

CHAPTER 34. ELECTRICAL SAFETY

3400. GENERAL. This chapter establishes minimum safety requirements to protect employees from shock hazards from electrical equipment during installation, or installed or used within or on buildings, structures or other premises. Such installations are pervasive at FAA worksites. This chapter references general requirements for compliance with the Department of Labor, Occupational Safety and Health Administration (OSHA) standards for:

a. General Industry at:

- (1) 29 CFR 1910, Subpart S, Electrical
- (2) 29 CFR 1910.137, Electrical Protective Devices (within Subpart I)
- (3) 29 CFR 1910.147, The Control of Hazardous Energy (Lockout/Tagout) (within Subpart J)
- (4) 29 CFR 1910.268, Telecommunication (within Subpart R)

b. Construction at:

- (1) 29 CFR 1926, Subpart K, Electrical

c. The chapter also references:

- (1) National Electrical Code (NEC), NFPA 70
- (2) Standard for Electrical Safety Requirements for Employee Workplaces, NFPA 70E
- (3) FAA Order 3900.19B, Chapter 1, General, paragraph 9c, Consensus Standards
- (4) FAA Order 3900.19B, Chapter 13, Hazardous Energy Control Program (Lockout/Tagout)
- (5) FAA Order 3900.19B, Chapter 24, Fire Prevention Program
- (6) FAA Order 3900.19B, Chapter 25, FAA Personal Protective Equipment

This chapter does not address every requirement of the documents referenced. Relevant portions of the most current version of each these documents should be reviewed in their entirety.

3401. GOALS AND OBJECTIVES. The common goal of the electrical safety programs of the various FAA regions and centers is to ensure that safety hazards associated with exposure to electrical equipment are addressed, so that FAA employees are protected at work. One of the specific objectives is that all employees exposed to electrical hazards shall be trained before they begin work.

3402. SCOPE. Electrical safety programs apply to all employees, both Government personnel and contractors, working at FAA facilities. This includes, but is not necessarily limited to, employees involved in design, acquisition, installation, modification, maintenance, or service work on machines, equipment or systems.

3403. KEY PROGRAM ELEMENTS.

a. Documented Program. As part of a documented electrical safety program, a written electrical safety plan must be developed and implemented to ensure that the following program elements are addressed before employees engage in installation, maintenance, modification, or servicing of machines, equipment, tools, or systems. The written plan must address how (a) each of the elements specified immediately below, and (b) the elements specified in paragraphs 3404 through 3407, will be implemented. Particular emphasis must be placed on those elements addressing training. The designated program administrator must evaluate the plan annually and take any steps necessary to ensure that it continues to address effectively the concerns of the electrical safety program.

b. Designated Program Administrator. A Technically Qualified Safety Person (TQSP), as specified in paragraph 11h of this Order, shall manage the electrical safety program and coordinate the overall implementation and oversight of each regional, center, service area, or Line of Business electrical safety program. A TQSP shall be responsible for each applicable installation, maintenance action, modification, or servicing of machines, equipment or systems.

c. Program Elements.

(1) Examination. Electrical equipment shall be free from recognized hazards that are likely to cause death or serious physical harm to employees. Potential safety hazards shall be evaluated through an examination by a TQSP who considers suitability for installation and use; mechanical strength and durability; electrical insulation; heating affects under conditions of use; arcing effects; classification by type, size, voltage, amperage, and specific use. The label of an OSHA-listed Nationally Recognized Testing Laboratory (NRTL) shall be evidence that the equipment is suitable for the specific installation or use, per NFPA 70E.

(2) Installation and Use. Equipment shall be installed and maintained in accordance with manufacturers' specifications and FAA requirements on electrical safety.

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

(4) Arcing Parts. Parts of electrical equipment which in ordinary operation produce arcs, sparks, flames, or molten metal shall be enclosed or separated and isolated from all combustible and flammable materials. A fire watch with an appropriate fire extinguisher shall be utilized in these operations to put out any smoldering materials or metals from the operation.

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

(6) Working Space Around Electrical Equipment. Sufficient access and working space, consistent with the requirements of the National Electrical Code (NEC) in effect at the time of the installation, or the contract date, shall be provided and maintained about all electrical equipment in new installations, to permit ready and safe operation and maintenance. Where "grandfathered" existing installations do not permit compliance with current NEC requirements, additional worker protection must be provided if required.

(a) Clear spaces. Working space required by 29 CFR 1910, Subpart S, or the National Electrical Code shall not be used for storage. When normally enclosed live parts are exposed for inspection or servicing, the working space, if in a passageway or general open space shall be suitably guarded. For more detailed guidance consult 29 CFR 1910. 303(g)(1) and 29 CFR 1910. 303 (h)(3).

(b) Access and entrance to working space. At least one entrance of sufficient width and area shall be provided to give access to the working space around electrical equipment.

(c) Front working space. Where there are live parts normally exposed; *e.g.*, on the front of switchboards or motor control centers, the working space in front of such equipment shall not be less than three feet.

(d) Illumination. Proper illumination shall be provided for all working spaces about service equipment, switchboards, panel boards, and motor control centers installed indoors. 29 CFR 1926.56(a) requires a minimum of 10 foot-candles for electrical equipment rooms. For more specifics, the American National Standards (ANSI) A11.1-1965, R1970, Practice for Industrial Lighting, should be consulted.

(e) Headroom. The minimum headroom of working spaces about service equipment, switchboards, panel-boards, or motor control centers shall be 6 feet 3 inches.

(7) Guarding (50-600 volts). Except as required or permitted elsewhere in 29 CFR 1910, Subpart S, live parts of electrical equipment employing a primary (input) power feed within the range of 50 to 600 volts, and having no unprotected or exposed components having a potential exceeding 600 volts, shall be guarded against accidental contact by personnel by means of approved cabinets or other forms of approved enclosures, or by any of the following means:

(a) By location in a room, vault, or similar enclosure that is accessible only to qualified persons.

(b) By suitable permanent, substantial partitions or screens so arranged that only qualified persons have access to the space within reach of the live parts. Any openings in such partitions or screens shall be so sized and located that personnel are not likely to come into accidental contact with the live parts or to bring conducting objects into contact with them.

(c) By location on a suitable balcony, gallery, or platform so elevated and arranged as to exclude unqualified persons, or by elevation of eight feet or more above the floor or other working surface.

(d) Entrances to rooms and other guarded locations containing exposed live parts shall be marked with conspicuous warning signs forbidding unqualified persons to enter.

(8) Guarding (more than 600 volts). Electrical feeds of, and equipment using a primary (input) power feed of, 600 or more volts, must comply with paragraphs 3403c(1)-c(7), as well as the following requirements. These requirements do not apply to equipment that is connected directly to the supply side of the service conductors:

(a) Enclosure for electrical installations. Electrical installations in a vault, room, closet, or area surrounded by a wall, screen or fence, access to which is controlled by a lock and key or other approved means, are considered to be accessible to qualified persons only. The entrance to all buildings, rooms, or enclosures containing exposed live parts or exposed conductors operating at more than 600 volts shall be kept secured or be under the observation of a qualified person at all times.

(b) Installations accessible to qualified persons only. Electrical installations having exposed live parts shall be accessible to qualified persons only.

(c) Installations accessible to unqualified persons. Electrical installations that are accessible to unqualified persons shall be made of metal-enclosed equipment, fiberglass cabinets or service boxes, or shall be enclosed in a vault or in an area access to which is controlled by a lock and key or other approved means.

(d) Workspace around equipment. Approved clearances in accordance with the National Electrical Code (NEC) shall be maintained around electrical equipment to permit ready and safe operation and maintenance. Where energized parts are exposed, the minimum clear workspace shall not be less than six feet, six inches high (measured vertically from the floor or platform) or less than three feet from the equipment footprint, or the projection of any protruding parts onto the surface on which the equipment rests, or in the case of equipment mounted on a wall, the projection onto the floor surface below. Adequate illumination shall be provided for all workspaces around electrical equipment according to references in paragraph 3403c (6)(d) above.

(e) Elevated work areas. Permanent ladders or stairways, man-lifts, or bucket trucks shall be provided to give safe access to the working space around electrical equipment installed on platforms, balconies, mezzanine floors, or in attic or roof-mounted rooms or spaces. All portable ladders shall be non-conductive.

3404. USE OF EQUIPMENT.

a. Portable Electrical Equipment. Portable cord-and-plug-connected equipment, and extension cords, shall be visually inspected for external defects before each use. A ground fault circuit interrupter (GFCI) is required for all electrically powered tools used in any environment in which the operator may be situated on a surface that is not insulated with respect to earth ground (*e.g.*, outdoors, or indoors on a damp concrete basement floor). Extension cords shall (a) have voltage and amperage ratings consistent with the requirements of the equipment or tool(s) to which they are providing power, (b) not have splices or taps, and (c) not be connected in series with one another. If there is a defect, or evidence of damage that might result in injury, the defective or damaged item shall be removed from service.

b. Grounded Equipment. An extension cord used with equipment requiring grounding for safety purposes shall have an equipment-grounding conductor, with three-pronged plug and receptacle. Facilities still equipped with duplex receptacles must have the duplex receptacles replaced.

c. Conductive Work Locations. Only battery-powered portable electrical equipment shall be used in any highly conductive environment such as a water-inundated area (*e.g.*, a flooded concrete floor, or wet earth).

d. Hazardous Locations. Equipment, wiring methods, and installations in hazardous (classified) locations shall be intrinsically safe, or approved for the hazardous (classified) location. Hazardous locations are classified in 29 CFR 1910.307 based on the properties of the flammable vapors, liquids or gases, or combustible dusts or fibers which may be present therein and the likelihood that a flammable or combustible concentration or quantity is present.

3405. SELECTION AND USE OF SAFETY-RELATED WORK PRACTICES.

a. General. FAA employees and contractors shall employ safety related work practices to prevent electric shock or other injuries resulting from either intentional or unintentional electrical contacts when work is performed on or near equipment or circuits that are or may be energized. The specific safety-related work practices shall be consistent with the nature and extent of the associated electrical hazards. Electrical work shall be performed in accordance with 29 CFR 1910, Subpart S, and NFPA 70E, Standard for Electrical Safety Requirements for Employee Workplaces, latest Edition.

b. De-energized parts. Live parts to which personnel may be exposed shall be de-energized before anyone works on or near them, unless FAA management can demonstrate that de-energizing introduces additional or increased hazards, or is infeasible because of equipment design or operational limitations. Live parts that operate at less than 50 volts with respect to ground need not be deenergized if there will be no increased exposure, *e.g.*, to an electrical burn or an explosion triggered by electric arcs.

c. Energized parts. If exposed live parts are not de-energized, other safety-related work practices shall be used to protect personnel who may be at risk. Such work practices shall be sufficient to (a) protect employees against bodily contact with energized circuit parts, whether such contact is direct or indirect (*e.g.*, by any conductor of electricity that is not a normal or usual part of the energized circuit); and (b) inadvertent approach to the proximity of circuits of a voltage sufficiently high as to present an electrocution or shock hazard by arcing.

d. Work practices. The work practices that are used shall be suitable for the conditions under which the work is to be performed and for the voltage level of the exposed electric conductors or circuit parts.

e. Lockout/Tagout. While any employee is exposed to contact with electrical equipment or circuits that have been de-energized, the means by which de-energizing was accomplished (*e.g.*, circuit breaker or switch operation, unplugging, fuse removal) shall be secured by being locked in the safe (“off”) position, and/or by tagging in accordance with the requirements of 29 CFR 1910.147, The Control of Hazardous Energy (Lockout/Tagout) and the FAA Order 3900.19B, Chapter 13, Hazardous Energy Control Program (Lockout/Tagout) and associated implementation guidance provided by individual Lines of Business (LOB).

f. Work on energized equipment. Only qualified persons may work on electrical equipment or circuits that have not been de-energized and locked out or tagged out. Such qualified persons shall be capable of working safely on energized circuits and shall be familiar with the proper use of special precautionary techniques, personal protective equipment, insulating and shielding materials, and insulated tools.

g. Entry. Employees may not enter areas in which there are exposed energized parts, unless they have been properly trained and provided personnel protective equipment as outlined below. Adequate illumination shall be provided for all workspaces around electrical equipment in accordance with the references cited herein in paragraph 3403c (6) (d), above. Additional requirements are required to safeguard the worker if the space being entered is a confined space as described in Chapter 11 of this order, and in 29 CFR 1910.146.

3406. USE OF PERSONAL PROTECTIVE EQUIPMENT.

a. FAA employees and contractors working in areas where there are potential electrical hazards shall be provided with, and shall use, protective clothing or other protective equipment that is appropriate the work to be performed. Contractors shall provide their own personal protective equipment. Personal protective equipment requirements are contained in FAA Order 3900.19B, Chapter 25, FAA Personal Protective Equipment. A Job Hazard Analysis procedure is covered in Chapter 23 of this Order to help identify personal protective equipment and clothing needs.

b. Personal protective equipment shall be maintained in a safe, reliable condition and shall be periodically inspected or tested.

c. If the insulating capability of personal protective equipment may be subject to damage during use, it shall be protected; *e.g.*, by an outer covering of leather, as sometimes used for the protection of rubber insulating material.

d. Personnel shall wear nonconductive head protection and protective equipment for the eyes and face wherever there is a danger from electrical shock or burns due to contact with exposed energized parts.

e. Neither wristwatches with electrically conductive cases, wristbands or straps, nor jewelry, shall be worn while performing electrical work. Wedding bands may be left on the ring finger if insulated by a piece of tape placed over the wedding band.

f. Employees shall wear protective equipment for the eyes, face, and head wherever there is danger of injury to same from electric arcs or flying objects resulting from electric arcs or an electrically triggered explosion

g. Fire-rated clothing, with the correct Arc Thermal Performance Exposure Value (ATPV) rating shall be worn whenever there is a flash hazard. The ATPV specification provides performance requirements for clothing worn by electric utility workers and other personnel working around energized parts. In addition to non-thermal requirements, the standard requires the fabric to be flame-resistant; that is, to not ignite and continue to burn after exposure to an ignition source.

h. General protective equipment and tools.

(1) When working near exposed energized conductors or circuit parts, employees shall use insulated tools or handling equipment if the tools or handling equipment might make contact with such conductors or parts. If the insulating capability of insulated tools or handling equipment is subject to damage, the insulation shall be inspected frequently, and any damage repaired, or the tool removed from service. Most insulated tools state on them "Not for personnel protection, but circuit protection." The proper "real" insulated tools are clearly color coded and marked for the voltage application. Use only properly marked insulated tools, marked for use with the applicable voltage.

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

(3) Ropes and handlines used near exposed energized parts shall be nonconductive.

(4) Protective shields or barriers, or insulating materials shall be used to protect personnel from shock, burns, or related injuries while working near exposed energized parts which might be accidentally contacted or where dangerous electrical heating or arcing might occur. When normally enclosed live parts are exposed for maintenance or repair, they shall be guarded to protect unqualified persons from contact with the live parts.

i. Alerting techniques. The following alerting techniques shall be used to warn and protect personnel from hazards that could cause injury from electrical shock, burns, or failure of electrical equipment parts:

(1) **Safety signs and tags.** Safety signs, safety symbols, or accident prevention tags shall be used where necessary to warn employees about electrical hazards that may endanger them.

(2) **Barricades.** Barricades shall be used in conjunction with safety signs where it is necessary to prevent or limit access by personnel to work areas exposing them to uninsulated energized conductors or circuit parts.

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

3407. TRAINING.

a. Scope of training. FAA employees shall be trained in, and become familiar with, the safety-related work practices that pertain to their respective job assignments where those job assignments place them at risk of electric shock that cannot be reduced to a safe level by engineering controls.

b. Content of training for Qualified Persons. Qualified Persons familiar with the construction and operation of the equipment they will be working with, and the hazards involved, and permitted to work on or near exposed energized parts shall at a minimum be trained and familiar with the following:

(1) The skills and techniques necessary to distinguish exposed live parts from other parts of electrical equipment

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

(3) The clearance distances specified by the NFPA, and the corresponding voltages to which the qualified person will be exposed.

Note 1: Whether an employee is considered to be a qualified person depends upon various circumstances in the workplace. It is possible, and in fact, likely, for an individual to be considered qualified with regard to certain equipment in the workplace, but unqualified as to other equipment.

Note 2: An employee who is undergoing on-the-job training, and who, in the course of such training, has demonstrated the 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.

c. Content of Training for Unqualified Persons. The training required shall be of the classroom or on-the-job type. The degree of training provided shall be based on an assessment of the risk of electrical shock by a person with the training to make that determination.

d. Recordkeeping. All training shall be properly documented in FAA's official training information system. Documentation shall include a written certification record that contains the course name or a complete and accurate description of the training, the name or other identifier of the employee trained, the date(s) of the training, and the signature of the competent person who performed the training.

3408. DEFINITIONS. *(Also see OSHA definitions in 29 CFR 1910.399)*

a. Accessible.

(1) As applied to wiring methods (a) capable of being removed or exposed without damage to the building or structure, or finish thereof, in which it is situated; or (b) not permanently enclosed by the building, structure, or finish thereof, in which it is situated. *(See also concealed and exposed.)*

(2) As applied to equipment, admitting close approach, not guarded by locked doors, elevation, or other effective means. *(See also readily accessible.)*

b. Cabinet. With respect to installations of electrical equipment, an enclosure designed either for surface or flush mounting, and provided with a frame, mat, or trim in which a swinging door or doors are or may be hung.

c. Certified.

(1) Of electrical equipment, having been tested or type-tested by an OSHA-listed nationally recognized testing laboratory (NRTL) and found to meet nationally recognized standards, or to be safe for use in a specified manner or given application, and labeled, tagged, or recorded as such.

(2) Of electrical equipment or components, being of a kind whose production is periodically inspected by an OSHA-listed nationally recognized testing laboratory (NRTL), found to meet nationally recognized standards, or to be safe for use in a specified manner or given application, and labeled, tagged, or recorded as such.

d. Circuit breaker. A device designed to open an electrical circuit automatically upon sensing a predetermined overcurrent, and sometimes, upon sensing other faults such as a ground fault, without injury to itself when properly applied within its rating. *Note:* A circuit breaker may also be operated manually to isolate an electrical circuit; *e.g.*, to permit work on the isolated section. It should be recognized that repeated manual operation of some circuit breakers may result in automatic operation, creating an open circuit under a lower-than-specified current.

e. Concealed. Rendered inaccessible by the structure or finish of the building. Wires in concealed raceways are considered concealed, even though they may become accessible by withdrawing them. [*See Accessible. (As applied to wiring methods.)*]

f. Conductor. Any substance in which ions or free electrons may facilitate the flow of an electrical current; specifically, a metallic strand or component used for the transfer of electrical energy or a communications signal. *Note:* In electrical power distribution, several classifications of conductor are recognized:

(1) A bare conductor is a conductor having no covering or electrical insulation whatsoever.

(2) A covered conductor is a conductor encased within material of composition or thickness that is not recognized as electrical insulation.

(3) An insulated conductor is a conductor encased within (usually in intimate contact with), or covered by, material of composition and thickness that is recognized as electrical insulation.

g. Explosion-proof apparatus.

(1) Apparatus enclosed in a case that is capable of withstanding (containing) an internal explosion; *e.g.*, of a specified gas mixture or vapor.

(2) Apparatus enclosed in a case that (a) is capable of preventing the ignition (*e.g.*, by sparks, flashes or an explosion generated by the apparatus) of a specified gas, gas mixture, or vapor external to the case, and (b) which apparatus operates at such a temperature that the case that encloses it will not reach a temperature capable of igniting a specified surrounding (external) gas, gas mixture, or vapor.

h. Exposed. With respect to electrically live parts, capable of being inadvertently touched, or approached to an unsafe distance. *See also accessible and concealed.*

i. Fuse. An overcurrent protective device having as its primary component a conducting medium that will melt and disperse when subjected to heating by a specified overcurrent, thus interrupting the flow of current to the protected circuit or apparatus.

j. Ground. A conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth, or allowing the electrical current to be safely dissipated to ground.

k. Grounded.

(1) In electrical contact with earth (“earth ground”).

(2) In electrical contact with a conductor that by design, or inadvertently, serves as a common return path for an electrical current or currents in place of the earth.

l. Ground-Fault Circuit Interrupter (GFCI). A device whose function is to interrupt the electrical circuit to a load when a fault current to ground exceeds some predetermined value that is less than that required to operate the overcurrent protective device of the supply circuit. *Note:* A ground-fault circuit interrupter is used to protect personnel from being subjected to potentially fatal or injurious electrical currents that are insufficient to trigger a circuit breaker, or melt a fuse, designed to protect only the electrical equipment.

m. Labeled. Of electrical equipment or components, referring to the presence of a label, symbol, or other identifying mark of an OSHA-listed nationally recognized testing laboratory (NRTL) which (a) makes periodic inspections of the production of such equipment or components, and (b) whose labeling indicates compliance with nationally recognized standards, or a determination by testing that the equipment or components are safe when used in a specified manner.

n. Location. With respect to installations of electrical equipment, the environment in which the equipment is installed. Several classifications of location, based on the presence or likelihood of moisture, are recognized:

(1) **Damp Location.** A location that is partially protected from direct exposure to wet weather. *Note:* Examples of damp locations are an area under a canopy, marquee, or roofed open porch, a basement subject to water intrusion, and some barns and cold-storage warehouses.

(2) **Dry Location.** A location not normally subject to dampness or water intrusion. *Note:* A location classified as dry may be temporarily subject to dampness or wetness, as in the case of a building under construction.

(3) **Wet Location** A location normally exposed directly to wet weather or water intrusion, such as an underground installation, an installation in direct contact with earth or a concrete slab in contact with earth, and an area used for washing motor vehicles.

Note: Locations at some FAA sites, such as on airport properties, may be subject to intrusion by hydrocarbon fuels. These hydrocarbons can be harmful even if intruding water is quickly dispersed. Hydrocarbons, which tend to coat objects with which they come into contact, even when relatively small quantities are transported by intruding water, can cause rapid deterioration of, *e.g.*, plastics used for insulation or cable jackets. Special protective construction or insulating materials such as polytetrafluoroethylene (PTFE, “Teflon”) may be indicated for such locations.

o. Panelboard. A single panel, or group of panel units assembled to create a single panel, including, *e.g.*, buses or automatic overcurrent devices, and with or without switches, for the control or protection of lighting, heating, or power distribution circuits, *etc.*, and designed to be placed in a cabinet or cutout box recessed within, or mounted on, a wall or partition, and accessible only from the front. (*See also switchboard.*)

p. Qualified Person. One familiar with the construction, safe operation of, and hazards associated with, a given installation, system, or piece or type of equipment.

Note 1: Whether an individual is considered to be a qualified person depends on various circumstances, including level of training and site-specific circumstances. It is quite possible for an individual to be qualified with respect to certain equipment in the workplace, and unqualified with respect to other equipment.

Note 2: See 29 CFR 1910.332 (b) (3) for training requirements that specifically apply to qualified persons.)

Note 3: An individual who is undergoing on-the-job training, and who, in the course of such training, has demonstrated the ability to perform specified duties safely at his or her level of training, and who is under the direct supervision of a qualified person, may be considered to be a qualified person for the performance of those duties.

q. Readily accessible. Capable of being reached quickly for operation, renewal, or inspections, so that those needing access do not have to climb over or remove obstacles or to resort to portable ladders, chairs, etc. (See **Accessible**.)

r. Switchboard. A usually large single panel, frame, or assembly of panels, having, *e.g.*, switches, buses, instruments, or overcurrent or other protective devices mounted on the front or back or both. *Note:* Switchboards are distinguished from panelboards in that they are usually accessible from the rear as well as from the front, and are not intended to be installed in cabinets. *See also* **panelboard**.

s. Voltage. The difference in electric potential, expressed in volts, between two points, *e.g.*, conductors in a circuit. Some related terms are:

(1) Voltage, Nominal. Of a circuit or load, a designated or assigned voltage value, the purpose of which is to express the voltage class (*e.g.*, 120/240, 480Y/277, 600). *Note:* The actual voltage at which a circuit operates will vary from the nominal, but is required to be within a range that permits satisfactory operation.

(2) Voltage Rating.

(a) The range of voltages over which a piece of electrical equipment, or a device, is specified to operate properly.

(b) The highest voltage at which an electrical insulator is specified be effective, or designed to withstand.

(c) The highest voltage that maybe applied to a conductor in conformity with a standard or specification.

(3) Volts, Alternating Current (Vac). The root-mean-square (rms) difference of potential between two conductors, which potential alternates in polarity, usually in a nominally sinusoidal, and sometimes (*e.g.*, in backup or uninterruptible power supplies) in a square-wave, waveform.

Note 1: The rms difference of potential is the effective difference of potential as applied to computing the electrical power, *e.g.*, transmitted by a power line, or consumed by a load.

Note 2: For a sinusoidal waveform, the rms value is approximately 0.707 times the peak voltage value; conversely, the peak value is approximately 1.414 times the rms value.

(4) Volts, Direct Current (Vdc) The voltage between two conductors, which voltage remains unchanged in polarity and is usually understood to be nominally constant in magnitude.