Occupational Safety Program

Electrical Safety Program

Manual

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Purpose

The purpose of the program is to minimize the risk of the following through appropriate code and standard enforcement: injury to faculty, staff, students, and visitors; fire and associated property damage; interrupted operation; and shortened equipment life.

Scope

The scope of the program applies to all employees, students, and visitors. All facilities and electrical equipment used on campus must comply with the program. This program shall conform to the requirements of at least 29 CFR 1910 Subpart S – Electrical; The National Electrical Code (NEC; also identified as ANSI Standard ANSI/NFPA 70); NFPA 70E – NEC Standard for Electrical Safety in the Workplace; and any other applicable standards.

Definitions

***Acceptable*:** An installation or equipment is acceptable to the Assistant Secretary of Labor, and approved within the meaning of this subpart S: (1) If it is accepted, or certified, or listed, or labeled, or otherwise determined to be safe by a nationally recognized testing laboratory recognized pursuant to § 1910.7; or (2) With respect to an installation or equipment of a kind that no nationally recognized testing laboratory accepts, certifies, lists, labels, or determines to be safe, if it is inspected or tested by another Federal agency, or by a State, municipal, or other local authority responsible for enforcing occupational safety provisions of the National Electrical Code, and found in compliance with the provisions of the National Electrical Code as applied in this subpart; or (3) With respect to custom-made equipment or related installations that are designed, fabricated for, and intended for use by a particular customer, if it is determined to be safe for its intended use by its manufacturer on the basis of test data which the employer keeps and makes available for inspection to the Assistant Secretary and his authorized representatives.

***Accepted*:** An installation is "accepted" if it has been inspected and found by a nationally recognized testing laboratory to conform to specified plans or to procedures of applicable codes.

Accessible: (As applied to wiring methods.) Capable of being removed or exposed without damaging the building structure or finish, or not permanently closed in by the structure or finish of the building. (See "concealed" and "exposed.")

Accessible: (As applied to equipment.) Admitting close approach; not guarded by locked doors, elevation, or other effective means. (See "Readily accessible.")

Ampacity: The current, in amperes, that a conductor can carry continuously under the conditions of use without exceeding its temperature rating.

Appliances: Utilization equipment, generally other than industrial, normally built in standardized sizes or types, that is installed or connected as a unit to perform one or more functions.

Approved: Acceptable to the authority enforcing this subpart. The authority enforcing this subpart is the Assistant Secretary of Labor for Occupational Safety and Health. The definition of "acceptable" indicates what is acceptable to the Assistant Secretary of Labor, and therefore approved within the meaning of this subpart.

Armored cable (Type AC): A fabricated assembly of insulated conductors in a flexible metallic enclosure.

Askarel: A generic term for a group of nonflammable synthetic chlorinated hydrocarbons used as electrical insulating media. Askarels of various compositional types are used. Under arcing conditions, the gases produced, while consisting predominantly of noncombustible hydrogen chloride, can include varying amounts of combustible gases depending upon the askarel type.

Attachment plug (Plug cap)(Cap): A device that, by insertion in a receptacle, establishes a connection between the conductors of the attached flexible cord and the conductors connected permanently to the receptacle.

Automatic: Self-acting, operating by its own mechanism when actuated by some impersonal influence, as, for example, a change in current strength, pressure, temperature, or mechanical configuration.

Bare conductor: See Conductor.

Barrier: A physical obstruction that is intended to prevent contact with equipment or live parts or to prevent unauthorized access to a work area.

Bathroom: An area including a basin with one or more of the following: a toilet, a tub, or a shower.

Bonding (Bonded): The permanent joining of metallic parts to form an electrically conductive path that ensures electrical continuity and the capacity to conduct safely any current likely to be imposed.

Bonding jumper: A conductor that assures the necessary electrical conductivity between metal parts required to be electrically connected.

Branch circuit: The circuit conductors between the final overcurrent device protecting the circuit and the outlets.

Building: A structure that stands alone or is cut off from adjoining structures by fire walls with all openings therein protected by approved fire doors.

Cabinet: 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 can be hung.

Cable tray system: A unit or assembly of units or sections and associated fittings forming a rigid structural system used to securely fasten or support cables and raceways. Cable tray systems include ladders, troughs, channels, solid bottom trays, and other similar structures.

Cablebus: An assembly of insulated conductors with fittings and conductor terminations in a completely enclosed, ventilated, protective metal housing.

Cell line: An assembly of electrically interconnected electrolytic cells supplied by a source of direct current power.

Cell line attachments and auxiliary equipment: Cell line attachments and auxiliary equipment include, but are not limited to, auxiliary tanks, process piping, ductwork, structural supports, exposed cell line conductors, conduits and other raceways, pumps, positioning equipment, and cell cutout or bypass electrical devices. Auxiliary equipment also includes tools, welding machines, crucibles, and other portable equipment used for operation and maintenance within the electrolytic cell line working zone. In the cell line working zone, auxiliary equipment includes the exposed conductive surfaces of ungrounded cranes and crane-mounted cell-servicing equipment.

Center pivot irrigation machine: A multi-motored irrigation machine that revolves around a central pivot and employs alignment switches or similar devices to control individual motors.

Certified: Equipment is "certified" if it bears a label, tag, or other record of certification that the equipment: (1) Has been tested and found by a nationally recognized testing laboratory to meet nationally recognized standards or to be safe for use in a specified manner; or (2) Is of a kind whose production is periodically inspected by a nationally recognized testing laboratory and is accepted by the laboratory as safe for its intended use.

Circuit breaker: A device designed to open and close a circuit by nonautomatic means and to open the circuit automatically on a predetermined overcurrent without damage to itself when properly applied within its rating.

Class I locations: Class I locations are those in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures. Class I locations include the following: (1) Class I, Division 1. A Class I, Division 1 location is a location: (i) In which ignitable concentrations of flammable gases or vapors may exist under normal operating conditions; or (ii) In which ignitable concentrations of such gases or vapors may exist frequently because of repair or maintenance operations or because of leakage; or (iii) In which

breakdown or faulty operation of equipment or processes might release ignitable concentrations of flammable gases or vapors, and might also cause simultaneous failure of electric equipment. Note to the definition of "Class I, Division 1:" This classification usually includes locations where volatile flammable liquids or liquefied flammable gases are transferred from one container to another; interiors of spray booths and areas in the vicinity of spraying and painting operations where volatile flammable solvents are used; locations containing open tanks or vats of volatile flammable liquids; drying rooms or compartments for the evaporation of flammable solvents; locations containing fat and oil extraction equipment using volatile flammable solvents; portions of cleaning and dyeing plants where flammable liquids are used; gas generator rooms and other portions of gas manufacturing plants where flammable gas may escape; inadequately ventilated pump rooms for flammable gas or for volatile flammable liquids; the interiors of refrigerators and freezers in which volatile flammable materials are stored in open, lightly stoppered, or easily ruptured containers; and all other locations where ignitable concentrations of flammable vapors or gases are likely to occur in the course of normal operations. (2) *Class I, Division 2*. A Class I, Division 2 location is a location: (i) In which volatile flammable liquids or flammable gases are handled, processed, or used, but in which the hazardous liquids, vapors, or gases will normally be confined within closed containers or closed systems from which they can escape only in the event of accidental rupture or breakdown of such containers or systems, or as a result of abnormal operation of equipment; or (ii) In which ignitable concentrations of gases or vapors are normally prevented by positive mechanical ventilation, and which might become hazardous through failure or abnormal operations of the ventilating equipment; or (iii) That is adjacent to a Class I, Division 1 location, and to which ignitable concentrations of gases or vapors might occasionally be communicated unless such communication is prevented by adequate positive-pressure ventilation from a source of clean air, and effective safeguards against ventilation failure are provided. Note to the definition of "Class I, Division 2:" This classification usually includes locations where volatile flammable liquids or flammable gases or vapors are used, but which would become hazardous only in case of an accident or of some unusual operating condition. The quantity of flammable material that might escape in case of accident, the adequacy of ventilating equipment, the total area involved, and the record of the industry or business with respect to explosions or fires are all factors that merit consideration in determining the classification and extent of each location. Piping without valves, checks, meters, and similar devices would not ordinarily introduce a hazardous condition even though used for flammable liquids or gases. Locations used for the storage of flammable liquids or liquefied or compressed gases in sealed containers would not normally be considered hazardous unless also subject to other hazardous conditions. Electrical conduits and their associated enclosures separated from process fluids by a single seal or barrier are classed as a Division 2 location if the outside of the conduit and enclosures is a nonhazardous location. (3) *Class I, Zone 0*. A Class I, Zone 0 location is a location in which one of the following conditions exists: (i) Ignitable concentrations of flammable gases or vapors are present continuously; or (ii) Ignitable concentrations of flammable gases or vapors are present for long periods of time. Note to the definition of "Class I, Zone 0:" As a guide in determining when flammable gases or vapors are present continuously or for long periods of time, refer to *Recommended Practice for Classification of Locations for Electrical Installations of Petroleum Facilities Classified as Class I, Zone 0, Zone 1 or Zone 2*, API

RP 505-1997; *Electrical Apparatus for Explosive Gas Atmospheres, Classifications of Hazardous Areas*, IEC 79-10-1995; *Area Classification Code for Petroleum Installations, Model Code -- Part 15*, Institute for Petroleum; and *Electrical Apparatus for Explosive Gas Atmospheres, Classifications of Hazardous (Classified) Locations*, ISA S12.24.01-1997. (4) *Class I, Zone 1*. A Class I, Zone 1 location is a location in which one of the following conditions exists: (i) Ignitable concentrations of flammable gases or vapors are likely to exist under normal operating conditions; or (ii) Ignitable concentrations of flammable gases or vapors may exist frequently because of repair or maintenance operations or because of leakage; or (iii) Equipment is operated or processes are carried on of such a nature that equipment breakdown or faulty operations could result in the release of ignitable concentrations of flammable gases or vapors and also cause simultaneous failure of electric equipment in a manner that would cause the electric equipment to become a source of ignition; or (iv) A location that is adjacent to a Class I, Zone 0 location from which ignitable concentrations of vapors could be communicated, unless communication is prevented by adequate positive pressure ventilation from a source of clean air and effective safeguards against ventilation failure are provided. (5) *Class I, Zone 2*. A Class I, Zone 2 location is a location in which one of the following conditions exists: (i) Ignitable concentrations of flammable gases or vapors are not likely to occur in normal operation and if they do occur will exist only for a short period; or (ii) Volatile flammable liquids, flammable gases, or flammable vapors are handled, processed, or used, but in which the liquids, gases, or vapors are normally confined within closed containers or closed systems from which they can escape only as a result of accidental rupture or breakdown of the containers or system or as the result of the abnormal operation of the equipment with which the liquids or gases are handled, processed, or used; or (iii) Ignitable concentrations of flammable gases or vapors normally are prevented by positive mechanical ventilation, but which may become hazardous as the result of failure or abnormal operation of the ventilation equipment; or (iv) A location that is adjacent to a Class I, Zone 1 location, from which ignitable concentrations of flammable gases or vapors could be communicated, unless such communication is prevented by adequate positive-pressure ventilation from a source of clean air, and effective safeguards against ventilation failure are provided.

Class II locations: Class II locations are those that are hazardous because of the presence of combustible dust. Class II locations include the following: (1) *Class II, Division 1*. A Class II, Division 1 location is a location: (i) In which combustible dust is or may be in suspension in the air under normal operating conditions, in quantities sufficient to produce explosive or ignitable mixtures; or (ii) Where mechanical failure or abnormal operation of machinery or equipment might cause such explosive or ignitable mixtures to be produced, and might also provide a source of ignition through simultaneous failure of electric equipment, through operation of protection devices, or from other causes; or (iii) In which combustible dusts of an electrically conductive nature may be present. Note to the definition of "Class II, Division 1:" This classification may include areas of grain handling and processing plants, starch plants, sugar-pulverizing plants, malting plants, hay-grinding plants, coal pulverizing plants, areas where metal dusts and powders are produced or processed, and other similar locations that contain dust producing machinery and equipment (except where the equipment is dust-tight or vented to the outside). These areas would have combustible dust in the air, under normal operating

conditions, in quantities sufficient to produce explosive or ignitable mixtures. Combustible dusts that are electrically nonconductive include dusts produced in the handling and processing of grain and grain products, pulverized sugar and cocoa, dried egg and milk powders, pulverized spices, starch and pastes, potato and wood flour, oil meal from beans and seed, dried hay, and other organic materials which may produce combustible dusts when processed or handled. Dusts containing magnesium or aluminum are particularly hazardous, and the use of extreme caution is necessary to avoid ignition and explosion. (2) *Class II, Division 2*. A Class II, Division 2 location is a location where: (i) Combustible dust will not normally be in suspension in the air in quantities sufficient to produce explosive or ignitable mixtures, and dust accumulations will normally be insufficient to interfere with the normal operation of electric equipment or other apparatus, but combustible dust may be in suspension in the air as a result of infrequent malfunctioning of handling or processing equipment; and (ii) Resulting combustible dust accumulations on, in, or in the vicinity of the electric equipment may be sufficient to interfere with the safe dissipation of heat from electric equipment or may be ignitable by abnormal operation or failure of electric equipment. Note to the definition of "Class II, Division 2:" This classification includes locations where dangerous concentrations of suspended dust would not be likely, but where dust accumulations might form on or in the vicinity of electric equipment. These areas may contain equipment from which appreciable quantities of dust would escape under abnormal operating conditions or be adjacent to a Class II Division 1 location, as described above, into which an explosive or ignitable concentration of dust may be put into suspension under abnormal operating conditions.

Class III locations: Class III locations are those that are hazardous because of the presence of easily ignitable fibers or flyings, but in which such fibers or flyings are not likely to be in suspension in the air in quantities sufficient to produce ignitable mixtures. Class III locations include the following: (1) *Class III, Division 1*. A Class III, Division 1 location is a location in which easily ignitable fibers or materials producing combustible flyings are handled, manufactured, or used. Note to the definition of "Class III, Division 1:" Such locations usually include some parts of rayon, cotton, and other textile mills; combustible fiber manufacturing and processing plants; cotton gins and cotton-seed mills; flax-processing plants; clothing manufacturing plants; woodworking plants, and establishments; and industries involving similar hazardous processes or conditions. Easily ignitable fibers and flyings include rayon, cotton (including cotton linters and cotton waste), sisal or henequen, istle, jute, hemp, tow, cocoa fiber, oakum, baled waste kapok, Spanish moss, excelsior, and other materials of similar nature. (2) *Class III, Division 2*. A Class III, Division 2 location is a location in which easily ignitable fibers are stored or handled, other than in the process of manufacture.

Collector ring: An assembly of slip rings for transferring electric energy from a stationary to a rotating member.

Competent Person: One who is capable of identifying existing and predictable hazards in the surroundings or working conditions that are unsanitary, hazardous, or dangerous to employees and who has authorization to take prompt corrective measures to eliminate them.

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.))

Conductor: (1) *Bare*. A conductor having no covering or electrical insulation whatsoever. (2) *Covered*. A conductor encased within material of composition or thickness that is not recognized by this subpart as electrical insulation. (3) *Insulated*. A conductor encased within material of composition and thickness that is recognized by this subpart as electrical insulation.

Conduit body: A separate portion of a conduit or tubing system that provides access through one or more removable covers to the interior of the system at a junction of two or more sections of the system or at a terminal point of the system. Boxes such as FS and FD or larger cast or sheet metal boxes are not classified as conduit bodies.

Controller: A device or group of devices that serves to govern, in some predetermined manner, the electric power delivered to the apparatus to which it is connected.

Covered conductor: See Conductor.

Cutout: (Over 600 volts, nominal.) An assembly of a fuse support with either a fuseholder, fuse carrier, or disconnecting blade. The fuseholder or fuse carrier may include a conducting element (fuse link), or may act as the disconnecting blade by the inclusion of a nonfusible member.

Cutout box: An enclosure designed for surface mounting and having swinging doors or covers secured directly to and telescoping with the walls of the box proper. (See Cabinet.)

Damp location: See Location.

Dead front: Without live parts exposed to a person on the operating side of the equipment

Deenergized (or De-energized): Free from any electrical connection to a source of potential difference and from electrical charge; not having a potential different from that of the earth.

Device: A unit of an electrical system that is intended to carry but not utilize electric energy.

Dielectric heating: The heating of a nominally insulating material due to its own dielectric losses when the material is placed in a varying electric field.

Disconnecting means: A device, or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply.

Disconnecting (or Isolating) switch: (Over 600 volts, nominal.) A mechanical switching device used for isolating a circuit or equipment from a source of power.

Electrolytic cell line working zone: The cell line working zone is the space envelope wherein operation or maintenance is normally performed on or in the vicinity of exposed energized surfaces of electrolytic cell lines or their attachments.

Electrolytic cells: A tank or vat in which electrochemical reactions are caused by applying energy for the purpose of refining or producing usable materials.

Enclosed: Surrounded by a case, housing, fence, or walls that will prevent persons from accidentally contacting energized parts.

Enclosure: The case or housing of apparatus, or the fence or walls surrounding an installation to prevent personnel from accidentally contacting energized parts, or to protect the equipment from physical damage.

Energized: Electrically connected to a source of potential difference.

Equipment: A general term including material, fittings, devices, appliances, fixtures, apparatus, and the like, used as a part of, or in connection with, an electrical installation.
Equipment grounding conductor: See Grounding conductor, equipment.

Explosion-proof apparatus: Apparatus enclosed in a case that is capable of withstanding an explosion of a specified gas or vapor that may occur within it and of preventing the ignition of a specified gas or vapor surrounding the enclosure by sparks, flashes, or explosion of the gas or vapor within, and that operates at such an external temperature that it will not ignite a surrounding flammable atmosphere.

Exposed: *(As applied to live parts.)* Capable of being inadvertently touched or approached nearer than a safe distance by a person. It is applied to parts not suitably guarded, isolated, or insulated. (See Accessible and Concealed.)

Exposed: *(As applied to wiring methods.)* On or attached to the surface, or behind panels designed to allow access. (See Accessible. (As applied to wiring methods.))

Exposed: *(For the purposes of § 1910.308(e).)* Where the circuit is in such a position that in case of failure of supports or insulation, contact with another circuit may result.

Externally operable: Capable of being operated without exposing the operator to contact with live parts.

Feeder: All circuit conductors between the service equipment, the source of a separate derived system, or other power supply source and the final branch-circuit overcurrent device.

Fitting: An accessory such as a locknut, bushing, or other part of a wiring system that is intended primarily to perform a mechanical rather than an electrical function.

Fountain: Fountains, ornamental pools, display pools, and reflection pools.
Note to the definition of "fountain:" This definition does not include drinking fountains.

Fuse: *(Over 600 volts, nominal.)* An overcurrent protective device with a circuit opening fusible part that is heated and severed by the passage of overcurrent through it. A fuse comprises all the parts that form a unit capable of performing the prescribed functions. It may or may not be the complete device necessary to connect it into an electrical circuit.

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

Grounded, effectively**:** Intentionally connected to earth through a ground connection or connections of sufficiently low impedance and having sufficient current-carrying capacity to prevent the buildup of voltages that may result in undue hazards to connected equipment or to persons.

Grounded conductor: A system or circuit conductor that is intentionally grounded.

Grounding conductor: A conductor used to connect equipment or the grounded circuit of a wiring system to a grounding electrode or electrodes.

Grounding conductor, equipment: The conductor used to connect the noncurrent-carrying metal parts of equipment, raceways, and other enclosures to the system grounded conductor, the grounding electrode conductor, or both, at the service equipment or at the source of a separately derived system.

Grounding electrode conductor: The conductor used to connect the grounding electrode to the equipment grounding conductor, to the grounded conductor, or to both, of the circuits at the service equipment or at the source of a separately derived system.

Ground-fault circuit-interrupter: A device intended for the protection of personnel that functions to deenergize a circuit or a portion of a circuit within an established period of time when a current to ground exceeds some predetermined value that is less than that required to operate the overcurrent protective device of the supply circuit.

Guarded: Covered, shielded, fenced, enclosed, or otherwise protected by means of suitable covers, casings, barriers, rails, screens, mats, or platforms to remove the likelihood of approach to a point of danger or contact by persons or objects.

Health care facilities: Buildings or portions of buildings in which medical, dental, psychiatric, nursing, obstetrical, or surgical care are provided. Note to the definition of "health care facilities:" Health care facilities include, but are not limited to, hospitals, nursing homes, limited care facilities, clinics, medical and dental offices, and ambulatory care centers, whether permanent or movable.

Heating equipment: For the purposes of § 1910.306(g), the term "heating equipment" includes any equipment used for heating purposes if heat is generated by induction or dielectric methods.

Hoistway: Any shaftway, hatchway, well hole, or other vertical opening or space that is designed for the operation of an elevator or dumbwaiter.

Identified: *(as applied to equipment)*. Approved as suitable for the specific purpose, function, use, environment, or application, where described in a particular requirement. Note to the definition of "identified:" Some examples of ways to determine suitability of equipment for a specific purpose, environment, or application include investigations by a nationally recognized testing laboratory (through listing and labeling), inspection agency, or other organization recognized under the definition of "acceptable."

Induction heating: The heating of a nominally conductive material due to its own I^2R losses when the material is placed in a varying electromagnetic field.

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

Insulated conductor: See Conductor, Insulated.

Interrupter switch: (Over 600 volts, nominal.) A switch capable of making, carrying, and interrupting specified currents.

Irrigation Machine: An electrically driven or controlled machine, with one or more motors, not hand portable, and used primarily to transport and distribute water for agricultural purposes.

Isolated: *(As applied to location.)* Not readily accessible to persons unless special means for access are used.

Isolated power system: A system comprising an isolating transformer or its equivalent, a line isolation monitor, and its ungrounded circuit conductors.

Labeled: Equipment is "labeled" if there is attached to it a label, symbol, or other identifying mark of a nationally recognized testing laboratory: (1) That makes periodic inspections of the production of such equipment, and (2) Whose labeling indicates compliance with nationally recognized standards or tests to determine safe use in a specified manner.

Lighting outlet: An outlet intended for the direct connection of a lampholder, a lighting fixture, or a pendant cord terminating in a lampholder.

Listed: Equipment is "listed" if it is of a kind mentioned in a list that: (1) Is published by a nationally recognized laboratory that makes periodic inspection of the production of such equipment, and (2) States that such equipment meets nationally recognized standards or has been tested and found safe for use in a specified manner.

Live parts: Energized conductive components.

Location: (1) *Damp location*. Partially protected locations under canopies, marquees, roofed open porches, and like locations, and interior locations subject to moderate degrees of moisture, such as some basements, some barns, and some cold-storage warehouses. (2) *Dry location*. A location not normally subject to dampness or wetness. 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*. Installations underground or in concrete slabs or masonry in direct contact with the earth, and locations subject to saturation with water or other liquids, such as vehicle-washing areas, and locations unprotected and exposed to weather.

Medium voltage cable (Type MV): A single or multiconductor solid dielectric insulated cable rated 2001 volts or higher.

Metal-clad cable (Type MC): A factory assembly of one or more insulated circuit conductors with or without optical fiber members enclosed in an armor of interlocking metal tape, or a smooth or corrugated metallic sheath.

Mineral-insulated metal-sheathed cable (Type MI): Type MI, mineral-insulated metal-sheathed, cable is a factory assembly of one or more conductors insulated with a highly compressed refractory mineral insulation and enclosed in a liquidtight and gastight continuous copper or alloy steel sheath.

Mobile X-ray: X-ray equipment mounted on a permanent base with wheels or casters or both for moving while completely assembled.

Motor control center: An assembly of one or more enclosed sections having a common power bus and principally containing motor control units.

Nonmetallic-sheathed cable (Types NM, NMC, and NMS): A factory assembly of two or more insulated conductors having an outer sheath of moisture resistant, flame-retardant, nonmetallic material.

Oil (filled) cutout: *(Over 600 volts, nominal.)* A cutout in which all or part of the fuse support and its fuse link or disconnecting blade are mounted in oil with complete immersion of the contacts and the fusible portion of the conducting element (fuse link), so that arc interruption by severing of the fuse link or by opening of the contacts will occur under oil.

Open wiring on insulators: Open wiring on insulators is an exposed wiring method using cleats, knobs, tubes, and flexible tubing for the protection and support of single insulated conductors run in or on buildings, and not concealed by the building structure.

Outlet: A point on the wiring system at which current is taken to supply utilization equipment.

Outline lighting: An arrangement of incandescent lamps or electric discharge lighting to outline or call attention to certain features, such as the shape of a building or the decoration of a window.

Overcurrent: Any current in excess of the rated current of equipment or the ampacity of a conductor. It may result from overload, short circuit, or ground fault.

Overhaul: To perform a major replacement, modification, repair, or rehabilitation similar to that involved when a new building or facility is built, a new wing is added, or an entire floor is renovated.

Overload: Operation of equipment in excess of normal, full-load rating, or of a conductor in excess of rated ampacity that, when it persists for a sufficient length of time, would cause damage or dangerous overheating. A fault, such as a short circuit or ground fault, is not an overload. (See Overcurrent.)

Panelboard: A single panel or group of panel units designed for assembly in the form of a single panel; including buses, automatic overcurrent devices, and with or without switches for the control of light, heat, or power circuits; designed to be placed in a cabinet or cutout box placed in or against a wall or partition and accessible only from the front. (See Switchboard.)

Permanently installed decorative fountains and reflection pools: Pools that are constructed in the ground, on the ground, or in a building in such a manner that the fountain or pool cannot be readily disassembled for storage, whether or not served by electrical circuits of any nature. These units are primarily constructed for their aesthetic value and are not intended for swimming or wading.

Permanently installed swimming, wading, and therapeutic pools: Pools that are constructed in the ground or partially in the ground, and all other capable of holding water in a depth greater

than 1.07 m (42 in.). The definition also applies to all pools installed inside of a building, regardless of water depth, whether or not served by electric circuits of any nature.

Portable X-ray: X-ray equipment designed to be hand-carried.

Power and control tray cable (Type TC): A factory assembly of two or more insulated conductors, with or without associated bare or covered grounding conductors under a nonmetallic sheath, approved for installation in cable trays, in raceways, or where supported by a messenger wire.

Power fuse: (Over 600 volts, nominal.) See Fuse.

Power-limited tray cable (Type PLTC): A factory assembly of two or more insulated conductors under a nonmetallic jacket.

Power outlet: An enclosed assembly, which may include receptacles, circuit breakers, fuseholders, fused switches, buses, and watt-hour meter mounting means, that is intended to supply and control power to mobile homes, recreational vehicles, or boats or to serve as a means for distributing power needed to operate mobile or temporarily installed equipment.

Premises wiring (Premises wiring system): The interior and exterior wiring, including power, lighting, control, and signal circuit wiring together with all of their associated hardware, fittings, and wiring devices, both permanently and temporarily installed, that extends from the service point of utility conductors or source of power (such as a battery, a solar photovoltaic system, or a generator, transformer, or converter) to the outlets. Such wiring does not include wiring internal to appliances, fixtures, motors, controllers, motor control centers, and similar equipment.

Qualified person: One who has received training in and has demonstrated skills and knowledge in the construction and operation of electric equipment and installations and the hazards involved. Note 1 to the definition of "qualified person:" Whether an employee is considered to be a "qualified person" will depend upon various circumstances in the workplace. For example, 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. (See 1910.332(b)(3) for training requirements that specifically apply to qualified persons.)
Note 2 to the definition of "qualified person:" 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.

Raceway: An enclosed channel of metal or nonmetallic materials designed expressly for holding wires, cables, or busbars, with additional functions as permitted in this standard. Raceways include, but are not limited to, rigid metal conduit, rigid nonmetallic conduit, intermediate metal conduit, liquidtight flexible conduit, flexible metallic tubing, flexible metal conduit,

electrical metallic tubing, electrical nonmetallic tubing, underfloor raceways, cellular concrete floor raceways, cellular metal floor raceways, surface raceways, wireways, and busways.

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

Receptacle: A receptacle is a contact device installed at the outlet for the connection of an attachment plug. A single receptacle is a single contact device with no other contact device on the same yoke. A multiple receptacle is two or more contact devices on the same yoke.

Receptacle outlet: An outlet where one or more receptacles are installed.

Remote-control circuit: Any electric circuit that controls any other circuit through a relay or an equivalent device.

Sealable equipment: Equipment enclosed in a case or cabinet that is provided with a means of sealing or locking so that live parts cannot be made accessible without opening the enclosure. The equipment may or may not be operable without opening the enclosure.

Separately derived system: A premises wiring system whose power is derived from a battery, a solar photovoltaic system, or from a generator, transformer, or converter windings, and that has no direct electrical connection, including a solidly connected grounded circuit conductor, to supply conductors originating in another system.

Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

Service cable: Service conductors made up in the form of a cable.

Service conductors: The conductors from the service point to the service disconnecting means.

Service drop: The overhead service conductors from the last pole or other aerial support to and including the splices, if any, connecting to the service-entrance conductors at the building or other structure.

Service-entrance cable: A single conductor or multiconductor assembly provided with or without an overall covering, primarily used for services, and is of the following types: (1) *Type SE*. Type SE, having a flame-retardant, moisture resistant covering; and (2) *Type USE*. Type USE, identified for underground use, having a moisture-resistant covering, but not required to have a flame-retardant covering. Cabled, single-conductor, Type USE constructions recognized for underground use may have a bare copper conductor cabled with the assembly. Type USE single, parallel, or cable conductor assemblies recognized for underground use may have a bare

copper concentric conductor applied. These constructions do not require an outer overall covering.

Service-entrance conductors, overhead system: The service conductors between the terminals of the service equipment and a point usually outside the building, clear of building walls, where joined by tap or splice to the service drop.

Service entrance conductors, underground system: The service conductors between the terminals of the service equipment and the point of connection to the service lateral.

Service equipment: The necessary equipment, usually consisting of one or more circuit breakers or switches and fuses, and their accessories, connected to the load end of service conductors to a building or other structure, or an otherwise designated area, and intended to constitute the main control and cutoff of the supply.

Service point: The point of connection between the facilities of the serving utility and the premises wiring.

Shielded nonmetallic-sheathed cable (Type SNM): A factory assembly of two or more insulated conductors in an extruded core of moisture-resistant, flame-resistant nonmetallic material, covered with an overlapping spiral metal tape and wire shield and jacketed with an extruded moisture-, flame-, oil-, corrosion-, fungus-, and sunlight-resistant nonmetallic material.

Show window: Any window used or designed to be used for the display of goods or advertising material, whether it is fully or partly enclosed or entirely open at the rear and whether or not it has a platform raised higher than the street floor level.

Signaling circuit: Any electric circuit that energizes signaling equipment.

Storable swimming or wading pool: A pool that is constructed on or above the ground and is capable of holding water to a maximum depth of 1.07 m (42 in.), or a pool with nonmetallic, molded polymeric walls or inflatable fabric walls regardless of dimension.

Switchboard: A large single panel, frame, or assembly of panels on which are mounted, on the face or back, or both, switches, overcurrent and other protective devices, buses, and (usually) instruments. Switchboards are generally accessible from the rear as well as from the front and are not intended to be installed in cabinets. (See Panelboard.)

Switch: (1) *General-use switch*. A switch intended for use in general distribution and branch circuits. It is rated in amperes, and it is capable of interrupting its rated current at its rated voltage. (2) *General-use snap switch*. A form of general-use switch constructed so that it can be installed in device boxes or on box covers, or otherwise used in conjunction with wiring systems recognized by this subpart. (3) *Isolating switch*. A switch intended for isolating an electric circuit from the source of power. It has no interrupting rating, and it is intended to be operated only

after the circuit has been opened by some other means. (4) *Motor-circuit switch*. A switch, rated in horsepower, capable of interrupting the maximum operating overload current of a motor of the same horsepower rating as the switch at the rated voltage.

Switching devices: *(Over 600 volts, nominal.)* Devices designed to close and open one or more electric circuits. Included in this category are circuit breakers, cutouts, disconnecting (or isolating) switches, disconnecting means, interrupter switches, and oil (filled) cutouts.

Transportable X-ray: X-ray equipment installed in a vehicle or that may readily be disassembled for transport in a vehicle.

Utilization equipment: Equipment that utilizes electric energy for electronic, electromechanical, chemical, heating, lighting, or similar purposes.

Ventilated: Provided with a means to permit circulation of air sufficient to remove an excess of heat, fumes, or vapors.

Volatile flammable liquid: A flammable liquid having a flash point below 38 °C (100 °F), or a flammable liquid whose temperature is above its flash point, or a Class II combustible liquid having a vapor pressure not exceeding 276 kPa (40 psia) at 38 °C (100 °F) and whose temperature is above its flash point.

Voltage (of a circuit): The greatest root-mean-square (rms) (effective) difference of potential between any two conductors of the circuit concerned.

Voltage, nominal: A nominal value assigned to a circuit or system for the purpose of conveniently designating its voltage class (as 120/240 volts, 480Y/277 volts, 600 volts). The actual voltage at which a circuit operates can vary from the nominal within a range that permits satisfactory operation of equipment.

Voltage to ground: For grounded circuits, the voltage between the given conductor and that point or conductor of the circuit that is grounded; for ungrounded circuits, the greatest voltage between the given conductor and any other conductor of the circuit.

Watertight: So constructed that moisture will not enter the enclosure.

Weatherproof: So constructed or protected that exposure to the weather will not interfere with successful operation. Rainproof, raintight, or watertight equipment can fulfill the requirements for weatherproof where varying weather conditions other than wetness, such as snow, ice, dust, or temperature extremes, are not a factor.

Wireways: Sheet-metal troughs with hinged or removable covers for housing and protecting electric wires and cable and in which conductors are laid in place after the wireway has been installed as a complete system.

Responsibilities

A. Environmental Health & Safety (EHS)

1. EHS will assist in development of electrical safety procedures.
2. EHS will provide electrical safety training.

B. Other Departments/Supervisors

1. Departments will develop procedures and guidelines for specific issues regarding electrical safety in their work area(s) or specific to assigned duties.
2. Supervisors will manage and monitor employees in areas where electrical safety issues are likely, and contact emergency services and EHS as required.
3. Supervisors will guide employees in work involving electrical equipment and focus on specific issues regarding electrical safety in their work area(s).
4. Supervisors will refer employees who require electrical safety training.

C. Employees

1. Employees are required to learn and understand electrical safety procedures.
2. Employees are required to be trained in electrical safety.

Introduction

Electrical safety refers to safe practices put in place to prevent incidents related to the use or presence of electrical tools, equipment, or infrastructure. Such incidents may lead to electric shock, electrocution, burns, falls, other serious injuries, explosion, fire, and property damage. These incidents can be caused by exposure to electrical current/voltage, electrical arcs or arc flashes, sparks, electrical static, contact with hot surfaces, overloaded circuits, improper grounding, collisions, etc. To ensure electrical safety, it is important to follow local, state, and federal laws, regulations, codes, and guidelines, TU Policy, EHS guidelines, and industry best practices. This document may be supplemented by other code requirements and internal documents, such as:

- State and local code requirements
- Unique location safety requirements
- Energy conservation requirements
- Installation and service requirements
- Special operating requirements
- Lockout/Tagout Program

Laws & Regulations

Laws and regulations regarding electrical safety established by local, state, and federal governments ensure that electrical equipment, installations, and practices meet specific safety standards. These laws and regulations may vary by jurisdiction, but cover the following areas:

- **Electrical installation standards:** Standards for the installation and use of electrical equipment, wiring, and appliances. This includes requirements for proper grounding, electrical panel protection, and use of electrical conduit and connectors.
- **Electrical tools and equipment standards:** Standards for the design, construction, and use of electrical equipment and appliances. These standards may cover grounding, electrical insulation, current capacity, and other safety features.

- **Electrical inspection and testing:** Periodic inspections and testing of electrical installations and equipment to ensure that they meet safety standards and are in good working order.
- **Electrical work practices:** Safe work practices and procedures for those working with or around electrical equipment, including requirements for personal protective equipment, lockout/tagout procedures, and proper use of tools and equipment.

Electrical Conductivity

Electricity travels or flows through any conductive material, material that contains a conductor to the ground, or electrically grounded material. These materials are typically attached directly to the earth or indirectly linked through circuitry. Your body is also a conductor, which is why you must take precautions to protect yourself.

Often, this conducting material is solid, but it may be a liquid or gas. A common example of such material is metal wiring, specifically placed along a circuit with the intent to distribute electricity where it is required, but conductors may take other forms. There are objects constructed of similar materials that may conduct electricity unintentionally.

Liquids such as water, which often has salts and other substances dissolved in it, may also conduct electricity. Although pure water is a poor conductor, water found in nature is almost never pure. Drinking water available through the tap is treated with additives, which will make it more conductive. Working with electrical equipment or doing electrical work in an environment where there is moisture indoors such as with pipes or high humidity, or outdoors in wet or rainy conditions will always be hazardous, so use proper hazard controls. Reduce electrical paths to ground through you by doing proper housekeeping, reducing conductive materials near your work (especially at your feet) and on your body, reduce exposure to live electrical wiring.

In some cases, air or other gases may conduct electricity. Lightning is a natural example of air conducting electricity. This often occurs where clouds have a build-up of charge and air has been ionized/charged, typically by heat, to allow an electrical path to the ground from these clouds; such a path can also be created due to dust or other impurities in the air as well, making certain regions of the air more conductive. A similar example takes place when an electric arc forms in air due to work such as welding, or unintentionally such as in a faulty circuit or with improper grounding. It essentially allows electricity to move through the air due to intense heat or if the gap between conductive objects is short enough (this may depend on the voltage of the specific conductors). The arc ionizes the air, creating plasma (ionized air) that can carry electrical current; typically, air is a poor conductor.

The type of material matters for conductivity, but it is also the size that matters. To go back to the wiring example, the thickness of the conductor will affect its resistance: the thicker the wire, the less resistance there is for the flow of electricity. This is part of why it is safer to use thicker wire for specific uses; less resistance (in ohms) means more electrical current (in amperes or amps) deliverable and often less heat build-up leading to fires or injuries.

Circuits and Loads
A circuit is a set of receptacles (e.g. outlets, lights) on one wire controlled by one power source or circuit breaker. Electricity requires a closed circuit in order to flow; the circuit is closed when a connection between the source or circuit breaker to the ground is completed, typically through a switch or other electrical equipment. This is why it is important to not touch or be near live wiring, you may unintentionally complete a circuit to the ground. A typical circuit is rated for 20 amps or 20,000 milliamps. Some circuits may be as high as 500 amps. 0.05 amps (50 milliamps) is enough to cause you to stop breathing and possibly cause death.

Circuit breakers are commonly located in the electrical panel and are used to protect electrical wiring and equipment from overheating and causing a fire, or a ground fault. A ground fault occurs when electricity follows a path other than through neutral wire for the electrical system. A ground fault may be due to a short circuit or current leakage. Electrical panels should have a minimum of 36 inches of clearance in all directions to avoid injuries or damage from creating accidental paths to ground.

The National Electrical Code requires that 80% of the maximum capacity for the power load for a circuit is not exceeded. That is, the difference between the maximum amperage rating (ampacity) for a circuit and its legally allowed current usage should be 20%, to avoid circuit overloading. For example, on a circuit with a 20-amp maximum rating, 16 amps (or 1,920 watts on a standard 120-volt circuit) is the legally allowed current load based on equipment.
One may find the amperage on equipment by viewing its electrical tag; add all amps on a circuit based on tags for each piece of equipment connected to the circuit to find the total potential electrical load. Overloaded circuits are fire hazards; plugging too many devices into one receptacle or receptacles that are not rated for the intended load.

Utilities/Power Lines
Beware of overhead power lines when working with ladders or elevated platforms. Such lines carry high voltage and can arc down to the ground when conductive materials are present. Minimum of 10 feet between metal tools and equipment, or materials and power lines that carry up to 50,000 V. Add 4 inches to the minimum 10 ft distance for every 10,000 V over the minimum 50,000 V. Only licensed high voltage electricians may work on overhead power lines. Always call the power utility company to interact with such equipment.

Injuries and Effects
The danger of injury is present whenever electrical power is used. All electrical equipment should be adequately insulated, grounded, or isolated to prevent bodily contact with any source of dangerous potentials. Use tools that are safe for the job. Make sure that you do not provide a lower-resistance path to the ground. Under certain conditions, people can be injured severely even from relatively low voltages coupled with high current.

The primary effects of electrical shock or electrocution are due to current actually flowing through the body. Electrical burns occur when the body, or a part of it, completes a circuit connecting the power source with the ground. Although the resistance of dry, unbroken skin to

electric current is relatively high, the amount of current necessary to kill a person is small. Therefore, it is easy to exceed lethal levels of current flow, especially if the skin is broken, wet, or damp with sweat. Specific issues regarding electrical safety must currently be covered locally by supervisors on standard operating procedures.

Applicable Regulations

- National Electrical Code
- ANSI/NFPA 70E
- 29 CFR 1910 Subpart S – Electrical (specifically, 29 CFR 1910.301 - 29 CFR 1910.308, 29 CFR 1910.331 - 29 CFR 1910.335, and 29 CFR 1910.399)

Procedure

A. General Guidelines

1. Awareness
   a) Be acquainted with all electrical hazards that may be encountered in your work area.
   b) Avoid unnecessary contact with electrical panels, circuit breakers, switches, electrical outlets, wires, transformers, and other related electrical devices.
   c) Keep away from electrical sources such as those mentioned in the previous step the following incompatible materials: chemicals and gases (especially flammables or oxygen); combustible dust; conductive objects (e.g. metals, magnets); organic matter and other combustibles; and water/moisture.
   d) Notify your supervisor of any potential electrical hazard that may be going unnoticed.
   e) Treat all electrical wires, switches, receptacles, and panels as if they are energized.
   f) See Office & Workplace Safety Guidelines for information regarding fire hazards, which are a result of electrical hazards found in Step B2.
   g) Extension cords are for temporary use and portable equipment (see Step G for more information). Never use light-duty household extension cords.
   h) Older buildings have older wiring that may not be able to handle the load/demand of modern equipment, leading to overheating and fire.
   i) Any electrical control (e.g. electrical panel), disconnect switches, transformers, or other electrical safety device used to stop energized circuits must not be blocked or otherwise impede their access. Such devices shall be unobstructed, have a minimum clearance of 36 inches from its edges in each direction, and shall be easily accessible.
   j) If live electrical parts or device (e.g. an electrical panel) cannot be fully secured or (en)closed, a physical barrier such as a shield or insulating material should be installed until a repair can be made. Signs should be placed to warn employees of the hazard, and the area in front of the electrical panel should be kept free of any obstructions.

2. Proper Housekeeping & Environment
    a) Where electrical shock hazards exist, first-line and backup protection shall be provided to prevent access to energized circuits and parts. This protection includes using lockouts, grounding hooks, barriers, and rubber mats.
    b) In places where electrical hazards exist, there shall be conspicuous visual indications of ON and OFF conditions, the type of hazard, and its exact location.
    c) Bench tops and bench edges in the immediate work area should be non-conductive and only a minimum of connected equipment should be on the bench tops. Rubber matting of adequate breakdown voltage should be used.
    d) Ensure that no energized circuits, wires, or parts are exposed (i.e., outlet cover plates are properly installed and electrical panel doors are kept closed).
    e) All energized parts of electrical circuits and equipment shall be guarded against accidental contact by using approved cabinets or enclosures.
    f) Keep dust and lint off electrical panels, receptacles, and appliances.
    g) Separate all combustible materials away from electrical equipment.
    h) Proper illumination shall be provided in all areas where electrical hazards are apt to be encountered and an emergency lighting system should be in place as well.
    i) Ambient conditions such as high heat/temperature, high humidity, wet/damp surroundings should be avoided. Proper insulation, ventilation, and temperature control may help avoid corrosion, condensation, and other issues that may result in damage or injury. Aside from direct damage/injury, reducing wet/damp surroundings may reduce biological activity from animals (e.g. rodents), which may shelter near electrical sources for warmth or cause damage by chewing through wiring.

3. Electrical Panel Use (e.g. circuit breaker box, circuit breaker panel, circuit boxes)
    a) Electrical panels may be located in offices, hallways, custodial closets, mechanical rooms, or classrooms.
    b) All electrical panels shall be unobstructed, have a minimum clearance of 36 inches from its edges in each direction, and shall be easily accessible.
        i. Such panels may arc and cause property damage, fire, injury, or death, so keep all objects from in front of or below an electrical panel.
        ii. Facilities Management or other emergency workers may require access to said panels at any time.
    c) Label all circuit box switches.
    d) Electrical panel doors should be closed and latched when not in use.
    e) Panels should be locked to avoid unauthorized access or unintentional contact.

4. Fuse/Conductor Use
    a) Fuses and current limiting devices
        i. Conductors must be protected by a fuse or current limiting device that matches their current carrying capacity. Fuses and current limiting devices must be installed according to the National Electrical Code (NEC).
    b) Wiring and equipment

i. *Motors and lighting circuits must be fused separately. Fuses and current limiting devices cannot be installed in grounding or neutral conductors.*

5. Tools & Other Equipment Specifications and Use
   a) Always inspect electrical tools and equipment before use. If your equipment runs erratically or if you feel a slight electrical tingle (a small electrical shock, "pins and needles" feeling at point of contact) when you touch it, stop using the tool, remove the tool from service by tagging it, and have it repaired or properly discarded.
   b) Follow manufacturer instructions and safety precautions for equipment and tools.
   c) New equipment or existing equipment that is to be relocated must be examined for recognized hazards when it is installed.
   d) For any tool/equipment that generates heat, unplug when not in use.
   e) Always turn off a tool or appliance before disconnecting it to avoid exposure to live electrical parts. See Lockout/Tagout Program.
   f) Equipment and handheld tools must have grounded three-prong plugs and/or double insulation. Only use equipment and tools that are properly grounded, are in good condition. All power tools and appliances must be free of damage such from cracks, fraying, and heat. All casing and insulation must be intact.
   g) Never unplug an appliance by pulling on the cord, always remove by the plug head.
   h) Attempt to limit one appliance per outlet. However, if more than one appliance is to be used for each circuit, an approved plug strip with circuit breaker should be used.
   i) Use appropriate equipment for the job. Ladders used near electrical equipment should be made of a non-conductive material such as fiberglass. Never use a metal ladder in this case.
   j) Never work with electrical equipment that has had the ground prong removed, damaged, or modified.
   k) Never use three-prong plug adapter to plug equipment into a two-hole receptacle without connecting the extra wiring to and approved ground.

6. Maintenance & Repairs
   a) De-energize any electrical system or equipment that is being repaired. Adequate and workable lockout-tagout procedures shall be used. See Lockout/Tagout Program.
   b) Never repair/modify electrical wiring unless shop-specific training is provided. Contact Facilities Management Work Control for assistance at 410-704-2481.
   c) Never work on electrical equipment that is hot.
   d) Never work alone on a live circuit; always have an observer.
   e) Remove moisture or standing water from surfaces that may come into contact with electrical equipment.

f) Never modify a plug by bending or removing the prongs. When plug prongs are bent, loose, or missing, replace the device.
g) Cuts in a power cord insulation cannot be repaired by using electrical tape; the damaged portion must be removed and a replacement properly installed by a licensed electrician or replace the equipment if possible.
h) Electrical work performed must be done by a licensed electrician and in accordance with the National Electric Code.
i) Always wear the appropriate PPE for the work being performed.
j) Ensure that all electrical devices, wiring, outlets, tools, and equipment are installed and maintained by qualified electricians, and regularly inspect such devices for damage or wear.

B. Damage or Misuse

1. Immediately report damaged or malfunctioning items to supervisor and take out of service until repaired by a qualified electrician.
2. Portable electric tools shall not be lifted, lowered, or hanged by means of the power cord. Ropes or approved methods shall be used.
3. Avoid overloading electrical outlets. Causes include but are not limited to: plugging in too many devices to one receptacle or those not rated for the receptacle; using broken, frayed, corroded, or otherwise damaged wiring; water damage; broken plug(s) or poor connections. Overloads may lead to devices overheating, which may cause fire, damage to said devices, to other property, and to physical health. Signs of overheating include burning odor, smoke, frayed wiring/cords, discolored outlets, or excessive warmth.
4. Do not press or overextend cords.
5. Cord adapters used to defeat the ground connection (i.e. three-prong to two-prong adapters) shall not be used.
6. Damaged electrical enclosures such as switches, receptacles, and junction boxes should be reported immediately to Facilities Management.

C. Personnel Protection

1. Protection shall be provided for the following:
   a) Where service is required with the power on and inadvertent contact is likely;
   b) Where it is necessary to reach over, under, around, or in close proximity to hazards; and
   c) Where dropped tools could cause shorts and arcing.

2. Protection shall be provided by one or more of the following:
   a) Shields
   b) Interlocks
   c) Remote or external test points
   d) Insulated potentiometer extensions
   e) Access holes
   f) Separation of low voltage and line voltage terminal blocks and relays

3. Specific Personal Protective Equipment (PPE) & Devices
    a) When any equipment may produce sparks or arcing during normal operation, safety glasses must be used at all times.
    b) Proper personal protective equipment, such as a hard hat, safety glasses, arm mats, appropriate suits or body protection, gloves, and footwear should be worn when maintaining any electrical equipment.
        i. Non-conductive goggles or safety glasses, and those that can protect from arc flashes, may be required.
        ii. Safety shoes and boots that do not conduct electricity should be worn, such as those that protect against the risk of electrical shock, such as electrical hazard (EH) resistant work boots (must meet ANSI F2413 standard). Though there may be impact hazards present during work, neither metal nor metal alloy footwear (e.g. steel-toed, aluminum, etc.) shall be worn during when there are electrical hazards.
        iii. Hot work that includes welding and similar operations will require PPE such as welding helmet, body protection, and related gloves, as appropriate.
    c) When using tools near electrical hazards, all tools must have a double insulated casing to prevent contact with energized parts.
    d) If uncertain about required PPE, contact your Supervisor or EHS.

4. Labels
    a) Warning Signs. Warning signs are needed to identify and locate potential hazards.
    b) The need for such warnings is particularly significant:
        i. Where the hazard may not be immediately apparent.
        ii. Where personnel may assume there is no hazard when, in fact, one exists.
        iii. Where the hazard may exist only under a certain set of conditions and not otherwise.

5. Hazard Warning
    a) Non-service personnel shall be warned of the presence of possible hazards in service areas. A sign mounted on a structural member of the machine reading *Hazardous Area - Trained Service Personnel Only* shall be used when there is exposure to chemical, electrical, thermal, or mechanical hazards. Excessive use of this sign shall be avoided.

6. Hazardous Potential Warning
    a) Hazardous potentials (other than line voltage) above 250 V (AC or DC) must be identified by a prominent sign located near energized parts. The sign applicable to the highest voltage present shall be used.

7. Main Control Enclosure
   a) A label indicating the following information shall be installed near the supply circuit disconnecting means:
      i. Voltage (V)
      ii. Amperage (A)
      iii. Phase (ph **or** ϕ)
      iv. Frequency (Hz)

8. Circuit Protection Devices
   a) The rated current (in amperes) of the circuit protection devices shall be visibly indicated near the device. Special fuses must also indicate type.

9. Emergency Off (EMO)
   a) EMO devices shall be engraved or have a red legend plate or label with white letters stating "EMERGENCY OFF."

10. Components (Devices)
    a) Shall be identified to (not on) the component with the same designation as shown on the diagram.

D. Nominal Voltages

1. Nominal voltages for circuits are 24 V (AC or DC), 120 / 208 VAC and 480 VAC. Table 1 is provided as a guide for determining equipment power requirements.

Equipment Power (kW) Requirements	Recommended Voltage (V) & Phase	Approximate Amperage Range (A)
0 kW - 3 kW	120 V, 1 ph	0 A - 25 A
0 kW - 5 kW	208 V, 1 ph	0 A - 25 A
3 kW - 30 kW	208 V, 3 ph	10 A - 80 A
≥ 15 kW	480 V, 3 ph	≥ 20 A

Table 1. Power Requirements. The table provides information on electrical requirements for equipment to be safely used.

E. High Voltage Safety

1. Basic Information
   a) In addition to the recommendations for general electrical safety, there are more stringent rules that apply to high voltage operations. High voltage pertains to electrical equipment that is operating at more than 600 volts in terminal-to-terminal operation or at more than 300 volts in voltage to ground operation. In addition, low voltage-high current AC or DC power supplies are also considered

to be high voltage applications. All switches, circuit breakers, and other control devices that are in high voltage equipment shall be labeled as such. For a more comprehensive listing of proper high voltage maintenance and operation, check the National Electrical Code.

2. Hazards of Working with High Voltage
    a) Care must be taken to ensure that unknown parties do not come in contact with energized parts. This can occur when there is a remote on/off switch relative to the energized conduits.
    b) Ensure that terminal voltage ratings can withstand any surges that may occur due to electrical faults or switching transients.
    c) Overload or improper cooling can cause excessive temperature rises, resulting in equipment damage.
    d) Be aware of output circuits even after input power is turned off to the system. Parallel power sources and energy storage devices such as capacitors can cause damage.
    e) When power supplies serve more than one experiment, switching errors can result in energizing the wrong equipment or load, creating possible hazards for nearby personnel.
    f) Overcurrent protective devices such as fuses and circuit breakers may not adequately limit or interrupt the total inductive energy and fault currents in highly inductive DC systems.

3. Safe Operating Procedures
    a) Prior to operation, inspect the power supply and check all protective devices.
    b) Employees shall be prohibited from working alone on energized lines or equipment over 600 volts.
    c) Before entering power supply or associated equipment enclosure, take the following precautions:
        i. De-energize the equipment.
        ii. Open and lockout the main input power circuit breaker.
        iii. Check for auxiliary power circuits which could still be energized.
        iv. Inspect automatic shorting devices to verify proper operation.
        v. Short the power supply from terminal-to-terminal, and terminal-to-ground with grounding hooks.
    d) Label equipment to identify input power sources, and label input power sources to identify their connected power supply loads.
    e) Equipment that is remotely controlled or unattended while energized should be labeled with emergency shutdown instructions and identification of personnel to contact in case of emergency.

F. Receptacles

1. Receptacles shall comply with the following:
    a) Voltage and current ratings shall not be less than that of the supply circuit.

b) When installed for convenience use, shall be rated at not less than 15 A at 125 V.
c) When installed for power distribution, shall not have a connected load exceeding 80% of rating.
d) Shall be grounding type specification grade receptacles.
e) Receptacles should be mounted firmly in their enclosures and should not move when the plug is inserted. Loose receptacles can cause short circuits.
f) Receptacles shall be enclosed.
g) Receptacles shall be securely mounted to a vertical surface or may be mounted to a horizontal surface with faceplate down.
h) Receptacles shall be accessible to service personnel.
i) Receptacles shall be accessible without removing covers or opening doors when installed as convenience outlet for operator use.
j) Faceplates shall be flush with the outer edges of the box.
k) Faceplate screws or faceplate screw holes shall not be used for receptacle mounting unless other provisions are made to counteract the plug insertion pressure.
l) All receptacles and any electrical conductors must be sufficiently grounded, and if uncertain whether or not this is true, call Facilities Management for assistance.
m) If plug prongs break off and remain in the receptacle slots after insertion or withdrawal, do not attempt to remove them. Call Facilities Managementt for assistance.

2. Receptacles with a T-shaped hole indicates a 20-amp dedicated circuit, which means that no other equipment is attached to that receptacle.
   a) Equipment or appliances such as refrigerators may have plugs that only fit into this receptacle type, but there is no issue in using them for standard lower amperage equipment if the plug fits.
   b) Receptacles should only be installed on circuits designed to handle the load. Only a licensed electrician is allowed to replace circuitry or circuit breakers.

3. Ground Fault Circuit Interrupters (GFCIs)
   a) Keep the floor in your workplace completely dry.
   b) Keep all electrical equipment away from any source of water unless the appliance is rated for use around water, such as a wet-dry shop vacuum.
   c) Ground fault circuit interrupters (GFCIs) should be used as much as possible. In any wet, damp, or moist environment, GFCIs are required.
   d) Receptacles shall be protected by ground fault circuit interrupter (GFCI) when installed in a damp or wet location, e.g., hose washdown area.

4. If anyone discovers loose receptacles or other faulty electrical equipment, it should be removed from service or tagged out until a qualified electrician from Facilities Management can make repairs.

G. Extension Cords

1. Extension cords should be used only when necessary and only on a temporary basis (> 90 days). Extension cords should not be used in place of permanent or fixed wiring.
2. Do not “daisy chain” extension cords and/ or power strips.
3. Prevent damage to the cord and plugs (i.e., avoid placing in walkways/driveways, and never staple, nail, or otherwise attach extension cords to a surface.)
    a) Keep all electrical cords away from areas where they may be pinched, such as off the floor, out of walkways, and out of doorways.
    b) Where possible, move the electrical appliance closer to the outlet.
4. Select electric extension cords wisely. Only use extension cords rated for the equipment power needs.
    a) Using undersized extensions cords may not trip a circuit breaker while being overloaded, so take care not to use them. For 120 V extension cord up to 50 ft, minimum 14-gauge cord required; 120V extension cord for use on over 50 ft up to 100 ft, min 12 gauge required. The higher the voltage running through a wire, the lower the gauge required for the cord.
5. Make sure all extension cords are the right size or rating for the tool you are using. Example: The diameter of the extension cord being used should be equal to or greater than the cord of the appliance being used.
6. Do not use any appliance or extension cord that exhibits signs of wear, such as frayed insulation or exposed wiring. To ensure safe operation, all electrical equipment should be visually inspected before use.

H. Emergencies

1. In case of fire:
    a) Call 911!
    b) It is TU Policy to evacuate immediately.
    c) Pull fire alarm in area upon exit, if possible.

2. In case of health emergency (electrocution, shock, burn, etc.):
    a) Call 911!
    b) Turn off the power, if possible.
        i. Turn off the source of electricity by unplugging the device, switching off the circuit breaker/fuse box/electrical panel, pulling the safety switch handle down, pressing the emergency stop button, or whatever method used to power down the source quickly. If the plug is damaged, you will need to shut off the power at the fuse box or circuit breaker.

    c) Move the person away from the power source or exposed energized parts:
        i. If you can't turn off the power, use a non-conducting object like a wooden broom handle, plastic chair, or rubber doormat to separate the person from the power source. If the person is in contact with water, be especially careful. You may become electrocuted or otherwise injured by the

energized parts through the other person, if not cautious. An electrical shock that enters through your hand and passes to the ground through your lower body will pass through your heart and lungs.

3. Check the condition of the injured person:
   a) Make sure that the person is breathing and conscious. If the person is not breathing or their breathing is dangerously slow or shallow, begin CPR.
   b) Call others for assistance in performing CPR prior to the arrival of emergency services.
   c) Use an AED where available; it may be retrieved by someone assisting you in a rescue prior to emergency services.
   d) A person may not appear to be injured, but medical attention or a hospital visit is recommended to evaluate the person for any underlying health issues or injuries from the shock.

4. Treat injuries:
   a) If the person has burns, cover them with a clean cloth or sterile gauze bandage.
   b) Do not break blisters or remove burned clothing.

5. Electrical shock can cause a number of short-term and long-term effects, including but not limited to the following:
   a) Loss of consciousness; numbness, tingling, or pins and needles; paralysis; seizure disorders; dizziness, loss of balance, or fainting; ringing in the ears or hearing loss; muscle spasms, contractions, or tremors; migraine; irregular heartbeat or other heart issues.

I. Training

Employees who are required will be trained in basic electrical safety through EHS. The training requirements apply to employees who face a risk of electrical shock that is not reduced to a safe level by the electrical installation requirements of 29 CFR 1910.303 through 1910.308. Employees in occupations facing a higher-than-normal risk of electrical accident are required to be trained. In addition, other employees who may reasonably be expected to face comparable risk of injury due to electric shock or other electrical hazards must be trained.

Training will be assigned virtually through Vector Solutions SafeColleges found at the following URL: https://towsonehs-md.safecolleges.com/training/home. Employees shall request training by emailing safety@towson.edu or by calling the Environmental Health & Safety (EHS) office at 410-704-2949.

Employees should be trained on shop-specific electrical hazards by Facilities Management or their Department for specialized equipment.

Employees who regularly work on or around energized electrical equipment shall be trained in the proper methods of cardiopulmonary resuscitation (CPR) and Automatic External Defibrillation (AED). For CPR/AED training, contact TU College of Health Professions, TU Campus Recreation, other TU-affiliated trainers, or other accredited CPR training provider. Training should involve hands-on learning. Trainees should be certified prior to work requiring electrical safety. CPR certifications are valid for two years after certification date. Employees should maintain training documentation, be able to provide documentation (such as a card or certificate) upon request, and be able to provide a photocopy to Facilities Management and EHS to keep on file.

Resources

A. EHS

To request documents, reviews for procedures, processes, or equipment, or general inquiries, contact EHS by emailing safety@towson.edu or by calling the Environmental Health & Safety (EHS) office at 410-704-2949.

B. American Wire Gauge Conductor Size Table & Related Information

Appendix A: Electrical Safety Standards & Regulations

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29 CFR 1910.301: Electrical, General, Introduction
https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.301

29 CFR 1910.302 – 29 CFR 1910.308: Design Safety Standards for Electrical Systems
https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.302
https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.303
https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.304
https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.305
https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.306
https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.307
https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.308

29 CFR 1910.331 – 29 CFR 1910.335: Safety-Related Work Practices
https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.331
https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.332
https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.333
https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.334
https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.335

29 CFR 1910.399: Definitions Applicable to this Subpart
https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.399

29 CFR 1910 Subpart S Appendix A: Reference Documents
https://www.ecfr.gov/current/title-29/subtitle-B/chapter-XVII/part-1910/subpart-S/appendix-Appendix%20A%20to%20Subpart%20S%20of%20Part%201910