (8 kN) if used with a body harness.
- Personal fall arrest systems must be rigged such that an employee can neither free fall more than 6 feet (1.8 m) nor contact any lower level.
- If vertical lifelines or droplines are used, not more than one employee may be attached to any one lifeline.
- Snaphooks may not be connected to loops made in webbing-type lanyards.
- Snaphooks may not be connected to each other.

Ladders, platforms, step bolts, and manhole steps

Ladders and platforms must meet the following requirements:

- Ladders and platforms must be secured to prevent their becoming accidentally dislodged.
- Ladders and platforms may not be loaded in excess of the working loads for which they are designed.
- Ladders and platforms may be used only in applications for which they were designed.
- Ladders and platforms must be capable of supporting without failure at least 2.5 times the maximum intended load.
- 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 may be used where the employer can demonstrate that nonconductive ladders would present a greater hazard than conductive ladders.

HAND AND PORTABLE POWER TOOLS

- Any cord and plug connected equipment supplied by other than premises wiring must 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
- It must be of the double-insulated type or
- It is required to be connected to the power supply through an isolating transformer with an ungrounded secondary.

- Portable and vehicle mounted generators used to supply cord and plug connected equipment must meet the following requirements:

1. 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.
2. The non-current-carrying metal parts of equipment and the equipment grounding conductor terminals of the receptacles must be bonded to the generator frame.
3. In the case of vehicle-mounted generators, the frame of the generator must be
4. bonded to the vehicle frame.
5. Any neutral conductor must be bonded to the generator frame.

HYDRAULIC AND PNEUMATIC TOOLS

- Safe operating pressures for hydraulic and pneumatic tools, hoses, valves, pipes, filters, and fittings may not be exceeded.
- 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.
- A hydraulic or pneumatic tool used where it may contact exposed live parts must be designed and maintained for such use.
- The hydraulic system supplying a hydraulic tool used where it may contact exposed live parts must provide protection against loss of insulating value for the voltage involved due to the formation of a partial vacuum in the hydraulic line. 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.
- A pneumatic tool used on energized electric lines or equipment or used where it may contact exposed live parts must provide protection against the accumulation of moisture in the air supply.
- Pressure must be released before connections are broken, unless quick acting, self-closing connectors are used. Hoses may not be kinked.
- Employees may not use any part of their bodies to locate or attempt to stop a hydraulic leak.

LIVE-LINE TOOLS

- Live-line tool rods, tubes, and poles must be designed and constructed to withstand the following minimum tests:
    1. 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
    2. 75,000 volts per foot (2461 volts per centimeter) of length for 3 minutes if the tool is made of wood
    3. Tests that the employer can demonstrate are equivalent.

CONDITION OF TOOLS

- Each live-line tool must be wiped clean and visually inspected for defects before use each day.
- 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 is required to be removed from service and examined and tested before being returned to service.
- Live-line tools used for primary employee protection are required to be removed from service every 2 years for examination, cleaning, repair, and testing as follows:
- Each tool must be thoroughly examined for defects.
- If a defect or contamination that could adversely affect the insulating qualities or mechanical integrity of the live-line tool is found, the tool must be repaired and refinished or is required to be permanently removed from service.
- If no such defect or contamination is found, the tool must be cleaned and waxed.
- Tools must be tested under the following conditions:

1. After the tool has been repaired or refinished
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.

- The test method used must 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.
- The voltage applied during the tests must 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.

Materials storage near energized lines or equipment

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:

- For lines and equipment energized at 50 kV or less, the distance is 10 feet (305 cm).
- For lines and equipment energized at more than 50 kV, the distance is 10 feet (305 cm) plus 4 inches (10 cm) for every 10 kV over 50 kV.
- In areas restricted to qualified employees, material may not be stored within the working space about energized lines or equipment.

EXPOSED ENERGIZED PARTS

- Work on exposed live parts, or near enough to them, to expose the employee to any hazard they present.
- 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 must be considered and treated as energized unless specific provisions have been followed.
- At least two employees must be present while the following types of work are being performed:

1. Installation, removal, or repair of lines that are energized at more than 600 volts,
2. Installation, removal, or repair of de-energized lines if an employee is exposed to contact with other parts energized at more than 600 volts,
3. 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,
4. Work involving the use of mechanical equipment, other than insulated aerial lifts, near parts energized at more than 600 volts, and
5. Other work that exposes an employee to electrical hazards greater than or equal to those posed by specific operations.

- The aforementioned does not apply to the following operations:
- Routine switching of circuits, if the employer can demonstrate that conditions at the site allow this work to be performed safely
- 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
- Emergency repairs to the extent necessary to safeguard the general public

Minimum approach distances

Employers must ensure that no employee approaches or takes any conductive object closer to exposed energized parts than set forth in the OSHA standard 1910.269 unless:

- The employee is insulated from the energized part (insulating gloves or insulating gloves and sleeves that are considered insulation of the employee only with regard to the energized part upon which work is being performed), or
- The energized part is insulated from the employee and from any other conductive object at a different potential, or
- The employee is insulated from any other exposed conductive object, as during live-line bare-hand work.

Substations contain requirements for the guarding and isolation of live parts. Parts of electric circuits that meet substation 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.

Type of Insulation

If the employee is to be insulated from energized parts by the use of insulating gloves insulating sleeves must also be used.

Insulating sleeves need not be used under the following conditions:

1. If exposed energized parts on which work is not being performed are insulated from the employee
2. If such insulation is placed from a position not exposing the employee's upper arm to contact with other energized parts.

The employer must 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.

The employer must ensure that connections are made as follows:

1. In connecting de-energized equipment or lines to an energized circuit by means of a conducting wire or device, an employee must first attach the wire to the de-energized part
2. When disconnecting equipment or lines from an energized circuit by means of a conducting wire or device, an employee must remove the source end first
3. When lines or equipment are connected to or disconnected from energized circuits, loose conductors must be kept away from exposed energized parts

APPAREL

- When work is performed within reaching distance of exposed energized parts of equipment, the employer must 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.
- The employer is required to train each employee who is exposed to the hazards of flames or electric arcs in the hazards involved.
- The employer must 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.
  Warning: Clothing made from the following types of fabrics, either alone or in blends, is prohibited, 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.

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 is required to 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 must ensure that each employee wears the proper eye protection, uses a tool rated for the voltage, and is clear of the exhaust path of the fuse barrel.

Covered (non-insulated) conductors: Requirements which pertain to the hazards of exposed live parts also apply when work is performed in the proximity of covered (non-insulated) wires.

Noncurrent-carrying metal parts: Noncurrent-carrying metal parts of equipment or devices, such as transformer cases and circuit breaker housings, must 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.

Opening circuits under load: Devices used to open circuits under load conditions must be designed to interrupt the current involved.

De-energizing lines and equipment for employee protection

- If a system operator is in charge of the lines or equipment and their means of disconnection, all of the requirements must be observed, in the order given.
- If no system operator is in charge of the lines or equipment and their means of disconnection, one employee in the crew is required to be designated as being in charge of the clearance. The employee in charge of the clearance must take the place of the system operator, as necessary.
- 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, this does not apply. Additionally, tags required by the remaining provisions need not be used.
- Any disconnecting means that are accessible to persons outside the employer's control (for example, the general public) must be rendered inoperable while they are open for the purpose of protecting employees.

De-energizing lines and equipment

- A designated employee must make a request of the system operator to have the particular section of line or equipment de-energized. The designated employee becomes the employee in charge and is responsible for the clearance.
- 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 de-energized must be opened. Such means must be rendered inoperable, unless its design does not so permit, and tagged to indicate that employees are at work.
- Automatically and remotely controlled switches that could cause the opened disconnecting means to close must also be tagged at the point of control.
- The automatic or remote control feature must be rendered inoperable, unless its design does not so permit.
- Tags are required to prohibit operation of the disconnecting means and shall indicate that employees are at work.
- After the applicable requirements 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 must be tested to ensure that they are de-energized.
- Protective grounds are required to be installed as required.
- After the applicable requirements have been followed, the lines and equipment involved may be worked as de-energized.
- If two or more independent crews will be working on the same lines or equipment, each crew must independently comply with the requirements.

Transferring 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) must inform the system operator; employees in the crew must be informed of the transfer; and the new employee in charge must be responsible for the clearance.

To release a clearance, the employee in charge is required to:

1. Notify employees under his or her direction that the clearance is to be released
2. Determine that all employees in the crew are clear of the lines and equipment
3. Determine that all protective grounds installed by the crew have been removed
4. Report this information to the system operator and release the clearance

- The person releasing a clearance must be the same person that requested the clearance, unless responsibility has been transferred.
- Tags may not be removed unless the associated clearance has been released.
- 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.

Grounding for the protection of employees

- For the employee to work lines or equipment as de-energized, the lines or equipment must be de-energized and must be grounded.
- 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 de-energized provided all of the following conditions are met:

1. The lines and equipment have been de-energized.
2. There is no possibility of contact with another energized source.
3. The hazard of induced voltage is not present.

Equipotential zone: Temporary protective grounds must 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.

Protective grounding equipment

- Protective grounding equipment must 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 is required to have an ampacity greater than or equal to that of No. 2 AWG copper.
- 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.
- 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.

Testing: Before any ground is installed, lines and equipment must be tested and found absent of nominal voltage, unless a previously installed ground is present.

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

Order of removal: When a ground is to be removed, the grounding device is required to be removed from the line or equipment using a live-line tool before the ground-end connection is removed.

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.**

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

Testing and test facilities

- Testing and test facilities 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.
- Routine inspection and maintenance measurements made by qualified employees are considered to be routine line work and are not included, 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.
- Two typical examples of such excluded test work procedures are "phasing-out" testing and testing for a "no-voltage" condition.

GENERAL REQUIREMENTS

- The employer must 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 are required to 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.
- Employees must be trained in safe work practices upon their initial assignment to the test area, with periodic reviews and updates provided as required.

Guarding of test areas

Permanent test areas are required to be guarded by walls, fences, or barriers designed to keep employees out of the test areas.

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

1. The test area is required to be guarded by the use of distinctively colored safety tape that is supported approximately waist high and to which safety signs are attached
2. The test area must be guarded by a barrier or barricade that limits access to the test area to a degree equivalent, physically and visually, to the barricade or
3. The test area is required to be guarded by one or more test observers stationed so that the entire area can be monitored.

- The barriers required must be removed when the protection they provide is no longer needed.
- Guarding must 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.

GROUNDING PRACTICES

- The employer must establish and implement safe grounding practices for the test facility.
- All conductive parts accessible to the test operator during the time the equipment is operating at high voltage must be maintained at ground potential except for portions of the equipment that are isolated from the test operator by guarding.
- Wherever ungrounded terminals of test equipment or apparatus under test may be present, they must be treated as energized until determined by tests to be de-energized.
- Visible grounds must be applied, either automatically or manually with properly insulated tools, to the high-voltage circuits after they are de-energized and before work is performed on the circuit or item or apparatus under test. Common ground connections are required to be solidly connected to the test equipment and the apparatus under test.
- In high-power testing, an isolated ground-return conductor system must be provided so that no intentional passage of current, with its attendant voltage rise, can occur in the ground grid or in the earth.
- An isolated ground-return conductor need not be provided if the employer can demonstrate that both the following conditions are met:

1. An isolated ground-return conductor cannot be provided due to the distance of the test site from the electric energy source, and
2. Employees are protected from any hazardous step and touch potentials that may develop during the test.

Protection from Step and Touch Potentials

- When a ground fault occurs on a power line, voltage is impressed on the grounded object faulting the line.
- The voltage to which is 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. The degree of the hazard depends upon the magnitude of the fault current and the time of exposure.
- This information deals 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.
- Grounding systems for these structures should be designed to minimize the step and touch potentials involved.

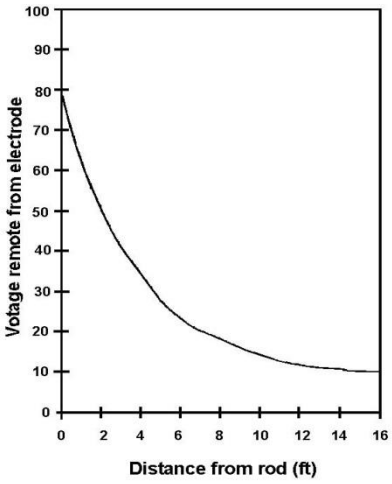
Voltage-Gradient Distribution Curve

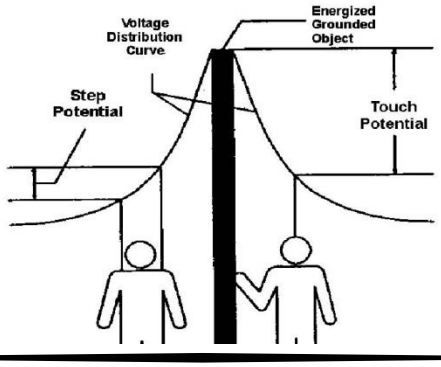
- The dissipation of voltage from a grounding electrode (or from the grounded end of an energized grounded object) is called the ground potential gradient. Voltage drops associated with this dissipation of voltage are called ground potentials. Figure 1 is a typical voltage-gradient distribution curve (assuming a uniform soil texture). This graph shows that voltage decreases rapidly with increasing distance from the grounding electrode.

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 different 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 clearly 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 touch potential nearly equal to the full fault voltage.





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.

- The creation of an equipotential zone will protect a worker standing within it from hazardous step and touch potentials. 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.)
- 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).
- Restricting employees from areas where hazardous step or touch potentials could arise can protect employees not directly involved in the operating 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.
- 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 must be provided, and the safety ground shall be clearly indicated in the test set-up.
- When the test area is entered after equipment is de-energized, a ground must be placed on the high-voltage terminal and any other exposed terminals.
- High capacitance equipment or apparatus must be discharged through a resistor rated for the available energy.
- A direct ground is required to be applied to the exposed terminals when the stored energy drops to a level at which it is safe to do so.
- If a test trailer or test vehicle is used in field testing, its chassis must be grounded.
- Protection against hazardous touch potentials with respect to the vehicle, instrument panels, and other conductive parts accessible to employees must be provided by bonding, insulation, or isolation.

Control and measuring circuits

- 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.
- Meters and other instruments with accessible terminals or parts must 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 must be provided to interrupt the power supply if the compartment cover is opened.
- The routing and connections of temporary wiring must be made secure against damage, accidental interruptions and other hazards. To the maximum extent possible, signal, control, ground, and power cables must be kept separate.
- If employees will be present in the test area during testing, a test observer must be present. The test observer must be capable of implementing the immediate de-energizing of test circuits for safety purposes.

Safety check

Safety practices governing employee work at temporary or field test areas must provide for a routine check of such test areas for safety at the beginning of each series of tests.

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

- That barriers and guards are in workable condition and are properly placed to isolate hazardous areas;
- That system test status signals, if used, are in operable condition;
- That test power disconnects are clearly marked and readily available in an emergency;
- That ground connections are clearly identifiable;
- That personal protective equipment is provided and used properly as required,
- That signal, ground, and power cables are properly separated.

Mechanical equipment

- The critical safety components of mechanical elevating and rotating equipment must receive a thorough visual inspection before use on each shift.
- 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.

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:

- The vehicle has a reverse signal alarm audible above the surrounding noise level, or
- The vehicle is backed up only when a designated employee signals that it is safe to do so.

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.

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, must have roll-over protective structures.

Outriggers

- Vehicular equipment, if provided with outriggers, must 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.
- 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.

Applied loads: Mechanical equipment used to lift or move lines or other material must be used within its maximum load rating and other design limitations for the conditions under which the work is being performed.

OPERATIONS NEAR ENERGIZED LINES OR EQUIPMENT

- Mechanical equipment must be operated so that the minimum approach distances of Table R-6 through Table R-10 are maintained from exposed energized lines and equipment. The insulated portion of an aerial lift operated by a qualified employee in the lift is exempt from this requirement.
- A designated employee other than the equipment operator must observe the approach distance to exposed lines and equipment and give timely warnings before the minimum approach distance is reached, unless the employer can demonstrate that the operator can accurately determine that the minimum approach distance is being maintained.
- If, during operation of the mechanical equipment, the equipment could become energized, follow the proper procedures listed to ensure safety.
- The energized lines exposed to contact must be covered with insulating protective material that will withstand the type of contact that might be made during the operation.
- The equipment is required to be insulated for the voltage involved.

- The equipment must 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.
- Each employee must be protected from hazards that might arise from equipment contact with the energized lines. The measures used must 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 are required to 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,
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.

- Refer to the information on hazardous step and touch potentials and on methods of protecting employees from hazards resulting from such potentials.

Overhead lines (Additional requirements)

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 must 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 must be braced or otherwise supported so as to prevent failure.

Methods of Inspecting and Testing Wood Poles

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.

- For these reasons, it is essential that an inspection and test of the condition of a wood pole be performed before it is climbed.
- A properly guyed pole in good condition should, at a minimum, be able to handle the weight of an employee climbing it. 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.

Inspection of Wood Poles

Wood poles should be inspected by a qualified employee for the following conditions:

- 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.

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.

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.

Holes: Hollow spots and woodpecker holes can reduce the strength of a wood pole.

Shell Rot and Decay: Rotting and decay are cutout hazards and are possible indications of the age and internal condition of the pole

Knots: One large knot or several smaller ones at the same height on the pole may be 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.

Soil conditions: Soft, wet, or loose soil may not support any changes of stress on the pole.

Burn Marks: Burning from transformer failures or conductor faults could damage the pole so that it cannot withstand mechanical stress changes.

Testing of Wood Poles

Hammer Test: Rap the pole sharply with a hammer weight 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.

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.

- When poles are set, moved, or removed near exposed energized overhead conductors, the pole may not contact the conductors.
- When a pole is set, moved, or removed near an exposed energized overhead conductor, the employer must 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.
- To protect employees from falling into holes into which poles are to be placed, the holes must be attended by employees or physically guarded whenever anyone is working nearby.

Installing and removing overhead lines

- The following provisions apply to the installation and removal of overhead conductors or cable:
- The employer must 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.
- The protective measures required for mechanical equipment must 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:

1. Failure of the pulling or tensioning equipment,
2. Failure of the wire or cable being pulled, or
3. Failure of the previously installed lines or equipment.

- 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 must be made inoperative.
- Before lines are installed parallel to existing energized lines, the employer must make a determination of the approximate voltage to be induced in the new lines, or work must 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:

  1. 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.
  2. The grounds must be left in place until the conductor installation is completed between dead ends.
  3. The grounds must be removed as the last phase of aerial cleanup.
  4. If employees are working on bare conductors, grounds must also be installed at each location where these employees are working, and grounds are required to be installed at all open dead-end or catch-off points or the next adjacent structure.

5. If two bare conductors are to be spliced, the conductors must be bonded and grounded before being spliced.

- Reel handling equipment, including pulling and tensioning devices, must be in safe operating condition and must be leveled and aligned.
- Load ratings of stringing lines, pulling lines, conductor grips, load-bearing hardware and accessories, rigging, and hoists may not be exceeded.
- Pulling lines and accessories must be repaired or replaced when defective.
- Conductor grips may not be used on wire rope, unless the grip is specifically designed for this application.
- Reliable communications, through two-way radios or other equivalent means, must be maintained between the reel tender and the pulling rig operator.
- The pulling rig may only be operated when it is safe to do so.
- Examples of unsafe conditions include employees in locations prohibited by conductor and pulling line hang-ups, and slipping of the conductor grip.
- 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.

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:

- Before using or supervising the use of the live-line bare-hand technique on energized circuits, employees must be trained in the technique and in the safety requirements.
- Employees are required to receive refresher training as necessary.

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

1. The nominal voltage rating of the circuit on which the work is to be performed
2. The minimum approach distances to ground of lines and other energized parts on which work is to be performed
3. The voltage limitations of equipment to be used

- The insulated equipment, insulated tools, and aerial devices and platforms used must be designed, tested, and intended for live-line bare-hand work. Tools and equipment are required to be kept clean and dry while they are in use.
- The automatic-reclosing feature of circuit-interrupting devices protecting the lines must be made inoperative, if the design of the devices permits.
- 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.
- 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, unless the grounded objects and other lines and equipment are covered by insulating guards.

Warning: 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.

Buckets: A conductive bucket liner or other conductive device must be provided for bonding the insulated aerial device to the energized line or equipment.

1. The employee must be connected to the bucket liner or other conductive device by the use of conductive shoes, leg clips, or other means.
2. Where differences in potentials at the worksite pose a hazard to employees, electrostatic shielding designed for the voltage being worked is required to be provided.

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

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

1. The upper controls must be within easy reach of the employee in the bucket. On a two-bucket-type lift, access to the controls must be within easy reach from either bucket.
2. The lower set of controls must be located near the base of the boom, and they are required to be so designed that they can override operation of the equipment at any time.

- Lower (ground-level) lift controls may not be operated with an employee in the lift, except in case of emergency.
- Before employees are elevated into the work position, all controls (ground level and bucket) must be checked to determine that they are in proper working condition.
- Before the boom of an aerial lift is elevated, the body of the truck must be grounded, or the body of the truck shall be barricaded and treated as energized.
- A boom-current test must 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 must 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 must be immediately suspended upon indication of a malfunction in the equipment.
- The minimum approach distances specified in Table R-6 through Table R-10 must 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.
- While an employee is approaching, leaving, or bonding to an energized circuit, the minimum approach distances in Table R-6 through Table R-10 must be maintained between the employee and any grounded parts, including the lower boom and portions of the truck.

- 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 must be maintained between all parts of the bucket and the grounded end of the bushing or insulator string or any other grounded surface.
- 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.
- 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.
- A minimum approach distance table reflecting the minimum approach distances listed in Table R-6 through Table R-10 must be printed on a plate of durable non-conductive material. This table is required to be mounted so as to be visible to the operator of the boom.
- A non-conductive measuring device is required to be readily accessible to assist employees in maintaining the required minimum approach distance.

Towers and Structures

The following applies to work performed on towers or other structures which support overhead lines:

- The employer must 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.
- Tag lines or other similar devices must 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.
- The loadline may not be detached from a member or section until the load is safely secured.
- Except during emergency restoration procedures, work must be discontinued when adverse weather conditions would make the work hazardous in spite of the work practices required by this section.

Warning: 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.

Line-clearance tree trimming operations (Additional requirements)

Electrical hazards (does not apply to qualified employees)

- Before an employee climbs, enters, or works around any tree, a determination must 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.

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

1. 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
2. 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
3. If roping is necessary to remove branches or limbs from such conductors or apparatus.

- Line-clearance tree trimmers must maintain the minimum approach distances from energized conductors given in Table R-6, Table R-9, and Table R-10.
- 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.
- A tool constructed of a material that the employer can demonstrate has insulating qualities is considered as insulated if the tool is clean and dry.
- 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.
- 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 must be trained in the special hazards related to this type of work.
- 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.

Brush chippers

- Brush chippers must be equipped with a locking device in the ignition system.
- Access panels for maintenance and adjustment of the chipper blades and associated drive train is required to be in place and secure during operation of the equipment.
- Brush chippers not equipped with a mechanical infeed system must be equipped with an infeed hopper of length sufficient to prevent employees from contacting the blades or knives of the machine during operation.
- Trailer chippers detached from trucks must be chocked or otherwise secured.
- Each employee in the immediate area of an operating chipper feed table is required to wear the proper personal protective equipment as required.

Sprayers and related equipment

- Walking and working surfaces of sprayers and related equipment must be covered with slip-resistant material. If slipping hazards cannot be eliminated, slip-resistant footwear or handrails and stair rails meeting the requirements of walking and working surfaces may be used instead of slip-resistant material.
- Equipment on which employees stand to spray while the vehicle is in motion must be equipped with guardrails around the working area. The guardrail shall be constructed in accordance with walking and working surfaces.

Stump cutters

- Stump cutters are required to be equipped with enclosures or guards to protect employees.
- Each employee in the immediate area of stump grinding operations (including the stump cutter operator) must wear the proper personal protective equipment as required.

Gasoline-engine power saws

Gasoline-engine power saw operations must meet the requirements of the following:

- Each power saw weighing more than 15 pounds (6.8 kilograms, service weight) that is used in trees is required to 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.
- Each power saw must be equipped with a control that will return the saw to idling speed when released.
- Each power saw is required to be equipped with a clutch and shall be so adjusted that the clutch will not engage the chain drive at idling speed.
- A power saw must 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.

- A power saw engine may be started and operated only when all employees other than the operator are clear of the saw.
- A power saw may not be running when the saw is being carried up into a tree by an employee.
- Power saw engines are required to be stopped for all cleaning, refueling, adjustments, and repairs to the saw or motor, except as the manufacturer's servicing procedures require otherwise.

Backpack power units for use in pruning and clearing

- 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.
- A backpack power unit is required to be equipped with a quick shutoff switch readily accessible to the operator.
- Backpack power unit engines must be stopped for all cleaning, refueling, adjustments, and repairs to the saw or motor, except as the manufacturer's servicing procedures require otherwise.

Rope

- Climbing ropes are required to be used by employees working aloft in trees.
- These ropes must have a minimum diameter of 0.5 inch (1.2 cm) with a minimum breaking strength of 2300 pounds (10.2 kN).
- Synthetic rope is required to have elasticity of not more than 7 percent.
- Rope must be inspected before each use and, if unsafe (for example, because of damage or defect), may not be used.
- Rope is required to be stored away from cutting edges and sharp tools. Rope contact with corrosive chemicals, gas, and oil shall be avoided.
- When stored, rope must be coiled and piled, or shall be suspended, so that air can circulate through the coils.
- Rope ends are required to be secured to prevent their unraveling.
- Climbing rope may not be spliced to effect repair.
- 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.
- Each employee is required to 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.

Communication facilities: Microwave transmission

- The employer must ensure that no employee looks into an open waveguide or antenna that is connected to an energized microwave source.
- If the electromagnetic radiation level within an accessible area associated with microwave communications systems exceeds the radiation protection guide, the area is required to be posted with the warning symbol.

The lower half of the warning symbol must include the following statements or ones that the employer can demonstrate are equivalent:

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

- When an employee works in an area where the electromagnetic radiation could exceed the radiation protection guide, the employer is required to 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.
- Power line carrier work, including work on equipment used for coupling carrier current to power line conductors, must be performed in accordance with the requirements pertaining to work on energized lines.

Underground electrical installations (Additional requirements)

Access: A ladder or other climbing device must 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.

Lowering equipment into manholes: Equipment used to lower materials and tools into manholes or vaults is required to be capable of supporting the weight to be lowered and must 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 must be clear of the area directly under the opening.

Attendants for manholes: While work is being performed in a manhole containing energized electric equipment, an employee with first aid and CPR training must be available on the surface in the immediate vicinity to render emergency assistance.

- Occasionally, the employee on the surface may briefly enter a manhole to provide assistance, other than emergency.
- An attendant may also be required. One person may serve to fulfill both requirements.

Attendants are not permitted to enter the manhole.

- Employees entering manholes containing unguarded, uninsulated energized lines or parts of electric equipment operating at 50 volts or more are required to be qualified.
- 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.
- Reliable communications, through two-way radios or other equivalent means, must be maintained among all employees involved in the job.

Duct rods: If duct rods are used, they must be installed in the direction presenting the least hazard to employees. An employee must be stationed at the far end of the duct line being rodded to ensure that the required minimum approach distances are maintained.

Multiple cables: When multiple cables are present in a work area, the cable to be worked must 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 must be protected from damage.

Moving cables: Energized cables that are to be moved must be inspected for defects.

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 must be de-energized 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 shields or other devices that are capable of containing the adverse effects of a fault in the joint.

Warning: 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.

Sheath continuity: When work is performed on buried cable or on cable in manholes, metallic sheath continuity is required to be maintained or the cable sheath must be treated as energized.

Substations (Additional requirements)

Access and working space

- Sufficient access and working space is required to be provided and maintained about electric equipment to permit ready and safe operation and maintenance of such equipment.
- 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.

An installation that does not conform to this ANSI standard will, nonetheless, be considered as complying 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 while they are working on exposed, energized parts
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

Draw-out-type circuit breakers: When draw-out-type circuit breakers are removed or inserted, the breaker is required to be in the open position. The control circuit must be rendered inoperative, if the design of the equipment permits.

Substation fences: Conductive fences around substations must be grounded. When a substation fence is expanded or a section is removed, fence grounding continuity must be maintained, and bonding shall be used to prevent electrical discontinuity.

Guarding of rooms containing electric supply equipment

Rooms and spaces in which electric supply lines or equipment are installed are required to meet specific requirements under the following conditions:

1. 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,
2. 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, or
3. If live parts operating at more than 600 volts are located within the room or space, unless:
4. 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

5. 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.

- Rooms and spaces must be so enclosed within fences, screens, partitions, or walls as to minimize the possibility that unqualified persons will enter.
- Signs warning unqualified persons to keep out must be displayed at entrances to the rooms and spaces.
- Entrances to rooms and spaces that are not under the observation of an attendant are required to be kept locked.
- Unqualified persons may not enter the rooms or spaces while the electric supply lines or equipment are energized.

Guarding of energized parts

- Guards are required to 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.
- 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.

An installation that does not conform to this ANSI standard will, nonetheless, be considered as complying 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
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

- 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.
- When guards are removed from energized equipment, barriers must 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.

Substation entry

- Upon entering an attended substation, each employee other than those regularly working in the station is required to report his or her presence to the employee in charge in order to receive information on special system conditions affecting employee safety.
- The job briefing is required to cover such additional subjects as the location of energized equipment in or adjacent to the work area and the limits of any de-energized work area.

Power generation (Additional requirements)

Interlocks and other safety devices

- Interlocks and other safety devices must be maintained in a safe, operable condition.
- No interlock or other safety device may be modified to defeat its function, except for test, repair, or adjustment of the device.

Changing brushes: Before exciter or generator brushes are changed while the generator is in service, the exciter or generator field must 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.

Access and working space: Sufficient access and working space must be provided and maintained about electric equipment to permit ready and safe operation and maintenance of such equipment.

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. An installation that does not conform to this ANSI standard will, nonetheless, be considered as complying 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 while they are working on exposed, energized parts
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

Guarding of rooms containing electric supply equipment

Rooms and spaces in which electric supply lines or equipment are installed are required to meet the specific requirements under the following conditions:

1. 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,
2. 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, or
3. If live parts operating at more than 600 volts are located within the room or space, unless:

- 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
- 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.
- The rooms and spaces must be so enclosed within fences, screens, partitions, or walls as to minimize the possibility that unqualified persons will enter.
- Signs warning unqualified persons to keep out are required to be displayed at entrances to the rooms and spaces.
- Entrances to rooms and spaces that are not under the observation of an attendant must be kept locked.
- Unqualified persons may not enter the rooms or spaces while the electric supply lines or equipment is energized.

Guarding of energized parts

Guards are required to 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.

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. An installation that does not conform to this ANSI standard will, nonetheless, be considered as complying 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
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

- Except for fuse replacement or other necessary access by qualified persons, the guarding of energized parts within a compartment is required to 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.
- When guards are removed from energized equipment, barriers must 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.

Water or steam spaces

Requirements applying to work in water and steam spaces associated with boilers:

- A designated employee is required to inspect conditions before work is permitted and after its completion.
- Eye protection, or full face protection if necessary, must be worn at all times when condenser, heater, or boiler tubes are being cleaned.
- Where it is necessary for employees to work near tube ends during cleaning, shielding is required to be installed at the tube ends.

Chemical cleaning of boilers and pressure vessels

Requirements applying to chemical cleaning of boilers and pressure vessels:

- Areas where chemical cleaning is in progress are required to 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:

1. The area must be posted with signs restricting entry and warning of the hazards of fire and explosion
2. Smoking, welding, and other possible ignition sources are prohibited in these restricted areas.

- The number of personnel in the restricted area must be limited to those necessary to accomplish the task safely.
- There must be ready access to water or showers for emergency use.
- Potable water must be provided.
- Washing facilities must be maintained in a sanitary condition.
- Employees in restricted areas must wear the proper protective equipment including, but not limited to, protective clothing, boots, goggles, and gloves.

Chlorine systems

Chlorine system enclosures must be posted with signs restricting entry and warning of the hazard to health and the hazards of fire and explosion.

Health effects of chlorine

Low concentrations: Burning in the eyes, nose, and throat; redness in the face, sneezing, and coughing

High concentrations: Tightness in throat and chest – pulmonary edema. 1000 PPM is rapidly fatal.

- Liquid chlorine causes severe irritation and blistering of skin.
- Eyewashes and oxygen should be available. Self- contained breathing apparatus or canister type respirators should also be accessible.
- Only designated employees may enter the restricted area. The number of personnel must be limited to those necessary to accomplish the task safely.
- Emergency repair kits must be available near the shelter or enclosure to allow for the prompt repair of leaks in chlorine lines, equipment, or containers.
- Before repair procedures are started, chlorine tanks, pipes, and equipment must be purged with dry air and isolated from other sources of chlorine.
- The employer must ensure that chlorine is not mixed with materials that would react with the chlorine in a dangerously exothermic or other hazardous manner.

Boilers

- Before internal furnace or ash hopper repair work is started, overhead areas must be inspected for possible falling objects. If the hazard of falling objects exists, overhead protection such as planking or nets must be provided.
- When opening an operating boiler door, employees are required to stand clear of the opening of the door to avoid the heat blast and gases which may escape from the boiler.

Turbine generators

- Smoking and other ignition sources are prohibited near hydrogen or hydrogen sealing systems, and signs warning of the danger of explosion and fire must be posted.
- Excessive hydrogen makeup or abnormal loss of pressure is required to be considered as an emergency and shall be corrected immediately.
- A sufficient quantity of inert gas must be available to purge the hydrogen from the largest generator.

Coal and ash handling

- Only designated persons may operate railroad equipment.
- Before a locomotive or locomotive crane is moved, a warning is required to be given to employees in the area.
- Employees engaged in switching or dumping cars may not use their feet to line up drawheads.
- Drawheads and knuckles may not be shifted while locomotives or cars are in motion.
- When a railroad car is stopped for unloading, the car is required to be secured from displacement that could endanger employees.
- An emergency means of stopping dump operations must be provided at railcar dumps.
- The employer must ensure that employees who work in coal- or ash-handling conveyor areas are trained and knowledgeable in conveyor operation.
- 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 de-energized and has been locked out or tagged.
- A conveyor that 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.
- If a conveyor that could cause injury when started is automatically controlled or is controlled from a remote location, an audible device must 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 must be actuated by the device starting the conveyor and must continue for a period of time before the conveyor starts; that are 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.
- Warning signs are required to be clear, concise, and legible and must indicate that conveyors and allied equipment may be started at any time, that danger exists, and that personnel must keep clear.
- Warning signs are required to be provided along the conveyor at areas not guarded by position or location.

Emergency stops

- 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 are required to be furnished with emergency stop buttons, pull cords, limit switches, or similar emergency stop devices.
- 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.
- Emergency stop devices must be easily identifiable in the immediate vicinity of such locations.
- An emergency stop device must act directly on the control of the conveyor involved and may not depend on the stopping of any other equipment.
- Emergency stop devices must be installed so that they cannot be overridden from other locations.

Combustible and flammable gas and dust

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

Locations that are hazardous because of the presence of combustible dust are classified as Class II hazardous locations.

Shifting coal

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.

Fall protection

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

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 must vacate such dangerous areas before water flow changes are made.

SPECIAL CONDITIONS

Capacitors (Additional requirements)

- Before employees work on capacitors, the capacitors must be disconnected from energized sources and, after a wait of at least 5 minutes from the time of disconnection, short-circuited.
- Before the units are handled, each unit in series-parallel capacitor banks must 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 must be bonded to ground.
- Any line to which capacitors are connected is required to be short-circuited before it is considered de-energized.

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 de-energized before work is performed on an instrument, a relay, or other section of a current transformer secondary circuit, the circuit must be bridged so that the current transformer secondary will not be opened.

Series Streetlighting

- If the open-circuit voltage exceeds 600 volts, the series streetlighting circuit must be worked as appropriate.
- A series loop may only be opened after the streetlighting transformer has been de-energized and isolated from the source of supply or after the loop is bridged to avoid an open-circuit condition.

Illumination

Sufficient illumination is required to be provided to enable the employee to perform the work safely.

Protection against drowning (PFD)

- Whenever an employee may be pulled or pushed or may fall into water where the danger of drowning exists, the employee must be provided with and is required to use U.S. Coast Guard approved personal flotation devices (PFD).
- Each personal flotation device is required to be maintained in safe condition and must 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.
- An employee may cross streams or other bodies of water only if a safe means of passage, such as a bridge, is provided.

Employee protection in public work areas

- Traffic control signs and traffic control devices used for the protection of employees must meet all traffic control.
- 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 must be placed in conspicuous locations to alert and channel approaching traffic.
- Where additional employee protection is necessary, barricades must be used.
- Excavated areas are required to be protected with barricades.
- At night, warning lights are required to be prominently displayed.

Voltage Backfeed

If there is a possibility of voltage backfeed from sources of cogeneration or from the secondary system (e.g. backfeed from more than one energized phase feeding a common load), all requirements apply if the lines or equipment are to be worked as energized, and if the lines or equipment are to be worked as de-energized.

Lasers: Laser equipment must be installed, adjusted, and operated properly.

Hydraulic fluids: Hydraulic fluids used for the insulated sections of equipment must provide insulation for the voltage involved.

Work on exposed energized parts

- 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 overvoltage expected to be impressed on the system.
- Such overvoltages can be caused by such conditions as switching surges, faults, or lighting. 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 here will assist employers in complying with the minimum approach distance requirements. The technical criteria and methodology presented herein is mandatory for employers using reduced minimum approach distances. This section 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.

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 electric 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.

Exposed energized parts over 300 Volts AC

- OSHA standard 1910.269 defines the safe approach working distances in the vicinity of energized electrical 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 (e.g., portable gaps or preventing the automatic control from initiating breaker reclosing) enables line design and operation based on reduced transient overvoltage values.

Voltages of 1.1kV 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.

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.

Provisions for Inadvertent Movement

- The minimum approach distances (working distances) must include an “adder” to compensate 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 (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 in response time-distance analysis. When this technique is used, the total response time to a hazardous incident is estimated and converted to distance traveled. 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 traveled before the car comes to a complete stop. The distance is dependent on the speed of the car at the time of 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.

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.

- Dielectric strength of air: The dielectric strength of air in the 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, humidity, by the shape, dimensions, and separation of the electrodes, and by the characteristics of the applied voltage (wave shape).
- 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 deg. C, 101.3 kPa, 11 g/cm3 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.
- 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% per 300 meters in the minimum approach distance for altitudes above 900 meters is required. Table R-10 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 have 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.

Determination of Reduced Minimum Approach Distances

Factors Affecting Voltage Stress at the Work Site

- 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.
- 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 distance.
- 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) 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 deviation below this value, that it, the withstand voltage, has a probability of flashover of approximately 1 in 1000.) Sigma “σ” is the symbol for standard deviation.
- Broken Insulators: Tests have shown that the insulation strength of an insulator string 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 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.

Minimum Approach Distances Based on Known Maximum Anticipated Per-Unit Transient

Overvoltages

Reduction of the minimum approach distance for AC system: When the transient overvoltage values are known and supplied by the employer, OSHA 1910.269 allows 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.

METHODS OF CONTROLLING POSSIBLE TRANSIENT OVERVOLTAGE STRESS FOUND ON A SYSTEM

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.

Operation of circuit breakers: 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 lie 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.
- 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.
- 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.

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, 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 arresters has not been used to reduce the length of the insulator string, it may be used to reduce the minimum approach distance instead.
- Surge arrestor application is beyond the scope of this appendix. However, if the arrestor is insulated near the work site, the application would be similar to protective gaps.

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.

Location of Protective Gaps

1. Installation of the protective gap on the 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.
3. 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.
4. 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.

There are two reasons to disable the automatic-reclosing feature of circuit-interrupting devices while employees are performing live-line maintenance:

1. 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;
2. 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.

Construction of electric transmission and distribution lines and equipment (OSHA Subpart V)

The occupational safety and health standards contained in this Subpart V must apply to the construction of electric transmission and distribution lines and equipment.

- As used in this Subpart V the term "construction" includes the erection of new electric transmission and distribution lines and equipment, and the alteration, conversion, and improvement of existing electric transmission and distribution lines and equipment.
- Existing electric transmission and distribution lines and electrical equipment need not be modified to conform to the requirements of applicable standards in this Subpart V, until such work is to be performed on such lines or equipment.
- The standards set forth in this Subpart V provide minimum requirements for safety and health. Employers may require adherence to additional standards which are not in conflict with the standards contained in this Subpart V.

Initial inspections, tests, or determinations

- Existing conditions must be determined before starting work, by an inspection or a test.
- Such conditions must include, but not be limited to, energized lines and equipment, conditions of poles, and the location of circuits and equipment, including power and communication lines, CATV and fire alarm circuits.
- Electric equipment and lines must be considered energized until determined to be de-energized by tests or other appropriate methods or means.
- Operating voltage of equipment and lines must be determined before working on or near energized parts.

Clearances

No employee will be permitted to approach or take any conductive object without an approved insulating handle closer to exposed energized parts than permitted by Subpart V unless:

1. The employee is insulated or guarded from the energized part (gloves or gloves with sleeves rated for the voltage involved must be considered insulation of the employee from the energized part), or
2. The energized part is insulated or guarded from him and any other conductive object at a different potential, or
3. The employee is isolated, insulated, or guarded from any other conductive object(s), as during live-line bare-hand work.

- The minimum working distance and minimum clear hot stick distances stated in OSHA Subpart V must not be violated. The minimum clear hot stick distance is that for the use of live- line tools held by linemen when performing live-line work.
- Conductor support tools, such as link sticks, strain carriers, and insulator cradles, may be used provided that the clear insulation is at least as long as the insulator string or the minimum distance specified by OSHA for the operating voltage.

DEENERGIZING LINES AND EQUIPMENT

- When de-energizing lines and equipment operated in excess of 600 volts, and the means of disconnecting from electric energy is not visibly open or visibly locked out, the provisions of this section must be complied with:
- The particular section of line or equipment to be de-energized must be clearly identified, and it must be isolated from all sources of voltage.
- Notification and assurance from the designated employee must be obtained that:

1. All switches and disconnectors through which electric energy may be supplied to the particular section of line or equipment to be worked have been de-energized;
2. All switches and disconnectors are plainly tagged indicating that men are at work;
3. And that where design of such switches and disconnectors permits, they have been rendered inoperable.

- After all designated switches and disconnectors have been opened, rendered inoperable, and tagged, visual inspection or tests are required to be conducted to insure that equipment or lines have been de-energized.
- Protective grounds are required to be applied on the disconnected lines or equipment to be worked on.
- Guards or barriers must be erected as necessary to adjacent energized lines.
- When more than one independent crew requires the same line or equipment to be de-energized, a prominent tag for each such independent crew must be placed on the line or equipment by the designated employee in charge.

- Upon completion of work on de-energized lines or equipment, each designated employee in charge must determine that all employees in his crew are clear, that protective grounds installed by his crew have been removed, and he must report to the designated authority that all tags protecting his crew may be removed.

  When a crew working on a line or equipment can clearly see that the means of disconnecting from electric energy are visibly open or visibly locked-out, the provisions of this section must apply:

  1. Guards or barriers are required to be erected as necessary to adjacent energized lines.
  2. Upon completion of work on de-energized lines or equipment, each designated employee in charge must determine that all employees in his crew are clear, that protective grounds installed by his crew have been removed, and he must report to the designated authority that all tags protecting his crew may be removed.

Emergency procedures and first aid

The employer is required to provide training or require that his employees are knowledgeable and proficient in:

1. Procedures involving emergency situations
2. First-aid fundamentals including resuscitation

Night work: When working at night, spotlights or portable lights for emergency lighting are required to be provided as needed to perform the work safely.

Work near and over water: When crews are engaged in work over or near water and when danger of drowning exists, suitable protection must be provided.

Hydraulic fluids: All hydraulic fluids used for the insulated sections of derrick trucks, aerial lifts, and hydraulic tools which are used on or around energized lines and equipment are required to be of the insulating type.

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.
- **Note:** 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. 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.
- **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.
- **De-energized**: 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. 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 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. 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, 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. Wires which are insulated, but not otherwise protected, are not considered as guarded.
- **Hazardous atmosphere**: 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:
- Flammable gas, vapor, or mist in excess of 10 percent of its lower flammable limit (LFL).
- Airborne combustible dust at a concentration that meets or exceeds its LFL. 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.
- Atmospheric oxygen concentration below 19.5 percent or above 23.5 percent.
- Atmospheric concentration of any substance for which a dose or a permissible exposure limit (in OSHA's Occupational Health and Environmental Control or in Toxic and Hazardous Substances), could result in employee exposure in excess of its dose or permissible exposure limit. An atmospheric concentration of any substance that is not capable of causing death, incapacitation, and impairment of ability to self-rescue, injury, or acute illness due to its health effects is not covered by this provision.
- Any other atmospheric condition that is immediately dangerous to life or health. 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, 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:
- An employee would be exposed to being blown from elevated locations, or
- An employee or material handling equipment could lose control of material being handled, or
- An employee would be exposed to other hazards not controlled by the standard involved.
- High wind warning: 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): 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.

- Some materials (hydrogen fluoride gas and cadmium vapor, e.g.) 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.
- 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.
- 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.
- A line-clearance tree trimmer is not considered to be a "qualified employee" unless he or she has the training required for a qualified employee. However, under the electrical safety-related work practices standard in the electrical section of this manual, a line-clearance tree trimmer is considered to be a "qualified employee".
- **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

- **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.
- 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.
- **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.
- An employee must have the proper training required in order to be considered a qualified employee.
- 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.