NFPA 70E

Standard for Electrical Safety Requirements for Employee Workplaces

2000 Edition

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An International Codes and Standards Organization

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This edition of NFPA 70E, *Standard for Electrical Safety Requirements for Employee Workplaces*, was prepared by the Technical Committee on *Electrical Safety Requirements for Employee Workplaces*, and acted on by the National Fire Protection Association, Inc., at its November Meeting held November 14–17, 1999, in New Orleans, LA. It was issued by the Standards Council on January 14, 2000, with an effective date of February 11, 2000, and supersedes all previous editions.

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This list represents the membership at the time the Committee was balloted on the final text of this edition. Since that time, changes in the membership may have occurred. A key to classifications is found at the back of the document.

NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

Committee Scope: This Committee shall have primary responsibility for documents on electrical safety requirements to provide a practical safe working area for employees in their pursuit of gainful employment relative to the hazards arising from the use of electricity, as covered in the scope of NFPA 70, *National Electrical Code*. This Committee shall have primary jurisdiction but shall report to the Association through the National Electrical Code Technical Correlating Committee.

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NOTICE: Information on referenced publications can be found in Appendix B.

Changes other than editorial are indicated by a vertical rule in the margin of the pages on which they appear. These lines are included as an aid to the user in identifying changes from the previous edition. Where one or more complete paragraph(s) has been deleted, the deletion is indicated by a bullet in the margin between the paragraphs that remain.

Foreword to NFPA 70E

The Standards Council of the National Fire Protection Association, Inc. (NFPA) announced on January 7, 1976, the formal appointment of a new electrical standards development committee. Entitled the Committee on Electrical Safety Requirements for Employee Workplaces, NFPA 70E, this new committee reported to the Association through the Electrical Correlating Committee of the *National Electrical Code® (NEC®)* Committee. This committee was formed to assist OSHA in preparing electrical safety standards that would serve OSHA's needs and that could be expeditiously promulgated through the provisions of Section 6(b) of the Occupational Safety and Health Act. OSHA found that in attempting to utilize the latest edition of NFPA 70, *National Electrical Code (NEC)*, it was confronted with the following problem areas:

(1) Updating to a new edition of the *NEC* would have to be through the OSHA 6(b) procedures. OSHA adopted the 1968 and then the 1971 *NEC* under Section 6(a) procedures of the Occupational Safety and Health Act of 1970. Today, however, OSHA can only adopt or modify a standard by the procedures of Section 6(b) of the OSHA Act, which provide for public notice, opportunity for public comment, and public hearings. The adoption of a new edition of the *NEC* by these procedures would require extensive effort and application of resources by OSHA and others. Even so, going through the "6(b)" procedures might result in requirements substantially different than those of the *NEC*, thereby creating the problem of conflict between the OSHA standard and other national and local standards.

(2) The *NEC* is intended for use primarily by those who design, install, and inspect electrical installations. OSHA's electrical regulations address the employer and employee in their workplace. The technical content and complexity of the *NEC* is extremely difficult for the average employer and employee to understand.

(3) Some of the detailed provisions within the *NEC* are not directly related to employee safety and therefore are of little value for OSHA's needs.

(4) Requirements for electrical safety-related work practices and maintenance of the electrical system considered critical to safety are not found in the *NEC*, which is essentially an electrical installation document. However, OSHA must also consider and develop these safety areas in its regulations.

With these problem areas, it became apparent that a need existed for a new standard, tailored to fulfill OSHA's responsibilities, that would still be fully consistent with the *NEC*.

This led to the concept that a document be put together by a competent group, representing all interests, that would extract suitable portions from the *NEC* and from other documents applicable to electrical safety. This concept and an offer of assistance was submitted in May, 1975, to the Assistant Secretary of Labor for OSHA, who said, "The concept, procedures, and scope of the effort discussed with my staff for preparing the subject standard appear to have great merit, and an apparent need exists for this proposed consensus document which OSHA could consider for promulgation under the provisions of Section 6(b) of the Act. OSHA does have an interest in this effort and believes the proposed standard would serve a useful purpose." With this positive encouragement from OSHA, a proposal to prepare such a document was presented to the NFPA Electrical Section, which unanimously supported a recommendation that the *NEC* Correlating Committee examine the feasibility of developing a document to be used as a basis for evaluating electrical safety in the workplace. In keeping with the recommendation of the Electrical Section and Correlating Committee, the Standards Council authorized the establishment of a committee to carry out this examination.

The committee found it feasible to develop a standard for electrical installations that would be compatible with the OSHA requirements for safety for the employee in locations covered by the *NEC*. The new standard was visualized as consisting of four major parts: Part I, Installation Safety Requirements; Part II, Safety-Related Work Practices; Part III, Safety-Related Maintenance Requirements; and Part IV, Safety Requirements for Special Equipment. Although desirable, it was not considered essential for all of the parts to be completed before the standard was published and made available. Each part is recognized as being an important aspect of electrical safety in the workplace, but the parts are sufficiently independent of each other to permit their separate publication. The new standard was named NFPA 70E, *Standard for Electrical Safety Requirements for Employee Workplaces*. The first edition was published in 1979 and included only Part I.

The second edition was published in 1981. It included Part I as originally published and a new Part II. In 1983, the third edition included Part I and Part II as originally published and a new Part III. In 1988, the fourth edition was published with only minor revisions.

The fifth edition was published in 1995. It included major revisions to Part I, updating it to the 1993, *National Electrical Code (NEC)*. In Part II of the fifth edition, the concepts of "limits of approach" and establishment of a "flash protection boundary" were introduced. In 2000, this sixth edition includes a complete Part I update to the 1999 *NEC*, as well as a new Part IV. Part II continues to focus on establishing flash protection boundaries and the use of personal protective equipment. Also, added to Part II for 2000 are charts to assist the user in applying appropriate protective clothing and personal protective equipment for common tasks.

Essential to the proper use of Part I of this standard is the understanding that it is not intended to be applied as a design, installation, modification, or construction standard for an electrical installation or system. Its content has been intentionally limited in comparison to the content of the *NEC* in order to apply to an electrical installation or system as part of an employee's workplace. This standard is compatible with corresponding provisions of the *NEC*, but is not intended to, nor can it, be used in lieu of the *NEC*.

It can be debated that all of the requirements of the *NEC*, when traced through a chain of events, may relate to an electrical hazard, but, for practical purposes, inclusion has not been made of those provisions that, in general, are not directly associated with employee safety. In determining what provisions should be included in Part I, the following guidelines were used:

(1) Its provisions should give protection to the employee from electrical hazards.

(2) Its provisions should be excerpted from the *NEC* in a manner that will maintain their intent as they apply to employee safety. In some cases it has been judged essential to the meaning of the excerpted passages to retain some material not applying to employee safety.

(3) The provisions should be selected in a manner that will reduce the need for frequent revision, yet avoid technical obsolescence.

(4) Compliance with the provisions should be determined by means of an inspection during the normal state of employee occupancy without removal of parts requiring shutdown of the electrical installation or by damaging the building structure or finish.

(5) The provisions should not be encumbered with unnecessary details.

(6) The provisions should be written to enhance their understanding by the employer and employee.

(7) The provisions must not add any requirements not found in the *NEC*, nor must the intent of the *NEC* be changed if the wording is changed.

Part I of NFPA 70E is therefore intended to serve a very specific need of OSHA and is in no way intended to be used as a substitute for the *NEC*. Omission of any requirements presently in the *NEC* does not in any way affect the *NEC*, nor should these omitted requirements be considered as unimportant. They are essential to the *NEC* and its intended application, that is, its use by those who design, install, and inspect electrical installations. NFPA 70E, on the other hand, is intended for use by employers, employees, and OSHA.

Introduction

I-1 Scope.

I-1.1 This standard addresses those electrical safety requirements for employee workplaces that are necessary for the practical safeguarding of employees in their pursuit of gainful employment. This standard covers the following:

(1) Electric conductors and equipment installed within or on buildings or other structures, including mobile homes and recreational vehicles, and other premises such as yards, carnival, parking and other lots, and industrial substations
(2) Conductors that connect the installations to a supply of electricity
(3) Other outside conductors on the premises

I-1.2 This standard does not cover the following:

(1) Installations in ships, watercraft, railway rolling stock, aircraft, or automotive vehicles other than mobile homes and recreational vehicles
(2) Installations underground in mines
(3) Installations of railways for generation, transformation, transmission, or distribution of power used exclusively for operation of rolling stock or installations used exclusively for signaling and communication purposes
(4) Installation of communication equipment under the exclusive control of communication utilities, located outdoors or in building spaces used exclusively for such installations
(5) Installations under the exclusive control of electric utilities for the purpose of communication or metering; or for the generation, control, transformation, transmission, and distribution of electric energy located in buildings used exclusively by utilities for such purposes or located outdoors on property owned or leased by the utility or on public highways, streets, roads, and so forth, or outdoors by established rights on private property

I-1.3 This standard is divided into the following four parts and two appendixes:

Part I, Installation Safety Requirements

Part II, Safety-Related Work Practices

Part III, Safety-Related Maintenance Requirements

Part IV, Safety Requirements for Special Equipment

Appendix A, Tables, Notes, and Charts [Reserved]

Appendix B, Referenced Publications

I-2 Definitions.

I-2.1 General. Definitions apply wherever the terms are used throughout this standard.

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.

Accessible. (as applied to equipment.) Admitting close approach; not guarded by locked doors, elevation, or other effective means.

Accessible, Readily (Readily Accessible). Capable of being reached quickly for operation, renewal, or inspections, without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, etc.

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

Appliance. 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 such as clothes washing, air conditioning, food mixing, deep frying, etc.

Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

Armored Cable. Type AC armored cable is 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 on 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 Hand Work. A technique of performing work on live parts, after the employee has been raised to the potential of the live part.

Barricade. A physical obstruction such as tapes, cones, or A-frame-type wood or metal structures intended to provide a warning about and to limit access to a hazardous area.

Barrier. A physical obstruction 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 will ensure electrical continuity and the capacity to conduct safely any current likely to be imposed.

Bonding Jumper. A reliable conductor to ensure the required 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 outlet(s).

Building. A structure that stands alone or that 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 mounting or flush mounting and is 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.

Cablebus. Cablebus is an assembly of insulated conductors with fittings and conductor terminations in a completely enclosed, ventilated protective metal housing. Cablebus is ordinarily assembled at the point of installation from the components furnished or specified by the manufacturer in accordance with instructions for the specific job. This assembly is designed to carry fault current and to withstand the magnetic forces of such current.

Center Pivot Irrigation Machine. A multimotored irrigation machine that revolves around a central pivot and employs alignment switches or similar devices to control individual motors.

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, Class II, and Class III Locations. (For Class I, Class II, and Class III, Divisions 1 and 2, see Part I, Chapter 5.) (For Class I, Zones 0, 1, and 2, see Part I, Chapter 5.)

Collector Rings. An assembly of slip rings for transferring electrical energy from a stationary to a rotating member.

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.

Conductive. Suitable for carrying electric current.

Conductor:

Bare. A conductor having no covering or electrical insulation whatsoever.

Covered. A conductor encased within material of composition or thickness that is not recognized by this standard as electrical insulation.

Insulated. A conductor encased within material of composition and thickness that is recognized by this standard as electrical insulation.

Conduit Body. A separate portion of a conduit or tubing system that provides access through a removable cover(s) 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.

Cooking Unit, Counter-Mounted. A cooking appliance designed for mounting in or on a counter and consisting of one or more heating elements, internal wiring, and built-in or separately mountable controls.

Cutout Box. An enclosure designed for surface mounting that has swinging doors or covers secured directly to and telescoping with the walls of the box proper.

Dead Front. Without live parts exposed to a person on the operating side of the equipment.

Deenergized. 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.

Electric Sign. A fixed, stationary, or portable self-contained, electrically illuminated utilization equipment with words or symbols designed to convey information or attract attention.

Electrical Hazard. A dangerous condition such that contact or equipment failure can result in electric shock, arc flash burn, thermal burn, or blast.

Electrical Safety. Recognizing hazards associated with the use of electrical energy and taking precautions so that hazards do not cause injury or death.

Electrical Single-Line Diagram. A diagram that shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used in the circuit or system.

Electrically Safe Work Condition. A state in which the conductor or circuit part to be worked on or near has been disconnected from energized parts, locked/tagged in accordance with established standards, tested to ensure the absence of voltage, and grounded if determined necessary.

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.

Explosionproof 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 a surrounding flammable atmosphere will not be ignited thereby.

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 that are not suitably guarded, isolated, or insulated.

Exposed. (as applied to wiring methods.) On or attached to the surface or behind panels designed to allow access.

Exposed. For the purposes of Part I, Chapter 6, the word "exposed" means that 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 separately 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.

Flash Hazard. A dangerous condition associated with the release of energy caused by an electric arc.

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

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

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

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.

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 circuit 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 de-energize a circuit or portion thereof 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 or contact by persons or objects to a point of danger.

Health Care Facilities. Buildings or portions of buildings that contain, but are not limited to, occupancies such as hospitals; nursing homes; limited care; supervisory care; clinics; medical and dental offices; and ambulatory care, whether permanent or movable.

Heating Equipment. For the purposes of Part I, Chapter 4, the term includes any equipment used for heating purposes whose heat is generated by induction or dielectric methods.

Hoistway. Any shaftway, hatchway, well hole, or other vertical opening or space in which an elevator or dumbwaiter is designed to operate.

Identified. (as applied to equipment.) Recognizable as suitable for the specific purpose, function, use, environment, application, etc., where described in a particular code or standard requirement.

NOTE: Suitability of equipment for a specific purpose, environment, or application may be determined by a qualified testing laboratory, inspection agency, or other organization concerned with product evaluation. Such identification may include labeleling or listing. (See definition of *Labeled* and *Listed*.)

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.

NOTE: When an object is said to be insulated, it is understood to be insulated for the conditions to which it is normally subject. Otherwise, it is, within the purpose of these rules, uninsulated.

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 or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance 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.

Limited Approach Boundary. A shock protection boundary to be crossed by only qualified persons (at a distance from a live part) which is not to be crossed by unqualified persons unless escorted by a qualified person.

Listed. Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

Live Parts. Electric conductors, buses, terminals, or components that are uninsulated or exposed and a shock hazard exists.

Location.

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.

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.

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 exposed to weather and unprotected.

Medium Voltage Cable. Type MV cable is a single or multiconductor solid dielectric insulated cable rated 2001 volts or higher.

Metal-Clad Cable. Type MC cable is 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, 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 and/or casters 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. Nonmetallic-sheathed cable is a factory assembly of two or more insulated conductors having an outer sheath of moisture-resistant, flame-retardant, nonmetallic material.

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 of 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.

Oven, Wall-Mounted. An oven for cooking purposes and consisting of one or more heating elements, internal wiring, and built-in or separately mountable controls.

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.

NOTE: A current in excess of rating may be accommodated by certain equipment and conductors for a given set of conditions. Therefore the rules for overcurrent protection are specific for particular situations.

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.

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 equipped 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.

Permanently Installed Decorative Fountains and Reflection Pools. Those that are constructed in the ground, on the ground, or in a building in such a manner that the fountain 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. Those that are constructed in the ground or partially in the ground, and all other capable of holding water in a depth greater than 42 in. (1.07 m), and all pools installed inside of a building, regardless of water depth, whether or not served by electrical circuits of any nature.

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

Power and Control Tray Cable. Type TC power and control tray cable is a factory assembly of two or more insulated conductors, with or without associated bare or covered grounding

conductors under a nonmetallic sheath, for installation in cable trays, in raceways, or where supported by a messenger wire.

Power-Limited Tray Cable. Type PLTC nonmetallic-sheathed cable is a factory assembly of two or more insulated conductors under a nonmetallic jacket.

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

Premises Wiring (System). That 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 outlet(s). Such wiring does not include wiring internal to appliances, fixtures, motors, controllers, motor control centers, and similar equipment.

Prohibited Approach Boundary. A shock protection boundary to be crossed by only qualified persons (at a distance from a live part) which, when crossed by a body part or object, requires the same protection as if direct contact is made with a live part.

Qualified Person. One familiar with the construction and operation of the equipment and the hazards involved.

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.

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.

Restricted Approach Boundary. A shock protection boundary to be crossed by only qualified persons (at a distance from a live part) which, due to its proximity to a shock hazard, requires the use of shock protection techniques and equipment when crossed.

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. Service-entrance cable is 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
(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.

NOTE: Where service equipment is located outside the building walls, there may be no service-entrance conductors, or they may be entirely outside the building.

Service Equipment. The necessary equipment, usually consisting of a circuit breaker(s) or switch(es) and fuse(s), 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.

Shock Hazard. A dangerous condition associated with the possible release of energy caused by contact or approach to live parts.

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.

Special Permission. The written consent of the authority having jurisdiction.

Step Potential. A ground potential gradient difference that can cause current flow from foot to foot through the body.

Storable Swimming or Wading Pool. Those that are constructed on or above the ground and are capable of holding water to a maximum depth of 42 in. (1.07 m), or a pool with nonmetallic, molded polymeric walls or inflatable fabric walls regardless of dimension.

Switches.

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 standard.

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.

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.

Motor-Circuit Switch. A switch rated in horsepower that is capable of interrupting the maximum operating overload current of a motor of the same horsepower rating as the switch at the rated voltage.

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.

Touch Potential. A ground potential gradient difference that can cause current flow from hand to hand or hand to foot through the body.

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

Unqualified Person. A person who is not a qualified person.

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 40 psia (276 kPa) at 38°C (100°F) 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.

NOTE: Some systems, such as 3-phase 4-wire, single-phase 3-wire, and 3-wire direct-current may have various circuits of various voltages.

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. Constructed so that moisture will not enter the enclosure under specified test conditions.

Weatherproof. Constructed or protected so that exposure to the weather will not interfere with successful operation.

NOTE: 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. Wireways are 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.

Working Near (live parts). Any activity inside a limited approach boundary.

Working On (live parts). Coming in contact with live parts with the hands, feet, or other body parts, with tools, probes, or with test equipment, regardless of the personal protective equipment a person is wearing.

I-2.2 Over 600 Volts, Nominal. Whereas the preceding definitions are intended to apply wherever the terms are used throughout this standard, the following definitions are applicable only to the parts of this standard that specifically cover installations and equipment operating at over 600 volts, nominal.

Fuse. An overcurrent protective device with a circuit-opening fusible part that is heated and severed by the passage of overcurrent through it.

NOTE: 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.

Switching Device. A device designed to close, open, or both, one or more electric circuits.

Switching Devices.

Circuit Breaker. A switching device capable of making, carrying, and breaking currents under normal circuit conditions, and also making, carrying for a specified time, and breaking currents under specified abnormal circuit conditions, such as those of short circuit.

Cutout. 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.

Disconnecting (or Isolating) Switch (Disconnector, Isolator). A mechanical switching device used for isolating a circuit or equipment from a source of power.

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

Interrupter Switch. A switch capable of making, carrying, and interrupting specified currents.

Oil Cutout (Oil-Filled Cutout). A cutout in which all or part of the fuse support and its fuse link or disconnecting blade is 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.

Oil Switch. A switch having contacts that operate under oil (or askarel or other suitable liquid).

Part I INSTALLATION SAFETY REQUIREMENTS

Chapter 1 General Requirements for Electrical Installations

1-1 General.

1-1.1 The requirements contained in Part I shall be based on the provisions of NFPA 70, *National Electrical Code*. Where installations of electric conductors and equipment have been found to conform with the safety requirements of the *National Electrical Code* in use at the time of installation by governmental bodies or agencies having legal jurisdiction for enforcement of the *National Electrical Code*, this conformance shall be prima facie evidence that such installations were adequately designed and installed.

1-1.2 Part I of this standard is divided into six chapters. Chapters 1, 2, and 3 apply generally. Chapter 4 applies to specific purpose equipment installations. Chapters 5 and 6 apply to hazardous (classified) locations and special systems. Chapters 4, 5, and 6 supplement or modify the general rules. Section 6-5 of Chapter 6 covers communications systems and is independent of the other paragraphs and chapters except where specifically referenced. Chapters 1, 2, and 3 apply except as amended by Chapters 4, 5, and 6 for the particular condition.

1-2 Approval. The conductors and equipment required or permitted by this standard shall be acceptable only if approved.

NOTE: See definitions of "Approved," "Identified," "Labeled," and "Listed" in I-2.1 of the introduction.

1-3 Examination, Identification, Installation, and Use of Equipment.

1-3.1 Examination. In judging equipment, considerations such as the following shall be evaluated:

(1) Suitability for installation and use in conformity with the provisions of this standard

NOTE: Suitability of equipment use may be identified by a description marked on or provided with a product to identify the suitability of the product for a specific purpose, environment, or application. Suitability of equipment may be evidenced by listing or labeling.

(2) Mechanical strength and durability, including, for parts designed to enclose and protect other equipment, the adequacy of the protection thus provided
(3) Wire-bending and connection space
(4) Electrical insulation
(5) Heating effects under normal conditions of use and also under abnormal conditions likely to arise in service
(6) Arcing effects
(7) Classification by type, size, voltage, current capacity, and specific use
(8) Other factors that contribute to the practical safeguarding of persons using or likely to come in contact with the equipment

1-3.2 Installation and Use. Listed or labeled equipment shall be installed and used in accordance with any instructions included in the listing or labeling.

1-3.3 Insulation Integrity. Completed wiring installations shall be free from short circuits and from grounds other than as required or permitted in conformity with this standard.

1-3.4 Interrupting Rating. Equipment intended to interrupt current at fault levels shall have an interrupting rating sufficient for the nominal circuit voltage and the current that is available at the line terminals of the equipment.

Equipment intended to interrupt current at other than fault levels shall have an interrupting rating at nominal circuit voltage sufficient for the current that must be interrupted.

1-3.5 Circuit Impedance and Other Characteristics. The overcurrent protective devices, the total impedance, the component short-circuit current ratings, and other characteristics of the circuit to be protected shall be selected and coordinated to permit the circuit-protective devices used to clear a fault to do so without extensive damage to the electrical components of the circuit. This fault shall be assumed to be either between two or more of the circuit conductors, or between any circuit conductor and the grounding conductor or enclosing metal raceway. Listed products applied in accordance with their listing shall be considered to meet the requirements of this section.

1-3.6 Deteriorating Agents. Unless identified for use in the operating environment, no conductors or equipment shall be located in damp or wet locations; where exposed to gases, fumes, vapors, liquids, or other agents that have a deteriorating effect on the conductors or equipment; or where exposed to excessive temperatures.

NOTE 1: In general, areas where acids and alkali chemicals are handled and stored *may* present such corrosive conditions, particularly when wet or damp. Severe corrosive conditions *may* also be present in portions of meat-packing plants, tanneries, glue houses, and some stables; installations immediately adjacent to a seashore and swimming pool areas; areas where chemical deicers are used; and storage cellars or rooms for hides, casings, fertilizer, salt, and bulk chemicals.

NOTE 2: Some cleaning and lubricating compounds can cause severe deterioration of many plastic materials used for insulating and structural applications in equipment.

Equipment identified only as "dry locations," "Type 1," or "indoor use only" shall be protected against permanent damage from the weather during building construction.

1-3.7 Mechanical Execution of Work. Electric equipment shall be installed in a neat and workmanlike manner.

1-3.7.1 Unused Openings. Unused openings in boxes, raceways, auxiliary gutters, cabinets, equipment cases, or housings shall be effectively closed to afford protection substantially equivalent to the wall of the equipment.

1-3.7.2 Subsurface Enclosures. Conductors shall be racked to provide ready and safe access in underground and subsurface enclosures, into which persons enter for installation and maintenance.

1-3.7.3 Integrity of Electrical Equipment and Connections. Internal parts of electrical equipment, including busbars, wiring terminals, insulators, and other surfaces shall not be damaged or contaminated by foreign materials such as paint, plaster, cleaners, abrasives, or corrosive residues. There

shall be no damaged parts that may adversely affect safe operation or mechanical strength of the equipment such as parts that are broken; bent; cut; or deteriorated by corrosion, chemical action, or overheating.

1-3.8 Mounting and Cooling of Equipment.

1-3.8.1 Mounting. Electric equipment shall be firmly secured to the surface on which it is mounted. Wooden plugs driven into holes in masonry, concrete, plaster, or similar materials shall not be used.

1-3.8.2 Cooling. Electrical equipment that depends on the natural circulation of air and convection principles for cooling of exposed surfaces shall be installed so that room airflow over such surfaces is not prevented by walls or by adjacent installed equipment. For equipment designed for floor mounting, clearance between top surfaces and adjacent surfaces shall be provided to dissipate rising warm air.

Electrical equipment provided with ventilating openings shall be installed so that walls or other obstructions do not prevent the free circulation of air through the equipment.

1-4 Electrical Connections. Because of different characteristics of dissimilar metals, devices such as pressure terminal or pressure splicing connectors and soldering lugs shall be identified for the material of the conductor and shall be properly installed and used. Conductors of dissimilar metals shall not be intermixed in a terminal or splicing connector where physical contact occurs between dissimilar conductors (such as copper and aluminum, copper and copper-clad aluminum, or aluminum and copper-clad aluminum), unless the device is identified for the purpose and conditions of use. Materials such as solder, fluxes, inhibitors, and compounds, where employed, shall be suitable for the use and shall be of a type that will not adversely affect the conductors, installation, or equipment.

NOTE: Many terminations and equipment are marked with a tightening torque.

1-4.1 Terminals. Connection of conductors to terminal parts shall ensure a thoroughly good connection without damaging the conductors and shall be made by means of pressure connectors (including set-screw type), solder lugs, or splices to flexible leads. Connection by means of wire bending screws or studs and nuts having upturned lugs or equivalent shall be permitted for No. 10 or smaller conductors.

Terminals for more than one conductor and terminals used to connect aluminum shall be so identified.

1-4.2 Splices. Conductors shall be spliced or joined with splicing devices identified for the use or by brazing, welding, or soldering with a fusible metal or alloy. Soldered splices shall first be spliced or joined so as to be mechanically and electrically secure without solder and then soldered. All splices and joints and the free ends of conductors shall be covered with an insulation equivalent to that of the conductors or with an insulating device identified for the purpose.

Wire connectors or splicing means installed on conductors for direct burial shall be listed for such use.

1-5 Arcing Parts. Parts of electric equipment, which in ordinary operation produce arcs, sparks, flames, or molten metal, shall be enclosed or separated and isolated from all combustible material.

1-6 Marking. The manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the product can be identified shall be placed on all electric equipment. Other markings that indicate voltage, current, wattage, or other ratings shall be provided as specified elsewhere in this standard. The marking shall be of sufficient durability to withstand the environment involved.

1-7 Identification of Disconnecting Means. Each disconnecting means required by this standard for motors and appliances, and each service, feeder, or branch circuit at the point where it originates, shall be legibly marked to indicate its purpose unless located and arranged so the purpose is evident. The marking shall be of sufficient durability to withstand the environment involved.

Where circuit breakers or fuses are applied in compliance with the series combination ratings marked on the equipment by the manufacturer, the equipment enclosure(s) shall be legibly marked in the field to indicate the equipment has been applied with a series combination rating. The marking shall be readily visible and state "Caution – Series Combination System Rated _____ Amperes Identified Replacement Components Required."

1-8 600 Volts, Nominal, or Less.

1-8.1 Spaces about Electrical Equipment. Sufficient access and working space shall be provided and maintained about all electric equipment to permit ready and safe operation and maintenance of such equipment. Enclosures having electrical apparatus that are controlled by lock and key shall be considered accessible to qualified persons.

1-8.1.1 Working Space. Working space for equipment operating at 600 volts, nominal, or less to ground and likely to require examination, adjustment, servicing, or maintenance while energized shall comply with the dimensions of 1-8.1.1.1, 1-8.1.1.2, and 1-8.1.1.3 or as required or permitted elsewhere in this standard.

1-8.1.1.1 Depth of Working Space. The depth of the working space in the direction of access to live parts shall not be less than indicated in Table 1-8.1.1. Distances shall be measured from the live parts if such are exposed or from the enclosure front or opening is such are enclosed.

Table 1-8.1.1 Working Spaces

Nominal Voltage to Ground	Minimum Clear Distance (ft)		
	Condition 1	Condition 2	Condition 3
0 – 150	3	3	3
151 – 600	3	$3^1/_2$	4

Notes:
1. For SI units: 1 in. = 25.4 mm; 1 ft = 0.3048 m.
2. Where the conditions are as follows:
Condition 1 — Exposed live parts on one side and no live or grounded parts on the other side of the working space, or exposed live parts on both sides effectively guarded by suitable wood or other insulating materials. Insulated wire or insulated busbars operating at not over 300 volts shall not be considered live parts.
Condition 2 — Exposed live parts on one side and grounded parts on the other side. Concrete, brick, or tile walls will be considered as grounded surfaces.
Condition 3 — Exposed live parts on both sides of the work space (not guarded as provided in Condition 1) with the operator between.

Exception No. 1: Working space shall not be required in back or sides of assemblies, such as dead-front switchboards or motor control centers, where there are no renewable or adjustable parts, such as fuses or switches, on the back or sides and where all connections are accessible from locations other than the back or sides. Where rear access is required to work on de-energized parts on the back of enclosed equipment, a minimum working space of 30 in. (762 mm) horizontally shall be provided.

Exception No. 2: By special permission, smaller spaces shall be permitted where all uninsulated parts are at a voltage no greater than 30 volts RMS, 42 volts peak, or 60 volts dc.

Exception No. 3: In existing buildings where electrical equipment is being replaced, Condition 2 working clearance shall be permitted between dead-front switchboards, panelboards, or motor control centers located across the aisle from each other where conditions of maintenance and supervision ensure that written procedures have been adopted to prohibit equipment on both sides of the aisle from being open at the same time and qualified persons who are authorized will service the installation.

1-8.1.1.2 Width of Working Space. The width of the working space in front of the electrical equipment shall be the width of the equipment or 30 in. (762 mm), whichever is greater. In all cases, the work space shall permit at least a 90 degree opening of equipment doors or hinged panels.

1-8.1.1.3 Height of Working Space. The work space shall be clear and extend from the grade, floor, or platform to the height required by 1-8.1.5. Within the height requirements of this section, other equipment associated with the electrical installation located above or below the electrical equipment shall be permitted to extend not more than 6 in. (153 mm) beyond the front of the electrical equipment.

1-8.1.2 Clear Spaces. Working space required by this standard 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.

1-8.1.3 Access and Entrance to Working Space. At least one entrance of sufficient area shall be provided to give access to the working space about electric equipment.

For equipment rated 1200 amperes or more and over 6 ft (1.83 m) wide, containing overcurrent devices, switching devices, or control devices, there shall be one entrance not less than 24 in. (610 mm) wide and $6^1/_2$ ft (1.98 m) high at each end of the working space.

Exception No. 1: Where the location permits a continuous and unobstructed way of exit travel, one means of access shall be permitted.

Exception No. 2: Where the work space required by 1-8.1.1 is doubled, only one entrance to the working space is required. It shall be located so that the edge of the entrance nearest the equipment is the minimum clear distance given in Table 1-8.1.1 away from such equipment.

1-8.1.4 Illumination. Illumination shall be provided for all working spaces about service equipment, switchboards, panelboards, or motor control centers installed indoors. Additional lighting fixtures shall not be required where the work space is illuminated by an adjacent light source. In electrical equipment rooms, the illumination shall not be controlled by automatic means only.

1-8.1.5 Headroom. The minimum headroom of working spaces about service equipment, switchboards, panelboards, or motor control centers shall be $6^1/_2$ ft (1.98 m) Where the electrical equipment exceeds $6^1/_2$ ft (1.98 m) in height, the minimum headroom shall not be less than the height of the equipment.

1-8.1.6 Dedicated Equipment Space. Switchboards, panelboards, and distribution boards installed for the control of light and power circuits, battery-charging panels supplied from light or power circuits, and motor control centers shall be located in dedicated spaces and protected from damage as covered in 1-8.1.6.1 and 1-8.1.6.2.

Exception: Control equipment that by its very nature or because of other rules of the standard must be adjacent to or within sight of its operating machinery shall be permitted in those locations.

1-8.1.6.1 Indoor. For indoor installation, the dedicated space shall comply with the following.

(a) **Dedicated Equipment Space.** The space equal to the width and depth of the equipment and extending from the floor to a height of 6 ft (1.83 m) above the equipment or to the structural ceiling, whichever is lower, shall be dedicated to the electrical installation. No piping, ducts, or equipment foreign to the electrical installation shall be located in this zone.

Exception: Equipment that is isolated from the foreign equipment by height or physical enclosures or covers that will afford adequate mechanical protection from vehicular traffic or accidental contact by unauthorized personnel or that complies with 1-8.1.6.1(b) shall be permitted in areas that do not have the dedicated space described in this rule.

(b) **Foreign Systems.** The space equal to the width and depth of the equipment shall be kept clear of foreign systems unless protection is provided to avoid damage from condensation, leaks, or breaks in such foreign systems. This zone shall extend from the top of the electrical equipment to the structural ceiling.

(c) **Sprinkler Protection.** Sprinkler protection shall be permitted for the dedicated space where the piping complies with this section.

(d) **Suspended Ceilings.** A dropped, suspended, or similar ceiling that does not add strength to the building structure shall not be considered a structural ceiling.

1-8.1.6.2 Outdoor. Outdoor electrical equipment shall be installed in suitable enclosures and shall be protected from accidental contact by unauthorized personnel, or by vehicular traffic, or by accidental spillage or leakage from piping systems. The working clearance space shall include the zone described in 1-8.1.1. No architectural appurtenance or other equipment shall be located in this zone.

1-8.2 Guarding of Live Parts.

1-8.2.1 Live Parts Guarded Against Accidental Contact. Except as elsewhere required or permitted by this standard, live parts of electric equipment operating at 50 volts or more shall be guarded against accidental contact by 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 arranged so that only qualified persons will have access to the space within reach of the live parts. Any openings in such partitions or screens shall be sized and located so that persons 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 elevated and arranged so as to exclude unqualified persons

(d) By elevation of 8 ft (2.44 m) or more above the floor or other working surface

1-8.2.2 Prevent Physical Damage. In locations where electric equipment is likely to be exposed to physical damage, enclosures or guards shall be so arranged and of such strength as to prevent such damage.

1-8.2.3 Warning Signs. Entrances to rooms and other guarded locations that contain exposed live parts shall be marked with conspicuous warning signs forbidding unqualified persons to enter.

1-9 Over 600 Volts, Nominal.

1-9.1 General. Conductors and equipment used on circuits over 600 volts, nominal, shall comply with Section 1-1 of this standard and with the following sections, which supplement or modify Section 1-1. In no case shall the provisions of 1-9.2, 1-9.3, and 1-9.4 apply to equipment on the supply side of the service point.

1-9.2 Enclosure for Electrical Installations. Electrical installations in a vault, room, or closet or in an area surrounded by a wall, screen, or fence, access to which is controlled by lock and key or other approved means, shall be considered to be accessible to qualified persons only. The type of enclosure used in a given case shall be designed and constructed according to the hazard(s) associated with the installation.

For installations other than equipment as described in 1-9.2.3, a wall, screen, or fence shall be used to enclose an outdoor electrical installation to deter access by persons who are not qualified. A fence shall not be less than 7 ft (2.13 m) in height or a combination of 6 ft (1.80 m) or more of fence fabric and a 1 ft (5 mm) or more extension utilizing three or more strands of barbed wire or equivalent.

1-9.2.1 Indoor Installations

1-9.2.1.1 In Places Accessible to Unqualified Persons. Indoor electrical installations that are open to unqualified persons shall be made with metal-enclosed equipment or shall be enclosed in a vault or in an area to which access is controlled by a lock. Metal-enclosed switchgear, unit substations, transformers, pull boxes, connection boxes, and other similar associated equipment shall be marked with appropriate caution signs. Openings in ventilated dry-type transformers and similar openings in other equipment shall be designed so that foreign objects inserted through these openings will be deflected from energized parts.

1-9.2.1.2 In Places Accessible to Qualified Persons Only. Indoor electrical installations considered accessible only to qualified persons only in accordance with this section shall comply with 1-9.3 of Part I.

1-9.2.2 Outdoor Installations.

1-9.2.2.1 In Places Accessible to Unqualified Persons. Outdoor electrical installations that are open to unqualified persons shall comply with Part I, Section 2-3.

NOTE: For clearances of conductors for system voltages over 600 volts, nominal, see *National Electrical Safety Code*, ANSI C2-1997.

1-9.2.2.2 In Places Accessible to Qualified Persons Only. Outdoor electrical installations having exposed live parts shall be accessible to qualified persons only in accordance with the first paragraph of this section and shall comply with 1-9.3 of Part I.

1-9.2.3 Enclosed Equipment Accessible to Unqualified Persons. Ventilating or similar openings in equipment shall be designed so that foreign objects inserted through these openings will be deflected from energized parts. Where exposed to physical damage from vehicular traffic, suitable guards shall be provided. Nonmetallic or metal-enclosed equipment located outdoors and accessible to the general public shall be designed so that exposed nuts or bolts cannot be readily removed, permitting access to live parts. Where nonmetallic or metal-enclosed equipment is accessible to the general public and the bottom of the enclosure is less than 8 ft (2.44 m) above the floor or grade level, the enclosure door or hinged cover shall be kept locked. Doors and covers of enclosures used solely as pull boxes, splice boxes, or junction boxes shall be locked, bolted, or screwed on. Underground box covers that weigh over 100 lb (45.4 kg) shall be considered as meeting this requirement.

1-9.3 Work Space about Equipment. Sufficient space shall be provided and maintained about electric equipment to permit ready and safe operation and maintenance of such equipment. Where energized parts are exposed, the minimum clear work space shall not be less than $6^1/_2$ ft (1.98 m) high (measured vertically from the floor or platform), or less than 3 ft (914 mm) wide (measured parallel to the equipment). The depth shall be as required in 1-9.5.1 of Part I. In all cases, the work space shall be adequate to permit at least a 90-degree opening of doors or hinged panels.

1-9.4 Entrance and Access to Work Space.

1-9.4.1 Entrance. At least one entrance not less than 24 in. (610 mm) wide and $6^1/_2$ ft (1.98 m) high shall be provided to give access to the working space about electric equipment.

1-9.4.1.1 On switchboard and control panels exceeding 6 ft (1.83 m) in width, there shall be one entrance at each end of such boards unless the location of the switchboards and control panels permits a continuous and unobstructed way of exit travel, or unless the work space required in 1-9.5.1 of Part I is doubled.

1-9.4.1.2 Where one entrance to the working space is permitted under the conditions described in 1-9.4.1.1, the entrance shall be located so that the edge of the entrance nearest the switchboards and control panels is the minimum clear distance given in Table 1-9.5.1 away from such equipment.

1-9.4.1.3 Where bare energized parts at any voltage or insulated energized parts above 600 volts, nominal, to ground are located adjacent to such entrance, they shall be suitably guarded.

1-9.4.2 Access. Permanent ladders or stairways shall be provided to give safe access to the working space around electric equipment installed on platforms, balconies, mezzanine floors, or in attic or roof rooms or spaces.

1-9.5 Work Space and Guarding.

1-9.5.1 Working Space. Except as elsewhere required or permitted in this standard, the minimum clear working space in the direction of access to live parts of electrical equipment shall not be less than specified in Table 1-9.5.1. Distances shall be measured from the live parts, if such are exposed, or from the enclosure front or opening if such are enclosed.

Exception: Working space shall not be required in back of equipment such as dead-front switchboards or control assemblies where there are no renewable or adjustable parts (such as fuses or switches) on the back and where all connections are accessible from locations other than the back. Where rear access is required to work on the de-energized parts on the back of enclosed equipment, a minimum working space of 30 in. (762 mm) horizontally shall be provided.

Table 1-9.5.1 Minimum Depth of Clear Working Space at Electric Equipment

Nominal Voltage to Ground	Minimum Clear Distance (ft)		
	Condition 1	Condition 2	Condition 3
601 – 2500 V	3	4	5
2501 – 9000 V	4	5	6
9001 – 25,000 V	5	6	9
25,001 – 75 kV	6	8	10
Above 75 kV	8	10	12

Notes:
1. For SI units: 1 ft = 0.3048 m.
2. Where the conditions are as follows:

Condition 1 — Exposed live parts on one side and no live or grounded parts on the other side of the working space, or exposed live parts on both sides effectively guarded by suitable wood or other insulating materials. Insulated wire or insulated busbars operating at not over 300 volts shall not be considered live parts.

Condition 2 — Exposed live parts on one side and grounded parts on the other side. Concrete, brick, or tile walls will be considered as grounded surfaces.

Condition 3 — Exposed live parts on both sides of the work space (not guarded as provided in Condition 1) with the operator between.

1-9.5.2 Separation from Low-Voltage Equipment. Where switches, cutouts, or other equipment operating at 600 volts, nominal, or less, are installed in a room or enclosure where there are exposed live parts or exposed wiring operating at over 600 volts, nominal, the high-voltage equipment shall be effectively separated from the space occupied by the low-voltage equipment by a suitable partition, fence, or screen.

Exception: Switches or other equipment operating at 600 volts, nominal, or less, and serving only equipment within the high-voltage vault, room, or enclosure shall be permitted to be installed in the high-voltage enclosure, room, or vault if accessible to qualified persons only.

1-9.5.3 Locked Rooms or Enclosures. The entrances to all buildings, rooms, or enclosures containing exposed live parts or exposed conductors operating at over 600 volts, nominal, shall be kept locked unless such entrances are under the observation of a qualified person at all times.

Where the voltage exceeds 600 volts, nominal, permanent and conspicuous warning signs shall be provided, reading as follows: "DANGER — HIGH VOLTAGE — KEEP OUT."

1-9.5.4 Illumination. Illumination shall be provided for all working spaces about electric equipment. The lighting outlets shall be arranged so that persons changing lamps or making repairs on the lighting system will not be endangered by live parts or other equipment.

The points of control shall be located so that persons are not likely to come in contact with any live part or moving part of the equipment while turning on the lights.

1-9.5.5 Elevation of Unguarded Live Parts. Unguarded live parts above working space shall be maintained at elevations not less than required in Table 1-9.5.5.

Table 1-9.5.5 Elevation of Unguarded Live Parts Above Working Space

Nominal Voltage Between Phases	Elevation
601 – 7500 V	8 ft 6 in.
7501 – 35,000 V	9 ft
Over 35 kV	9 ft + 0.37 in./kV above 35

For SI units: 1 in. = 25.4 mm; 1 ft = 0.3048 m.

1-9.5.6 Protection of Service Equipment, Metal-Enclosed Power Switchgear, and Industrial Control Assemblies. Pipes of ducts foreign to the electrical installation that require periodic maintenance or whose malfunction would endanger the operation of the electrical system shall not be located in the vicinity of the service equipment, metal-enclosed power switchgear, or industrial control assemblies. Protection shall be provided where necessary to avoid damage from condensation leaks and breaks in such foreign systems. Piping and other facilities shall not be considered foreign if provided for fire protection of the electrical installation.

Chapter 2 Wiring Design and Protection

2-1 Use and Identification of Grounded and Grounding Conductors.

2-1.1 Identification of Conductors. A conductor used as a grounded conductor shall be identifiable and distinguishable from all other conductors. A conductor used as an equipment grounding conductor shall be identifiable and distinguishable from all other conductors.

2-1.2 Polarity of Connections. No grounded conductor shall be attached to any terminal or lead so as to reverse designated polarity.

2-2 Branch Circuits.

2-2.1 Identification of Multiwire Branch Circuits. Where more than one nominal voltage system exists in a building, each ungrounded conductor of a multiwire branch circuit, where accessible, shall be identified by phase and system.

The means of identification shall be permitted to be by separate color coding, marking tape, tagging, or other approved means and shall be permanently posted at each branch circuit panelboard.

2-2.2 Receptacles and Cord Connectors.

2-2.2.1 Grounding Type. Receptacles installed on 15- and 20-ampere branch circuits shall be of the grounding type. Grounding-type receptacles shall be installed only on circuits of the voltage class and current for which they are rated, except as provided in Tables 2-2.5(b)(2) and 2-2.5(b)(3).

Exception: Nongrounding-type receptacles installed in accordance with 2-2.2.4 of Part I.

2-2.2.2 To Be Grounded. Receptacles and cord connectors that have grounding contacts shall have those contacts effectively grounded.

Exception No. 1: Receptacles mounted on portable and vehicle-mounted generators in accordance with this standard.

Exception No. 2: Replacement receptacles as permitted by 2-2.2.4.

2-2.2.3 Methods of Grounding. The grounding contacts of receptacles and cord connectors shall be grounded by connection to the equipment grounding conductor of the circuit supplying the receptacle or cord connector.

The branch circuit wiring method shall include or provide an equipment grounding conductor to which the grounding contacts of the receptacle or cord connector shall be connected.

2-2.2.4 Replacements. Replacement of receptacles shall comply with 2-2.2.4.1, 2-2.2.4.2, and 2-2.2.4.3 as applicable.

2-2.2.4.1 Where a grounding means exists in the receptacle enclosure or a grounding conductor is installed, grounding-type receptacles shall be used and shall be connected to the grounding conductor.

2-2.2.4.2 Ground-fault circuit-interrupter protected receptacles shall be provided where replacements are made at receptacle outlets that are required to be so protected elsewhere in this standard.

2-2.2.4.3 Where a grounding means does not exist in the receptacle enclosure, the installation shall comply with the following (a), (b) or (c):

(a) A nongrounding-type receptacle(s) shall be permitted to be replaced with another nongrounding-type receptacle(s).

(b) A nongrounding-type receptacle(s) shall be permitted to be replaced with a ground-fault circuit-interrupter-type of receptacle(s). These receptacles shall be marked "No Equipment Ground." An equipment grounding conductor shall not be connected from the ground-fault circuit-interrupter-type receptacle to any outlet supplied from the ground-fault circuit-interrupter receptacle.

(c) A nongrounding-type receptacle(s) shall be permitted to be replaced with a grounding-type receptacle(s) where supplied through a ground-fault circuit-interrupter. Grounding-type receptacles supplied through the ground-fault circuit-interrupter shall be marked "GFCI Protected" and "No Equipment Ground." An equipment grounding conductor shall not be connected between the grounding-type receptacles.

2-2.2.5 Cord- and Plug-Connected Equipment. The installation of grounding-type receptacles shall not be used as a requirement that all cord- and plug-connected equipment be of the grounded type.

2-2.2.6 Noninterchangeable Types. Receptacles connected to circuits that have different voltages, frequencies, or types of current (ac or dc) on the same premises shall be of such design that the attachment plugs used on these circuits are not interchangeable.

2-2.3 Identification of Ungrounded Conductors. Where more than one nominal voltage system exists in a building, each ungrounded conductor of a multiwire branch circuit, where accessible, shall be identified by phase and system.

The means of identification shall be permanently posted at each branch-circuit panelboard.

NOTE: This means of identification shall be permitted to be by separate color coding, marking tape, tagging, or other approved means and shall be permanently posted at each branch circuit panelboard.

2-2.4 Ground-Fault Circuit-Interrupter Protection for Personnel.

2-2.4.1 Other than Dwelling Units. All 125-volt, single-phase, 15- and 20-ampere receptacles installed in the locations specified below shall have ground-fault circuit-interrupter protection for personnel.

(1) Bathrooms
(2) Rooftops

2-2.4.2 Ground-Fault Protection for Personnel. Ground-fault protection for personnel for all temporary wiring installations shall be provided to comply with 2-2.4.2.1 or 2-2.4.2.2. This section shall apply only to temporary wiring installations used to to supply temporary power to equipment used by personnel during construction, remodeling, maintenance, repair, or demolition of buildings, structures, equipment or similar activities.

2-2.4.2.1 Receptacle Outlets. All 125-volt, single-phase, 15- and 20- and 30-ampere receptacle outlets that are not a part of the permanent wiring of the building or structure and that are in use by personnel shall have ground-fault circuit-interrupter protection for personnel. If a receptacle(s) is installed or exists as part of the permanent wiring of the building or structure and is used for temporary electric power, ground-fault circuit-interrupter protection for personnel shall be provided. For the purposes of this section, cord sets or devices incorporating listed ground-fault circuit-interrupter protection for personnel identified for portable use shall be permitted.

Exception No. 1: Receptacles on a 2-wire, single-phase portable or vehicle-mounted generator rated not more than 5 kW, where the circuit conductors of the generator are insulated from the generator frame and all other grounded surfaces, shall be permitted without ground-fault protection for personnel.

Exception No. 2: In industrial establishments only, where conditions of maintenance and supervision ensure that only qualified personnel are involved, an assured equipment grounding conductor program as specified in 2-2.4.2.2.2 shall be permitted to be utilized for all receptacle outlets.

2-2.4.2.2 Use of Other Outlets. Receptacles other than 125 volt, single-phase, 15-, 20-, and 30-ampere receptacles shall have protection in accordance with 2-2.4.2.2.1 or, the assured equipment grounding conductor program in accordance with 2-2.4.2.2.2.

2-2.4.2.2.1 Ground-fault circuit-interrupter protection for personnel.

2-2.4.2.2.2 Assured Grounding Programs. A written assured equipment grounding conductor program continuously enforced at the site by one or more designated persons to ensure that equipment grounding conductors for all cord sets, receptacles that are not a part of the permanent wiring of the building or structure, and equipment connected by cord and plug are installed and maintained.

The following tests shall be performed on all cord sets, receptacles that are not part of the permanent wiring of the building or structure, and cord- and plug-connected equipment required to be grounded.

(1) All equipment grounding conductors shall be tested for continuity and shall be electrically continuous.
(2) Each receptacle and attachment plug shall be tested for correct attachment of the equipment grounding conductor. The equipment grounding conductor shall be connected to its proper terminal.
(3) All required tests shall be performed.
   a. Before first use on site
   b. When there is evidence of damage
   c. Before equipment is returned to service following any repairs
   d. At intervals not exceeding 3 months
(4) The test required in 2-2.4.2.2.2(1) and (2) shall be recorded and made available to the authority having jurisdiction.

2-2.5 Outlet Devices. Outlet devices shall have an ampere rating not less than the load to be served and shall comply with (a) and (b).

(a) **Lampholders.** Where connected to a branch circuit having a rating in excess of 20 amperes, lampholders shall be of the heavy-duty type. A heavy-duty lampholder shall have a rating of not less than 660 watts if of the admedium type and not less than 750 watts if of any other type.

(b) **Receptacles.**

(1) A single receptacle installed on an individual branch circuit shall have an ampere rating of not less than that of the branch circuit.
(2) Where connected to a branch circuit supplying two or more receptacles or outlets, a receptacle shall not supply a total cord- and plug-connected load in excess of the maximum specified in Table 2-2.5(b)(2).

Table 2-2.5(b)(2) Maximum Cord- and Plug-Connected Load to Receptacle

Circuit Rating (Amperes)	Receptacle Rating (Amperes)	Maximum Load (Amperes)
15 or 20	15	12
20	20	16
30	30	24

(3) Where connected to a branch circuit supplying two or more receptacles or outlets, receptacle ratings shall conform to the values listed in Table 2-2.5(b)(3), or, where larger than 50 amperes, the receptacle rating shall not be less than the branch-circuit rating.

Exception: Receptacles for one or more cord- and plug-connected arc welders shall be permitted to have ampere ratings not less than the minimum branch-circuit conductor ampacity.

Table 2-2.5(b)(3) Receptacle Ratings for Various Size Circuits

Circuit Rating (Amperes)	Receptacle Rating (Amperes)
15	Not over 15
20	15 or 20
30	30
40	40 or 50
50	50

2-2.6 Cord Connections. A receptacle outlet shall be installed wherever flexible cords with attachment plugs are used. Where flexible cords are permitted to be permanently connected, receptacles shall be permitted to be omitted for such cords.

2-3 Outside Branch Circuit, Feeder, and Service Conductors, 600 Volts, Nominal, or Less. Paragraphs 2-3.1, 2-3.2, 2-3.3, and 2-3.4 apply to branch circuit, feeder, and service conductors run outdoors as open conductors.

2-3.1 Conductors on Poles. Conductors supported on poles shall have a separation of not less than 1 ft (305 mm) where not placed on racks or brackets. Conductors supported on poles shall provide a horizontal climbing space not less than the following:

(1) Power conductors below communications conductors — 30 in. (762 mm)
(2) Power conductors alone or above communications conductors:

   300 volts or less — 24 in. (610 mm)

   Over 300 volts — 30 in. (762 mm)

(3) Communications conductors below power conductors — same as power conductors
(4) Communications conductors alone — no requirement

2-3.2 Vertical Clearance from Ground. Open conductors, open multiconductor cables, and service-drop conductors of not over 600 volts, nominal, shall conform to the following minimum clearances:

10 ft (3.05 m) — above finished grade, sidewalks, or from any platform or projection from which they might be reached where the voltage does not exceed 150 volts to ground and accessible to pedestrians only.

12 ft (3.66 m) — over residential property and driveways, and those commercial areas not subject to truck traffic where the voltage does not exceed 300 volts to ground.

15 ft (4.57 m) — for those areas listed in the 12-ft (3.66-m) classification where the voltage exceeds 300 volts to ground.

18 ft (5.49 m) — over public streets, alleys, roads, parking areas subject to truck traffic, driveways on other than residential property, and other land traversed by vehicles such as cultivated, grazing, forest, and orchard.

2-3.3 Clearance from Building Openings. Service conductors installed as open conductors or multiconductor cable without an overall outer jacket shall have a clearance of not less than 3 ft (914 mm) from windows that are designed to be opened, doors, porches, balconies, ladders, stairs, fire escapes, or similar locations. Vertical clearance of final spans above, or within 3 ft (914 mm) measured horizontally of, platforms, projections, or surfaces from which they might be reached shall be maintained in accordance with 2-3.2.

Exception: Conductors run above the top level of a window shall be permitted to be less than the 3 ft (914 mm) requirement above.

Overhead service conductors shall not be installed beneath openings through which materials may be moved, such as openings in farm and commercial buildings, and shall not be installed where they will obstruct entrance to these building openings.

2-3.4 Clearances from Buildings for Conductors of Not Over 600 Volts, Nominal.

2-3.4.1 Above Roofs. Overhead spans of open conductors and open multiconductor cables shall have a vertical clearance of not less than 8 ft (2.44 m) above the roof surface. The vertical clearance above the roof level shall be maintained for a distance not less than 3 ft (914 mm) in all directions from the edge of the roof.

Exception No. 1: The area above a roof surface subject to pedestrian or vehicular traffic shall have a vertical clearance from the roof surface in accordance with the clearance requirements of 2-3.2.

Exception No. 2: Where the voltage between conductors does not exceed 300, and the roof has a slope of 4 in. (102 mm) in 12 in. (305 mm) or greater, a reduction in clearance to 3 ft (914 mm) shall be permitted.

Exception No. 3: Where the voltage between conductors does not exceed 300, a reduction in clearance above only the overhanging portion of the roof to not less than 18 in. (457 mm) shall be permitted if (1) not more than 6 ft (1.83 m) of the conductors, 4 ft (1.22 m) horizontally, pass above the roof overhang, and (2) they are terminated at a through-the-roof raceway or approved support.

Exception No. 4: The requirement for maintaining the vertical clearance 3 ft (914 mm) from the edge of the roof shall not apply to the final conductor span where the conductors are attached to the side of a building.

2-3.5 Location of Outdoor Lamps. Locations of lamps for outdoor lighting shall be below all energized conductors, transformers, or other electric utilization equipment, unless

(1) Clearances or other safeguards are provided for relamping operations, or

(2) Equipment is controlled by a disconnecting means that can be locked in the open position.

2-4 Services.

2-4.1 Service Equipment — Disconnecting Means.

2-4.1.1 General. Means shall be provided to disconnect all conductors in a building or other structure from the service-entrance conductors.

(a) **Location.** The service disconnecting means shall be installed at a readily accessible location either outside of a building or structure or inside nearest the point of entrance of the service conductors.

Service disconnecting means shall not be installed in bathrooms.

(b) **Marking.** Each service disconnect shall be permanently marked to identify it as a service disconnect.

(c) **Suitable for Use.** Each service disconnecting means shall be suitable for the pervailing conditions.

2-4.2 Services Exceeding 600 Volts, Nominal.

2-4.2.1 Guarding. Service-entrance conductors installed as open wires shall be guarded to make them accessible only to qualified persons.

2-4.2.2 Warning Signs. Signs with the words "DANGER — HIGH VOLTAGE — KEEP OUT" shall be posted in plain view where unauthorized persons might come in contact with energized parts.

2-5 Overcurrent Protection.

2-5.1 600 Volts, Nominal, or Less.

2-5.1.1 Protection of Conductors and Equipment. Conductors and equipment shall be protected from overcurrent in accordance with their ability to safely conduct current.

2-5.1.2 Grounded Conductors. No overcurrent device shall be connected in series with any conductor that is intentionally grounded, unless one of the following two conditions are met:

(1) The overcurrent device opens all conductor of the circuit, including the grounded conductor, and is designed so that no pole can operate independently

(2) Where required for motor overload protection

2-5.1.3 Disconnecting Means for Fuses. A disconnecting means shall be provided on the supply side of all fuses in circuits over 150 volts to ground and cartridge fuses in circuits of any voltage where accessible to other than qualified persons so that each individual circuit containing fuses can be independently disconnected from the source of power. A current-limiting device without a disconnecting means shall be permitted on the supply side of the service disconnecting means. A single disconnecting means shall be permitted on the supply side of more than one set of fuses as permitted by the exception to 3-10.5.5, for group operation of motors and for fixed electric space-heating equipment.

2-5.1.4 Arcing or Suddenly Moving Parts. Arcing or suddenly moving parts shall comply with (a) and (b).

(a) **Location.** Fuses and circuit breakers shall be located or shielded so that persons will not be burned or otherwise injured by their operation.

(b) **Suddenly Moving Parts.** Handles or levers of circuit breakers, and similar parts that may move suddenly in such a way that persons in the vicinity are likely to be injured by being struck by them, shall be guarded or isolated.

2-5.1.5 Circuit Breakers. Circuit breakers shall clearly indicate whether they are in the open "off" or closed "on" position.

Where circuit breaker handles are operated vertically rather than rotationally or horizontally , the "up" position of the handle shall be the "on" position.

2-5.1.5.1 Used as Switches. Circuit breakers used as switches in 120-volt and 277-volt fluorescent lighting circuits shall be listed and shall be marked "SWD."

2-5.1.5.2 Applications. A circuit breaker with a straight voltage rating, such as 240 volts or 480 volts, shall be permitted to be applied in a circuit in which the nominal voltage between any two conductors does not exceed the circuit breaker's voltage rating. A two-pole circuit breaker shall not be used for protecting a 3-phase, corner-grounded delta circuit unless the circuit breaker is marked 1 ϕ – 3 ϕ to indicate such suitability.

A circuit breaker with a slash rating, such as 120/240 volts or 480Y/277 volts, shall be permitted to be applied in a circuit where the nominal voltage of any conductor to ground does not exceed the lower of the two values of the circuit breaker's voltage rating and the nominal voltage between any two conductors does not exceed the higher value of the circuit breaker's voltage rating.

2-5.2 Overcurrent Protection, Over 600 Volts, Nominal.

2-5.2.1 Feeders and Branch Circuits.

2-5.2.1.1 Feeder and branch-circuit conductors shall have overcurrent protection in each ungrounded conductor located at the point where the conductor receives its supply or at a location in the circuit determined under engineering supervision. The overcurrent protection shall be permitted to be provided by one of the following.

(a) **Overcurrent Relays and Current Transformers.** Circuit breakers used for overcurrent protection of 3-phase circuits shall have a minimum of three overcurrent relays operated from three current transformers. On 3-phase, 3-wire circuits, an overcurrent relay in the residual circuit of the current transformers shall be permitted to replace one of the phase relays.

An overcurrent relay, operated from a current transformer that links all phases of a 3-phase, 3-wire circuit, shall be permitted to replace the residual relay and one other phase-conductor current transformers. Where the neutral is not regrounded on the load side of the circuit, the current transformer shall be permitted to link all 3-phase conductors and the grounded circuit conductor (neutral).

(b) **Fuses.** A fuse shall be connected in series with each ungrounded conductor.

2-5.2.1.2 Protective Devices. The protective device(s) shall be capable of detecting and interrupting all values of current that can occur at their location in excess of their trip setting or melting point.

2-5.2.1.3 Conductor Protection. The operating time of the protective device, the available short-circuit current, and the conductor used shall be coordinated to prevent damaging or dangerous temperatures in conductors or conductor insulation under short-circuit conditions.

2-5.2.2 Additional Requirements for Feeders.

2-5.2.2.1 Rating or Setting of Overcurrent Protective Devices. The continuous ampere rating of a fuse shall not exceed three times the ampacity of the conductors. The long-time trip element setting of a breaker or the minimum trip setting of an electronically actuated fuse shall not exceed six times the ampacity of the conductor. For fire pumps, conductors shall be permitted to be protected for short-circuit only.

2-5.2.2.2 Feeder Taps. Conductors tapped to a feeder shall be permitted to be protected by the feeder overcurrent device where that overcurrent device also protects the tap conductor.

2-6 Grounding. Paragraphs 2-6.1 through 2-6.7 cover grounding requirements for systems, circuits, and equipment.

2-6.1 Systems to Be Grounded. The following systems, which supply premises wiring, shall be grounded:

2-6.1.1 All 3-wire dc systems shall have their neutral conductor grounded.

2-6.1.2 Two-wire dc systems operating at over 50 volts through 300 volts between conductors shall be grounded.

Exception No. 1: Where they supply only industrial equipment in limited areas and are equipped with a ground detector; or

Exception No. 2: Where they are rectifier-derived from an ac system complying with 2-6.3, 2-6.1.4, and 2-6.1.5; or

Exception No. 3: Where they are fire-protective signaling circuits having a maximum current of 0.030 ampere.

2-6.1.3 All ac circuits of less than 50 volts shall be grounded where they are installed as overhead conductors outside of buildings or where they are supplied by transformers and the transformer primary supply system is ungrounded or exceeds 150 volts to ground.

2-6.1.4 AC systems of 50 volts to 1000 volts that are not covered in 2-6.1.5 shall be grounded under any of the following conditions:

(1) Where the system can be so grounded that the maximum voltage to ground on the ungrounded conductors does not exceed 150 volts
(2) Where the system is rated 3-phase, 4-wire wye in which the neutral is used as a circuit conductor
(3) Where the system is rated 3-phase, 4-wire delta in which the midpoint of one phase is used as a circuit conductor
(4) Where a service conductor is uninsulated

2-6.1.5 AC systems of 50 volts to 1000 volts shall not be required to be grounded under any of the following conditions:

(1) Where the system is used exclusively to supply industrial electric furnaces for melting, refining, tempering, and the like
(2) Where the system is separately derived and is used exclusively for rectifiers supplying only adjustable speed industrial drives
(3) Where the system is separately derived and is supplied by a transformer that has a primary voltage rating less than 1000 volts, provided all of the following conditions are met:
    a. The system is used exclusively for control circuits.
    b. The conditions of maintenance and supervision ensure that only qualified persons will service the installation.
    c. Continuity of control power is required.
    d. Ground detectors are installed on the control system.
(4) Where the system is an isolated power system that supplies circuits in health care facilities.
(5) Where high-impedance grounded neutral systems in which a grounding impedance, usually a resistor, limits the ground-fault current to a low value. High-impedance grounded neutral systems shall be permitted for 3-phase ac systems of 480 volts to 1000 volts where all of the following conditions are met:
    a. The conditions of maintenance and supervision ensure that only qualified persons will service the installation.
    b. Continuity of power is required.
    c. Ground detectors are installed on the system.
    d. Line-to-neutral loads are not served.

2-6.1.6 Alternating Current Systems of 1 kV and Over. AC systems supplying mobile or portable equipment shall be grounded. Where supplying other than portable equipment, such systems shall be permitted to be grounded. Where such systems are grounded, they shall comply with the applicable provisions of Section 2-6.

2-6.1.7 Portable and Vehicle-Mounted Generators.

2-6.1.7.1 Portable Generators. Under the following conditions, the frame of a portable generator shall not be required to be grounded and shall be permitted to serve as the grounding electrode for a system supplied by the generator:

(1) The generator supplies only equipment mounted on the generator or cord- and plug-connected equipment through receptacles mounted on the generator, or both, and
(2) The noncurrent-carrying metal parts of equipment and the equipment grounding conductor terminals of the receptacles are bonded to the generator frame.

2-6.1.7.2 Vehicle-Mounted Generators. Under the following conditions, the frame of a vehicle shall be permitted to serve as the grounding electrode for a system supplied by a generator located on the vehicle:

(1) The frame of the generator is bonded to the vehicle frame, and
(2) The generator supplies only equipment located on the vehicle or cord- and plug-connected equipment through receptacles mounted on the vehicle or both equipment located on the vehicle and cord- and plug-connected equipment through receptacles mounted on the vehicle or on the generator, and
(3) The noncurrent-carrying metal parts of equipment and the equipment grounding conductor terminals of the receptacles are bonded to the generator frame, and
(4) The system complies with all other provisions of Section 2-6.

2-6.1.7.3 Neutral Conductor Bonding. A neutral conductor shall be bonded to the generator frame where the generator is a component of a separately derived system. The bonding of any conductor other than a neutral within the generator to its frame shall not be required.

2-6.2 Grounding Connections.

2-6.2.1 For a grounded system, a grounding electrode conductor shall be used to connect both the equipment grounding conductor and the grounded circuit conductor to the grounding electrode. Both the equipment grounding conductor and the grounding electrode conductor shall be connected to the grounded circuit conductor on the supply side of the service disconnecting means or on the supply side of the system disconnecting means or overcurrent devices if the system is separately derived.

2-6.2.2 For an ungrounded service-supplied system, the equipment grounding conductor shall be connected to the grounding electrode conductor at the service equipment. For an ungrounded separately derived system, the equipment grounding conductor shall be connected to the grounding electrode conductor at, or ahead of, the system disconnecting means or overcurrent devices.

2-6.2.3 On extensions of existing branch circuits that do not have an equipment grounding conductor, grounding-type receptacles shall be permitted to be grounded to a grounded cold water pipe near the equipment.

2-6.3 Grounding Path. The path to ground from circuits, equipment, and enclosures shall be permanent, continuous, and effective.

2-6.4 Supports, Enclosures, and Equipment to Be Grounded.

2-6.4.1 Supports and Enclosures for Conductors. Metal raceways and metal enclosures for conductors shall be grounded.

Exception No. 1: Metal enclosures, such as sleeves and similar enclosures that are used to protect cable assemblies from physical damage, shall not be required to be grounded.

Exception No. 2: Metal enclosures for conductors added to existing installations of open wire, knob-and-tube wiring, and nonmetallic-sheathed cable, if in runs of less than 25 ft (7.63 m), if free from probable contact with ground, grounded metal, metal laths, or other conductive materials, and if guarded against contact by persons, shall not be required to be grounded.

2-6.4.2 Service Equipment Enclosures. Metal enclosures for service equipment shall be grounded.

2-6.4.3 Frames of Ranges and Clothes Dryers. Frames of electric ranges, wall-mounted ovens, counter-mounted cooking units, clothes dryers, and metal outlet or junction boxes that are part of the circuit for these appliances shall be grounded.

2-6.4.4 Fixed Equipment. Exposed noncurrent-carrying metal parts of fixed equipment likely to become energized shall be grounded under any of the conditions specified in (1) through (6):

(1) Where within 8 ft (2.44 m) vertically or 5 ft (1.52 m) horizontally of ground or grounded metal objects and subject to contact by persons
(2) Where located in a wet or damp location and not isolated
(3) Where in electrical contact with metal
(4) Where in a hazardous (classified) location
(5) Where supplied by a metal-clad, metal-sheathed, or grounded metal raceway wiring method
(6) Where equipment operates with any terminal at over 150 volts to ground

Exception No. 1 to (1) through (6): Metal frames of electrically heated appliances, exempted by special permission, in which case the frames shall be permanently and effectively insulated from ground.

Exception No. 2 to (1) through (6): Distribution apparatus, such as transformer and capacitor cases, mounted on wooden poles, at a height exceeding 8 ft (2.44 m) above ground or grade level.

Exception No. 3 to (1) through (6): Listed equipment protected by a system of double insulation, or its equivalent, shall not be required to be grounded. Where such a system is employed, the equipment shall be distinctively marked.

2-6.4.5 Equipment Connected by Cord and Plug. Under any of the conditions described in 2-6.4.5(1) through 2-6.4.5(3), exposed noncurrent-carrying metal parts of cord- and plug-connected equipment likely to become energized shall be grounded.

(1) In hazardous (classified) locations as described in Chapter 5 of Part I
(2) Where operated at over 150 volts to ground, except guarded motors and metal frames of electrically heated appliances where the appliance frames are permanently and effectively insulated from ground
(3) In other than residential occupancies:
    a. Refrigerators, freezers, and air conditioners
    b. Clothes-washing, clothes-drying, and dishwashing machines, sump pumps, and electrical aquarium equipment
    c. Hand-held motor-operated tools, stationary and fixed motor-operated tools, and light industrial motor-operated tools
    d. Motor-operated appliances of the following types: hedge clippers, lawn mowers, snow blowers, and wet scrubbers
    e. Cord- and plug-connected appliances used in damp or wet locations or by persons standing on the ground or on metal floors or working inside of metal tanks or boilers
    f. Portable and mobile X-ray and associated equipment
    g. Tools likely to be used in wet and conductive locations, and
    h. Portable hand lamps.

Exception: Tools and portable hand lamps likely to be used in wet or conductive locations shall not be required to be grounded where supplied through an isolating transformer with an ungrounded secondary of not over 50 volts.

Listed portable tools and appliances covered in 2-6.4.5(2) through 2-6.4.5(3)h and protected by an approved system of double insulation, or its equivalent, shall not be required to be grounded. Where such a system is employed, the equipment shall be distinctively marked to indicate that the tool or appliance utilizes an approved system of double insulation.

2-6.4.6 Nonelectrical Equipment. The metal parts of the following nonelectrical equipment shall be grounded:

(1) Frames and tracks of electrically operated cranes and hoists
(2) Frames of nonelectrically driven elevator cars to which electric conductors are attached
(3) Hand-operated metal shifting ropes or cables of electric elevators

2-6.5 Methods of Grounding Equipment. Noncurrent-carrying metal parts of fixed equipment, if required to be grounded, shall be grounded by an equipment grounding conductor that is contained within the same raceway, cable, or cord, or run with the circuit conductors. For dc circuits only, the equipment grounding conductor shall be permitted to be run separately from the circuit conductors.

(a) Electric equipment secured to, and in electrical contact with, a grounded metal rack or structure provided for its support shall be considered to be effectively grounded. The structural metal frame of a building shall not be used as the required equipment grounding conductor for ac equipment.

(b) Metal car frames supported by metal hoisting cables attached to or running over metal sheaves or drums of grounded elevator machines shall also be considered to be effectively grounded.

2-6.6 General Bonding. Bonding shall be provided where necessary to ensure electrical continuity and the capacity to conduct safely any fault current likely to be imposed.

2-6.7 Grounding of Systems and Circuits of 1 kV and Over (High Voltage).

2-6.7.1 General. Where high voltage systems are grounded, they shall comply with all applicable provisions of Section 2-6 and with 2-6.7.2 and 2-6.7.3, which supplement and modify the preceding paragraphs.

2-6.7.2 Grounding of Systems Supplying Portable Equipment. Systems supplying portable high voltage equipment, other than substations installed on a temporary basis, shall comply with (a) through (d).

(a) Portable high voltage equipment shall be supplied from a system having its neutral grounded through an impedance. Where a delta-connected high voltage system is used to supply portable equipment, a system neutral shall be derived.

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

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

(d) The grounding electrode to which the portable equipment system neutral impedance is connected shall be isolated from and separated in the ground by at least 20 ft (6.1 m) from any other system or equipment grounding electrode, and there shall be no direct connection between the grounding electrodes, such as buried pipe, fence, and so forth.

2-6.7.3 Grounding of Equipment. All noncurrent-carrying metal parts of portable equipment and fixed equipment including their associated fences, housings, enclosures, and supporting structures shall be grounded.

Exception No. 1: Where isolated from ground and located so as to prevent any person who can make contact with ground from contacting such metal parts when the equipment is energized.

Exception No. 2: Distribution apparatus, such as transformer and capacitor cases, mounted on wooden poles, at a height exceeding 8 ft (2.44 m) above ground or grade level.

Chapter 3 Wiring Methods, Components, and Equipment for General Use

3-1 Wiring Methods. The provisions of this chapter shall not apply to the conductors that are an integral part of factory-assembled listed equipment.

3-1.1 Bonding Other Enclosures.

3-1.1.1 General. Metal raceways, cable trays, cable armor, cable sheath, enclosures, frames, fittings, and other metal noncurrent-carrying parts that are to serve as grounding conductors, with or without the use of supplementary equipment grounding conductors, shall be effectively bonded where necessary to ensure electrical continuity and the capacity to conduct safely any fault current likely to be imposed on them. Any nonconductive paint, enamel, or similar coating shall be removed at threads, contact points, and contact surfaces or be connected by means of fittings designed so as to make such removal unnecessary.

3-1.1.2 Isolated Grounding Circuits. Where required for the reduction of electrical noise (electromagnetic interference) of the grounding circuit, and equipment enclosure supplied by a branch circuit shall be permitted to be isolated from a raceway containing circuits supply only that equipment by one or more listed nonmetallic raceway fittings located at the point of attachment of the raceway to the equipment enclosure. The metal raceway shall comply with provisions of this standard and shall be supplemented by an internal insulated equipment grounding conductor installed to ground the equipment enclosure.

NOTE: Use of an isolated equipment grounding conductor does not relieve the requirement for grounding the raceway system.

3-1.1.3 Ducts for Dust, Loose Stock, or Vapor Removal. No wiring systems of any type shall be installed in ducts used to transport dust, loose stock, or flammable vapors. No wiring system of any type shall be installed in any duct, or shaft containing only such ducts, used for vapor removal or for ventilation of commercial-type cooking equipment.

3-1.2 Temporary Wiring. Temporary electrical power and lighting wiring methods may be of a class less than would be required for a permanent installation.

Except as specifically modified in 3-1.2.1 through 3-1.2.3, all other requirements of this standard for permanent wiring shall apply to temporary wiring installations.

3-1.2.1 Uses Permitted, 600 Volts, Nominal, or Less. Temporary electrical power and lighting installations shall be permitted:

(a) **During the Period of Construction.** Temporary electric power and lighting installations shall be permitted during the period of construction, remodeling, maintenance, repair, or demolition of buildings, structures, equipment, or similar activities.

(b) **90 Days.** Temporary electrical power and lighting installations shall be permitted for a period not to exceed 90 days for Christmas decorative lighting and similar purposes.

(c) **Emergencies and Tests.** Temporary electrical power and lighting installations shall be permitted during emergencies and for tests, experiments, and developmental work.

(d) **Removal.** Temporary wiring shall be removed immediately upon completion of construction or purpose for which the wiring was installed.

3-1.2.2 Uses Permitted, Over 600 Volts, Nominal. Temporary wiring shall be permitted during periods of construction, tests, experiments, or emergencies.

3-1.2.3 General Requirements for Temporary Wiring.

3-1.2.3.1 Feeders. Feeders shall originate in an approved distribution center. Conductors shall be permitted within cable assemblies, or within cords or cables of a type identified for hard usage or extra-hard usage.

Exception: Single insulated conductors shall be permitted where installed for the purpose(s) specified in 3-1.2.1(c) where accessible only to qualified persons.

3-1.2.3.2 Branch Circuits. All branch circuits shall originate in an approved power outlet or panelboard. Conductors shall be permitted within cable assemblies, or within multiconductor cord or cable of a type identified for hard usage or extra-hard usage. All conductors shall be protected as provided in Section 2-5 of Part I. For the purpose of this section, Type NM and NMC cables shall be permitted to be used in any dwelling, building, or structure without any height limitation.

Branch circuits installed for the purpose specified in 3-1.2.1(b) or 3-1.2.1(c) shall be permitted to be run as single insulated conductors. Where the wiring is installed in accordance with 3-1.2.1(b), the voltage to ground shall not exceed 150 volts, the wiring shall not be subject to physical damage, and the conductors shall be supported on insulators at intervals of not more than 10 ft (3.05 m); or, for festoon lighting, the conductors shall be arranged so that excessive strain is not transmitted to the lampholders.

3-1.2.3.3 Receptacles. All receptacles shall be of the grounding type. Unless installed in a continuous grounded metal raceway or metal-covered cable, all branch circuits shall contain a separate equipment grounding conductor, and all receptacles shall be electrically connected to the equipment grounding conductors. Receptacles on construction sites shall not be installed on branch circuits that supply temporary lighting. Receptacles shall not be connected to the same ungrounded conductor of multiwire circuits that supply temporary lighting.

3-1.2.3.4 Earth Returns. No bare conductors or earth returns shall be used for the wiring of any temporary circuit.

3-1.2.3.5 Disconnecting Means. Suitable disconnecting switches or plug connectors shall be installed to permit the disconnection of all ungrounded conductors of each temporary circuit. Multiwire branch circuits shall be provided with a means to disconnect simultaneously all ungrounded conductors at the power outlet or panelboard where the branch circuit originated. Approved handle ties shall be permitted.

3-1.2.3.6 Lamp Protection. All lamps for general illumination shall be protected from accidental contact or breakage by a suitable fixture or lampholder with a guard.

Brass shell, paper-lined sockets, or other metal-cased sockets shall not be used unless the shell is grounded.

3-1.2.3.7 Splices. On construction sites, a box shall not be required for splices or junction connections where the circuit conductors are multiconductor cord or cable assemblies. A box, conduit body, or terminal fitting having a separately bushed hole for each conductor shall be used wherever a change is made to a conduit or tubing system or a metal-sheathed cable system.

3-1.2.3.8 Protection from Accidental Damage. Flexible cords and cables shall be protected from accidental damage. Sharp corners and projections shall be avoided. Where passing through doorways or other pinch points, protection shall be provided to avoid damage.

3-1.2.3.9 Termination(s) at Devices. Flexible cords and cables entering enclosures containing devices requiring termination shall be secured to the box with fittings designed for the purpose.

3-1.2.3.10 Support. Cable assemblies and flexible cords and cables shall be supported in place at intervals that ensure that they will be protected from physical damage. Support shall be in the form of staples, cable ties, straps, or similar type fittings installed so as not to cause damage.

3-1.3 Cable Trays.

3-1.3.1 Uses Permitted. Cable tray installations shall not be limited to industrial establishments.

3-1.3.2 Wiring Methods. The following wiring methods shall be permitted to be installed in cable tray systems: armored cable, electrical metallic tubing, electrical nonmetallic tubing, fire alarm cables, flexible metal conduit, flexible metallic tubing, instrumentation tray cable, intermediate metal conduit, liquidtight flexible metal conduit and liquidtight flexible nonmetallic conduit, metal-clad cable, mineral-insulated, metal-sheathed cable, multiconductor service-entrance cable, multiconductor underground feeder and branch-circuit cable, multipurpose and communications cables, nonmetallic-sheathed cable, power and control tray cable, power-limited tray cable, optical fiber cables, other factory-assemble, multiconductor control, signal, or power cables that are specifically approved for installation in cable trays, rigid metal conduit, and rigid nonmetallic conduit.

3-1.3.3 In Industrial Establishments. The wiring methods in 3-1.3.2 shall be permitted to be used in any industrial establishment under the conditions described in their respective articles. In industrial establishments only, where conditions of maintenance and supervision ensure that only qualified persons will service the installed cable tray system, any of the cables in (a) through (b) shall be permitted to be installed in ladder, ventilated trough, or ventilated channel cable trays.

(a) **Single Conductors.** Single conductors shall be permitted to be installed in accordance with the following:

(1) Single conductor cable shall be No. 1/0 or larger and shall be of a type listed and marked on the surface for use in cable trays. Where Nos. 1/0 through 4/0 single con-

ductor cables are installed in ladder cable tray, the maximum allowable run spacing for the ladder cable tray shall be 9 in. (229 mm). Where exposed to direct rays of the sun, cables shall be identified as being sunlight resistant.

(2) Welding cables installed in dedicated cable trays, as permitted.

(3) Single conductors used as equipment grounding conductors shall be insulated, covered, or bare and they shall be No. 4 or larger.

(b) **Multiconductor.** Multiconductor cable, Type MV where exposed to direct rays of the sun, shall be identified as being sunlight resistant.

(c) **Equipment Grounding Conductors.** Metallic cable trays shall be permitted to be used as equipment grounding conductors where continuous maintenance and supervision ensure that qualified persons will service the installed cable tray system.

(d) **Hazardous (Classified) Locations.** Hazardous (classified) locations as permitted.

(e) **Nonmetallic Cable Tray.** Nonmetallic cable tray shall be permitted in corrosive areas and in areas requiring voltage isolation.

3-1.3.4 Uses Not Permitted. Cable tray systems shall not be used in hoistways or where subject to severe physical damage. Cable tray systems shall not be used in environmental airspaces, except as permitted in 3-1.1.2 to support wiring methods recognized for use in such spaces.

3-1.4 Open Wiring on Insulators.

3-1.4.1 Uses Permitted. Open wiring on insulators shall be permitted on systems of 600 volts, nominal, or less, only for industrial or agricultural establishments, indoors or outdoors, in wet or dry locations, where subject to corrosive vapors, and for services.

3-1.4.2 Conductor Supports.

3-1.4.2.1 Conductor Sizes Smaller Than No. 8. Conductors smaller than No. 8 shall be rigidly supported on noncombustible, nonabsorbent insulating materials and shall not contact any other objects.

Supports shall be installed as follows:

(1) Within 6 in. (152 mm) from a tap or splice

(2) Within 12 in. (305 mm) of a dead-end connection to a lampholder or receptacle

(3) At intervals not exceeding $4^1/_2$ ft (1.37 m) and at closer intervals sufficient to provide adequate support where likely to be disturbed

3-1.4.3 Flexible Nonmetallic Tubing. In dry locations, where not exposed to severe physical damage, conductors shall be permitted to be separately enclosed in flexible nonmetallic tubing. The tubing shall be in continuous lengths not exceeding 15 ft (4.57 m) and secured to the surface by straps at intervals not exceeding $4^1/_2$ ft (1.37 m).

3-1.4.4 Through Walls, Floors, Wood Cross Members, etc. Open conductors shall be separated from contact with walls, floors, wood cross members, or partitions through which they pass by tubes or bushings of noncombustible, nonabsorbent insulating material. Where the bushing is shorter than the hole, a waterproof sleeve of noninductive material shall be inserted in the hole and an insulating bushing slipped into the sleeve at each end in such a manner as to keep the conductors absolutely out of contact with the sleeve. Each conductor shall be carried through a separate tube or sleeve.

3-1.4.5 Protection from Physical Damage. Conductors within 7 ft (2.13 m) from the floor shall be considered exposed to physical damage. Where open conductors cross ceiling joists and wall studs and are exposed to physical damage, they shall be protected by one of the following methods:

(1) Guard strips not less than 1 in. (25.4 mm) nominal in thickness and at least as high as the insulating supports, placed on each side of and close to the wiring

(2) A substantial running board at least $^1/_2$ in. (12.7 mm) thick in back of the conductors with side protections. Running boards shall extend at least 1 in. (25.4 mm) outside the conductors, but not more than 2 in. (50.8 mm), and the protecting sides shall be at least 2 in. (50.8 mm) high and at least 1 in. (25.4 mm) nominal in thickness.

3-2 Cabinets, Cutout Boxes, and Meter Socket Enclosures.

3-2.1 Cabinets, Cutout Boxes, and Meter Socket Enclosures. Conductors entering enclosures within the scope of this standard shall be protected from abrasion and shall comply with 3-2.1.1 through 3-2.1.3.

3-2.1.1 Openings to Be Closed. Opening through which conductors enter shall be adequately closed.

3-2.1.2 Metal Cabinets, Cutout Boxes, and Meter Socket Enclosures. Where metal enclosures within the scope of this standard are installed with open wiring or concealed knob-and-tube wiring, conductors shall enter through insulating bushings or, in dry locations, through flexible tubing extending from the last insulating support and firmly secured to the enclosure.

3-2.1.3 Cables. Where cable is used, each shall be secured to the cabinet, cutout box, or meter socket enclosure.

Exception: Cable with entirely nonmetallic sheaths shall be permitted to enter the top of a surface-mounted enclosure through one or more nonflexible raceways not less than 18 in. (457 mm) or more than 10 ft (3.05 m) in length, provided all the following conditions are met:

(a) Each cable is fastened within 12 in. (305 mm), measured along the sheath, of the outer end of the raceway.

(b) The raceway extends directly above the enclosure and does not penetrate a structural ceiling.

(c) A fitting is provided on each end of the raceway to protect the cable(s) from abrasion and the fittings remain accessible after installation.

(d) The raceway is sealed or plugged at the outer end using approved means so as to prevent access to the enclosure through the raceway.

(e) The cable sheath is continuous through the raceway and extends into the enclosure beyond the fitting not less than $^1/_4$ in. (6.35 mm).

(f) The raceway is fastened at its outer end and at other point in accordance with applicable section.

(g) Where installed as conduit or tubing, the allowable cable fill does not exceed that permitted for complete conduit or tubing systems.

3-2.2 Covers and Canopies. In complete installations, each box shall have a cover, faceplate, or fixture canopy.

3-2.2.1 Nonmetallic or Metal Covers and Plates. Nonmetallic or metal covers and plates shall be permitted. Where metal covers and plates are used, they shall comply with grounding requirements.

3-2.2.2 Exposed Combustible Wall or Ceiling Finish. Where a fixture canopy or pan is used, any combustible wall or ceiling finish exposed between the edge of the canopy or pan and the outlet box shall be covered with noncombustible material.

3-2.2.3 Flexible Cord Pendants. Covers of outlet boxes and conduit bodies having holes through which flexible cord pendants pass shall be provided with bushings designed for the purpose or shall have smooth, well-rounded surfaces on which the cords may bear. So-called hard rubber or composition bushings shall not be used.

3-2.3 Pull and Junction Boxes for Systems Over 600 Volts, Nominal. In addition to other requirements in this standard for pull and junction boxes, (a) and (b) shall apply:

(a) Boxes shall provide a complete enclosure for the contained conductors or cables.

(b) Boxes shall be closed by suitable covers securely fastened in place. Underground box covers that weigh over 100 lb (45.4 kg) shall be considered meeting this requirement. Covers for boxes shall be permanently marked "DANGER — HIGH VOLTAGE — KEEP OUT." The marking shall be on the outside of the box cover and shall be readily visible. Letters shall be block type and at least $^1/_2$ in. (12.7 mm) in height.

3-3 Position and Connection of Switches.

3-3.1 Single-Throw Knife Switches. Single-throw knife switches shall be placed so that gravity will not tend to close them. Single-throw knife switches, approved for use in the inverted position, shall be provided with a locking device that will ensure that the blades remain in the open position when so set.

3-3.2 Double-Throw Knife Switches. Double-throw knife switches shall be permitted to be mounted so that the throw will be either vertical or horizontal. Where the throw is vertical, a locking device shall be provided to hold the blades in the open position when so set.

3-3.3 Connection of Switches. Single-throw switches and switches with butt contacts shall be connected so that the blades are de-energized when the switch is in the open position. Single-throw knife switches, molded-case switches, switches with butt contacts, and circuit breakers used as switches shall be connected so that the terminals supplying the load are de-energized when the switch is in the open position.

Exception: The blades and terminals supplying the load of a switch shall be permitted to be energized when the switch is in the open position where the switch is connected to circuits or equipment inherently capable of providing a backfeed source of power. For such installations, a permanent sign shall be installed on the switch enclosure or immediately adjacent to open switches that reads:

"WARNING — LOAD SIDE TERMINALS MAY BE ENERGIZED BY BACKFEED."

3-3.4 Provisions for Snap Switch Faceplates.

3-3.4.1 Position. Snap switches mounted in boxes shall have faceplates installed so as to completely cover the opening and seat against the finished surface.

3-3.4.2 Grounding. Snap switches, including dimmer switches, shall be effectively grounded and shall provide a means to ground metal faceplates, whether or not a metal faceplate is installed. Snap switches shall be considered effectively grounded if either of the following conditions are met:

(1) The switch is mounted with metal screws to a metal box or to a nonmetallic box with integral means for grounding devices
(2) An equipment grounding conductor or equipment bonding jumper is connected to an equipment grounding termination of the snap switch

Exception: Where no grounding means exists within the snap-switch enclosure or where the wiring method does not include or provide an equipment ground, a snap switch without a grounding connection shall be permitted for replacement purposes only. A snap switch wired under the provisions of this exception and located within reach of conducting floors or other conducting surfaces shall be provided with a faceplate of nonconducting, noncombustible material.

3-4 Switchboards and Panelboards. Switchboards that have any exposed live parts shall be located in permanently dry locations and shall be accessible only to qualified persons. Panelboards shall be mounted in cabinets, cutout boxes, or enclosures designed for the purpose and shall be dead front.

Exception: Panelboards other than of the dead-front externally operable type shall be permitted where accessible only to qualified persons.

3-5 Enclosures for Damp or Wet Locations.

3-5.1 Damp or Wet Locations. In damp or wet locations, surface-type enclosures within the scope of this standard shall be placed or equipped so as to prevent moisture or water from entering and accumulating within the cabinet or cutout box, and shall be mounted so there is at least $^1/_4$-in. (6.35-mm) airspace between the enclosure and the wall or other supporting surface. Enclosures installed in wet locations shall be weatherproof.

Exception: Nonmetallic enclosures shall be permitted to be installed without the airspace on a concrete, masonry, tile, or similar surface.

3-5.2 A switch or circuit breaker in a wet location or outside of a building shall be enclosed in a weatherproof enclosure or cabinet that shall comply with 3-5.1.

3-6 Conductor Identification.

3-6.1 Grounded Conductors. Insulated or covered grounded conductors shall be identified in accordance with this standard.

3-6.2 Equipment Grounding Conductors. Equipment grounding conductors shall be identified in accordance with this standard.

3-6.3 Ungrounded Conductors. Conductors that are intended for use as ungrounded conductors, whether used as single conductors or in multiconductor cables, shall be finished to be clearly distinguishable from grounded and grounding conductors. Ungrounded conductors shall be distinguished by colors other than white, natural gray, or green, or by a combination of color plus distinguishing marking. Distinguishing markings shall also be in a color other than white, natural gray, or green and shall consist of a stripe or stripes or a regularly spaced series of identical marks.

3-7 Flexible Cords and Cables, 600 Volts, Nominal, or Less.

3-7.1 Suitability. Flexible cords and cables and their associated fittings shall be suitable for the conditions of use and location.

3-7.2 Uses Permitted. Flexible cords and cables shall be used only for the following: pendants; wiring of fixtures; connection of portable lamps, portable and mobile signs, or appliances; elevator cables; wiring of cranes and hoists; connection of stationary equipment to facilitate their frequent interchange; prevention of the transmission of noise or vibration; appliances where the fastening means and

mechanical connections are specifically designed to permit ready removal for maintenance and repair, and the appliance is intended or identified for flexible cord connection; data processing cables approved as a part of the data processing system; connection of moving parts; or temporary wiring as permitted in 3-1.2.3.

3-7.3 Uses Not Permitted. Unless specifically permitted in 3-7.2, flexible cords and cables shall not be used for the following: as a substitute for the fixed wiring of a structure; where run through holes in walls, structural ceilings, suspended ceilings, dropped ceilings, or floors; where run through doorways, windows, or similar openings; where attached to building surfaces; where concealed behind building walls, structural ceilings, suspended ceilings, dropped ceilings, or floors; where installed in raceways, except as otherwise permitted in this standard.

3-7.4 In Show Windows and Show Cases. Flexible cords used in show windows and show cases shall be Type S, SE, SEO, SEOO, SJ, SJE, SJEO, SJEOO, SJO, SJOO, SJT, SJTO, SJTOO, SO, SOO, ST, STO, or STOO.

Exception No. 1: For the wiring of chain-supported lighting fixtures.

Exception No. 2: As supply cords for portable lamps and other merchandise being displayed or exhibited.

3-7.5 Markings, Splices, and Pull at Joints and Terminals.

3-7.5.1 Standard Markings. Flexible cords and cables shall be marked by means of a printed tag attached to the coil reel or carton. The tag shall contain the required information. Types S, SC, SCE, SCT, SE, SEO, SEOO, SJ, SJE, SJEO, SJEOO, SJO, SJT, SJTO, SJTOO, SO, SOO, ST, STO, and STOO flexible cords and G, G-GC, PPE, and W flexible cables shall be durably marked on the surface at intervals not exceeding 24 in. (610 mm) with the type designation, size, and number of conductors.

3-7.5.2 Splices. Flexible cord shall be used only in continuous lengths without splice or tap where initially installed in applications permitted by this section. The repair of hard-service cord and junior hard-service cord No. 14 and larger shall be permitted if conductors are spliced in accordance with this standard and the completed splice retains the insulation, outer sheath properties, and usage characteristics of the cord being spliced.

3-7.5.3 Pull at Joints and Terminals. Flexible cords and cables shall be connected to devices and to fittings so that tension will not be transmitted to joints or terminals.

Exception: Listed portable single-pole devices that are intended to accommodate such tension at their terminals shall be permitted to be used with single conductor flexible cable.

3-8 Portable Cables Over 600 Volts, Nominal.

3-8.1 Construction.

3-8.1.1 Conductors. The conductors shall be No. 8 copper or larger and shall employ flexible stranding.

Exception: The size of the insulated ground-check conductor of Type G-GC cables shall be not smaller than No. 10.

3-8.1.2 Shields. Cables operated at over 2000 volts shall be shielded. Shielding shall be for the purpose of confining the voltage stresses to the insulation.

3-8.1.3 Equipment Grounding Conductor(s). An equipment grounding conductor(s) shall be provided. The total area shall not be less than that of the size of the equipment grounding conductor required in this standard.

3-8.2 Shielding. All shields shall be grounded.

3-8.3 Grounding. Grounding conductors shall be connected in accordance with this standard.

3-8.4 Minimum Bending Radii. The minimum bending radii for portable cables during installation and handling in service shall be adequate to prevent damage to the cable.

3-8.5 Fittings. Connectors used to connect lengths of cable in a run shall be of a type that lock firmly together. Provisions shall be made to prevent opening or closing these connectors while energized. Suitable means shall be used to eliminate tension at connectors and terminations.

3-8.6 Splices and Terminations. Portable cables shall not contain splices unless the splices are of the permanent molded, vulcanized types in accordance with this standard. Terminations on portable cables rated over 600 volts, nominal, shall be accessible only to authorized and qualified personnel.

3-9 Fixture Wires.

3-9.1 General. Fixture wires shall be a type approved for the voltage, temperature, and location of use. A fixture wire that is used as a grounded conductor shall be identified.

3-9.2 Uses Permitted. Fixture wires shall be permitted for the following conditions:

(1) Installation in lighting fixtures and in similar equipment where enclosed or protected and not subject to bending or twisting in use
(2) Connecting lighting fixtures to the branch-circuit conductors supplying the fixtures

3-9.3 Uses Not Permitted. Fixture wires shall not be used as branch-circuit conductors.

Exception: As permitted for Class 1 power-limited circuits and for fire alarm circuits.

3-10 Equipment for General Use.

3-10.1 Live Parts. Fixtures, lampholders, lamps, and receptacles shall have no live parts normally exposed to contact. Exposed accessible terminals in lampholders, receptacles, and switches shall not be installed in metal fixture canopies or in open bases or portable table or floor lamps.

Exception: Cleat-type lampholders and receptacles located at least 8 ft (2.44 m) above the floor shall be permitted to have exposed terminals.

(a) **Portable Handlamps.** Portable handlamps shall comply with the following:

(1) Metal shell, paper-lined lampholders shall not be used.
(2) Handlamps shall be equipped with a handle of molded composition or other insulating material.
(3) Handlamps shall be equipped with a substantial guard attached to the lampholder or handle.
(4) Metallic guards shall be grounded by the means of an equipment grounding conductor run with circuit conductors within the power-supply cord.
(5) Portable handlamps shall not be required to be grounded where supplied through an isolating transformer with an ungrounded secondary of not over 50 volts.

(b) **Lampholders.** Lampholders of the screw-shell type shall be installed for use as lampholders only. Where supplied by a circuit having a grounded conductor, the grounded conductor shall be connected to the screw shell. Lampholders installed in wet or damp locations shall be of the weatherproof type.

(c) **Wet and Damp Locations.** Fixtures installed in wet or damp locations shall be installed so that water cannot enter or accumulate in wiring compartments, lampholders, or other electrical parts. All fixtures installed in wet locations shall be marked, "Suitable for Wet Locations." All fixtures installed in damp locations shall be marked, "Suitable for Wet Locations" or "Suitable for Damp Locations."

3-10.2 Receptacles, Cord Connectors, and Attachment Plugs (Caps).

3-10.2.1 Attachment Plugs. All 15- and 20-ampere attachment plugs and connectors shall be constructed so that there are no exposed current-carrying parts except the prongs, blades, or pins. The cover for wire terminations shall be a part, which is essential for the operation of an attachment plug or connector (dead-front construction). Attachment plugs shall be installed so that their prongs, blades, or pins are not energized unless inserted into an energized receptacle. No receptacle shall be installed so as to require an energized attachment plug as its source of supply.

3-10.2.2 Noninterchangeability. Receptacles, cord connectors, and attachment plugs shall be constructed so that receptacle or cord connectors will not accept an attachment plug with a different voltage or current rating than that for which the device is intended; however, a 20-ampere T-slot receptacle or cord connector shall be permitted to accept a 15-ampere attachment plug of the same voltage rating. Nongrounding-type receptacles and connectors shall not accept grounding-type attachment plugs.

3-10.2.3 Receptacles in Damp or Wet Locations.

3-10.2.3.1 Damp Locations. A receptacle installed outdoors in a location protected from the weather or in other damp locations shall have an enclosure for the receptacle that is weatherproof when the receptacle is covered (attachment plug cap not inserted and receptacle covers closed).

An installation suitable for wet locations shall also be considered suitable for damp locations.

A receptacle shall be considered to be in a location protected from the weather where located under roofed open porches, canopies, marquees, and the like, and will not subjected to a beating rain or water runoff.

3-10.2.3.2 Wet Locations.

3-10.2.3.2.1 A receptacle installed in a wet location where the product intended to be plugged into it is not attended while in use (e.g., sprinkler system controllers, landscape lighting, holiday lights, etc.) shall have an enclosure that is weatherproof with the attachment plug cap inserted or removed.

3-10.2.3.2.2 A receptacle installed in a wet location where the product intended to be plugged into it will be attended while in use (e.g., portable tools, etc.) shall have an enclosure that is weatherproof when the attachment plug cap is removed.

3-10.3 Appliances.

3-10.3.1 Live Parts. Appliances shall have no live parts normally exposed to contact other than those parts functioning as open-resistance heating elements, such as the heating element of a toaster, which are necessarily exposed.

3-10.3.2 Disconnecting Means. A means shall be provided to disconnect each appliance from all ungrounded conductors. If an appliance is supplied by more than one source, the disconnecting means shall be grouped and identified.

3-10.3.3 Nameplate.

3-10.3.3.1 Nameplate Marking. Each electric appliance shall be provided with a nameplate giving the identifying name and the rating in volts and amperes, or in volts and watts. If the appliance is to be used on a specific frequency or frequencies, it shall be so marked.

Where motor overload protection external to the appliance is required, the appliance shall be so marked.

3-10.3.3.2 To Be Visible. Marking shall be located so as to be visible or easily accessible after installation.

3-10.4 Motors.

3-10.4.1 In Sight From (Within Sight From, Within Sight). Where one piece of equipment shall be "in sight from," "within sight from," or "within sight," etc., of another equipment, the specified equipment is to be visible and not more than 50 ft (15.24 m) distant from the other.

3-10.4.2 Disconnecting Means.

3-10.4.2.1 Location.

3-10.4.2.1.1 Controller. An individual disconnecting means shall be provided for each controller and shall disconnect the controller. The disconnecting means shall be located in sight from the controller location.

Exception No. 1: For motor circuits over 600 volts, nominal, a controller disconnecting means capable of being locked in the open position shall be permitted to be out of sight of the controller, provided the controller is marked with a warning label giving the location of the disconnecting means.

Exception No. 2: A single disconnecting means shall be permitted for a group of coordinated controllers that drive several parts of a single machine or piece of apparatus. The disconnecting means and the controllers shall be located in sight from the machine or apparatus.

3-10.4.2.1.2 Motor. A separate disconnecting means shall be located in sight from the motor location and the driven machinery location.

Exception: A disconnecting means in addition to the controller disconnecting means as required in accordance with 3-10.4.2.1.1 shall not be required for the motor where the disconnecting means for the controller is individually capable of being locked in the open position.

3-10.4.3 To Be Indicating. The disconnecting means shall plainly indicate whether it is in the open (off) or closed (on) position.

3-10.4.4 Readily Accessible. One of the disconnecting means shall be readily accessible.

3-10.4.5 Motor Served by Single Disconnecting Means. Each motor shall be provided with an individual disconnecting means.

Exception: A single disconnecting means shall be permitted to serve a group of motors under any one of the following conditions of (a), (b), and (c):

(a) Where a number of motors drive several parts of a single machine or piece of apparatus, such as metal and woodworking machines, cranes, and hoists

(b) Where a group of motors is under the protection of one set of branch-circuit protective devices

(c) Where a group of motors is in a single room within sight from the location of the disconnecting means

3-10.4.6 Motor and Branch-Circuit Overload Protection. Overload devices are intended to protect motors, motor-control apparatus, and motor branch-circuit conductors against excessive heating due to motor overloads and failure to start.

Overload in electrical apparatus is an operating overcurrent that, when it persists for a sufficient length of time, would cause damage or dangerous overheating of the apparatus. It does include short circuits or ground faults.

These provisions shall not be interpreted as requiring overload protection where it might introduce additional or increased hazards, as in the case of fire pumps.

3-10.4.7 Guarding of Live Parts.

3-10.4.7.1 Live Parts Guarded Against Accidental Contact. Except as elsewhere required or permitted by this standard, live parts of electric equipment operating at 50 volts or more shall be guarded against accidental contact by approved enclosures or by any of the following means:

(1) By location in a room, vault, or similar enclosure that is accessible only to qualified persons
(2) By suitable permanent, substantial partitions or screens arranged so that only qualified persons will have access to the space within reach of the live parts. Any openings in such partitions or screens shall be sized and located so that persons are not likely to come into accidental contact with the live parts or to bring conducting objects into contact with them.
(3) By location on a suitable balcony, gallery, or platform elevated and arranged so as to exclude unqualified persons
(4) By elevation of 8 ft (2.44 m) or more above the floor or other working surface

3-10.4.7.2 Prevent Physical Damage. In locations where electric equipment is likely to be exposed to physical damage, enclosures or guards shall be so arranged and of such strength as to prevent such damage.

3-10.4.7.3 Warning Signs. Entrances to rooms and other guarded locations that contain exposed live parts shall be marked with conspicuous warning signs forbidding unqualified persons to enter.

3-10.4.8 Guards for Attendants. Where live parts of motors or controllers operating at over 150 volts to ground are guarded against accidental contact only by location, and where adjustment or other attendance might be necessary during the operation of the apparatus, suitable insulating mats or platforms shall be provided so that the attendant cannot readily touch live parts unless standing on the mats or platforms.

3-10.5 Transformers.

3-10.5.1 Paragraphs 3-10.5.2 through 3-10.5.6 cover the installation of all transformers. The following transformers are not covered by 3-10.5.

(1) Current transformers
(2) Dry-type transformers that constitute a component part of other apparatus and comply with requirements for such apparatus
(3) Transformers that are an integral part of an X-ray, high-frequency, or electrostatic-coating apparatus
(4) Transformers used with Class 2 and Class 3 circuits
(5) Transformers used for sign and outline lighting
(6) Transformers for electric-discharge lighting
(7) Transformers used for power-limited fire alarm circuits
(8) Transformers used for research, development, or testing, where effective arrangements are provided to safeguard persons from contacting energized parts

3-10.5.2 Voltage Warning. The operating voltage of exposed live parts of transformer installations shall be indicated by signs or visible markings on the equipment or structures.

3-10.5.3 Dry-Type Transformers Installed Indoors. Dry-type transformers installed indoors and rated over 35 kV shall be installed in a vault.

3-10.5.4 Oil-Insulated Transformers Installed Indoors. Oil-insulated transformers installed indoors shall be installed in a vault.

3-10.5.5 Oil-Insulated Transformers Installed Outdoors. Combustible material, combustible buildings, and parts of buildings, fire escapes, and door and window openings shall be safeguarded from fires originating in oil-insulated transformers installed on roofs, attached to or adjacent to a building or combustible material.

3-10.5.6 Doorways. Vault doorways shall be protected as follows:

(a) **Type of Door.** Each doorway leading into a vault from the building interior shall be provided with a tight-fitting door that has a minimum fire rating of 3 hours. The authority having jurisdiction shall be permitted to require such a door for an exterior wall opening where conditions warrant.

Exception: Where transformers are protected with automatic sprinkler, water spray, carbon dioxide, or halon, construction of 1-hour rating shall be permitted.

(b) **Sills.** A door sill or curb that is of sufficient height to confine the oil from the largest transformer within the vault shall be provided, and in no case shall the height be less than 4 in. (102 mm).

(c) **Locks.** Doors shall be equipped with locks, and doors shall be kept locked, access being allowed only to qualified persons. Personnel doors shall swing out and be equipped with panic bars, pressure plates, or other devices that are normally latched but open under simple pressure.

3-10.5.7 Water Pipes and Accessories. Any pipe or duct system foreign to the electrical installation shall not enter or pass through a transformer vault. Piping or other facilities provided for vault fire protection, or for transformer cooling, shall not be considered foreign to the electrical installation.

3-10.5.8 Storage in Vaults. Materials shall not be stored in transformer vaults.

3-10.6 Capacitors.

3-10.6.1 Switching.

3-10.6.1.1 Load Current. Group-operated switches shall be used for capacitor switching and shall be capable of the following:

(1) Carrying continuously not less than 135 percent of the rated current of the capacitor installation
(2) Interrupting the maximum continuous load current of each capacitor, capacitor bank, or capacitor installation that will be switched as a unit

(3) Withstanding the maximum inrush current, including contributions from adjacent capacitor installations

(4) Carrying currents due to faults on capacitor side of switch

3-10.6.1.2 Isolation.

3-10.6.1.2.1 A means shall be installed to isolate from all sources of voltage each capacitor, capacitor bank, or capacitor installation that will be removed from service as a unit.

3-10.6.1.2.2 The isolating means shall provide a visible gap in the electrical circuit adequate for the operating voltage.

3-10.6.1.2.3 Isolating or disconnecting switches (with no interrupting rating) shall be interlocked with the load-interrupting device or shall be provided with prominently displayed caution signs to prevent switching load current.

3-10.6.1.3 Additional Requirements for Series Capacitors. The proper switching sequence shall be ensured by use of one of the following:

(1) Mechanically sequenced isolating and bypass switches

(2) Interlocks

(3) Switching procedure prominently displayed at the switching location

3-10.7 Storage Batteries. Provisions shall be made for sufficient diffusion and ventilation of the gases from the battery to prevent the accumulation of an explosive mixture.

Chapter 4 Specific Purpose Equipment and Installations

4-1 Electric Signs and Outline Lighting.

4-1.1 Disconnects. Each sign and outline lighting system, or feeder circuit or branch circuit supplying a sign or outline lighting system, shall be controlled by an externally operable switch or circuit breaker that will open all ungrounded conductors. Signs and outline lighting systems located within fountains shall have the disconnect located at least 5 ft (1.52 m) from the inside walls of the fountain.

Exception No. 1: A disconnecting means shall not be required for an exit directional sign located within a building.

Exception No. 2: A disconnecting means shall not be required for cord-connected signs with an attachment plug.

4-1.2 Location. The disconnecting means shall be within sight of the sign or outline lighting system that it controls. Where the disconnecting means is out of the line of sight from any section that may be energized, the disconnecting means shall be capable of being locked in the open position.

Signs or outline lighting systems operated by electronic or electromechanical controllers located external to the sign or outline lighting system shall be permitted to have a disconnecting means located within sight of the controller or in the same enclosure with the controller. The disconnecting means shall disconnect the sign or outline lighting system and the controller from all ungrounded supply conductors. It shall be designed so no pole can be operated independently and shall be capable of being locked in the open position.

4-2 Cranes and Hoists.

4-2.1 Disconnecting Means.

4-2.1.1 Runway Conductor Disconnecting Means. A disconnecting means shall be provided between the runway contact conductors and the power supply. Such disconnecting means shall consist of a motor-circuit switch, circuit breaker, or molded case switch. The disconnecting means shall be as follows:

(1) Readily accessible and operable from the ground or floor level

(2) Arranged to be locked in the open position

(3) Open all ungrounded conductor simultaneously

(4) Placed within view of the runway contact conductors

4-2.1.2 Disconnecting Means for Cranes and Monorail Hoists. A motor circuit switch or circuit breaker arranged to be locked in the open position shall be provided in the leads from the runway contact conductors or other power supply on all cranes and monorail hoists. A motor-circuit switch, circuit breaker, or molded case switch arranged to be locked in the open position shall be provided.

Where a monorail hoist or hand-propelled crane bridge installation meets all of the following, the disconnecting means shall be permitted to be omitted.

(1) The unit is controlled from the ground or floor level.

(2) The unit is within view of the power supply disconnecting means.

(3) No fixed work platform has been provided for servicing the unit.

Where the disconnecting means is not readily accessible from the crane or monorail hoist operating station, means shall be provided at the operating station to open the power circuit to all motors of the crane or monorail hoist.

4-2.2 Limit Switch. A limit switch or other device shall be provided to prevent the load block from passing the safe upper limit of travel of all hoisting mechanisms.

4-2.3 Clearance. The dimension of the working space in the direction of access to live parts that are likely to require examination, adjustment, servicing, or maintenance while energized shall be a minimum of $2^1/_2$ ft (762 mm). Where controls are enclosed in cabinets, the door(s) shall either open at least 90 degrees or be removable.

4-3 Elevators, Dumbwaiters, Escalators, Moving Walks, Wheelchair Lifts, and Stairway Chair Lifts.

4-3.1 Disconnecting Means. A single means for disconnecting all ungrounded main power supply conductors for each unit shall be provided and be designed so that no pole can be operated independently. Where multiple driving machines are connected to a single elevator, escalator, moving walk, or pumping unit, there shall be one disconnecting means to disconnect the motor(s) and control valve operating magnets.

The disconnecting means for the main power supply conductors shall not disconnect the branch circuit.

Branch circuit supplying such items as

(1) Car lighting, receptacle(s), ventilation, heating, and air conditioning

(2) Machine room/machinery space lighting and receptacle(s)

(3) Hoistway pit lighting and receptacle(s)

4-3.1.1 Type. The disconnecting means shall be an enclosed externally operable fused motor circuit switch or circuit breaker capable of being locked in the open position. The disconnecting means shall be a listed device.

4-3.1.2 Operation. No provision shall be made to open or close this disconnecting means from any other part of the premises. If sprinklers are installed in hoistways, machine rooms, or machinery spaces, the disconnecting means shall be permitted to automatically open the power supply to the affected elevator(s) prior to the application of water. No provision shall be made to automatically close this disconnecting means. Power shall only be restored by manual means.

4-3.1.3 Location. The disconnecting means shall be located where it is readily accessible to qualified persons.

(a) **On Elevators Without Generator Field Control.** On elevators without generator field control, the disconnecting means shall be located within sight of the motor controller. Driving machines or motion and operation controllers not within sight of the disconnecting means shall be provided with a manually operated switch installed in the control circuit to prevent starting. The manually operated switch(s) shall be installed adjacent to this equipment.

Where the driving machine is located in a remote machinery space, a single disconnecting means for disconnecting all ungrounded main power supply conductors shall be provided and be capable of being locked in the open position.

(b) **On Elevators with Generator Field Control.** On elevators with generator field control, the disconnecting means shall be located within sight of the motor controller for the driving motor of the motor-generator set. Driving machines, motor-generator sets, or motion and operation controllers not within sight of the disconnecting means shall be provided with a manually operated switch installed in the control circuit to prevent starting. The manually operated switch(s) shall be installed adjacent to this equipment.

Where the driving machine or the motor-generator set is located in a remote machinery space, a single means for disconnecting all ungrounded main power supply conductors shall be provided and be capable of being locked in the open position.

(c) **On Escalators and Moving Walks.** On escalators and moving walks, the disconnecting means shall be installed in the space where the controller is located.

(d) **On Wheelchair Lifts and Stairway Chair Lifts**. On wheelchair lifts and stairway chair lifts, the disconnecting means shall be located within sight of the motor controller.

4-3.1.4 Identification and Signs. Where there is more than one driving machine in a machine room, the disconnecting means shall be numbered to correspond to the identifying number of the driving machine that they control.

The disconnecting means shall be provided with a sign to identify the location of the supply side overcurrent protective device.

4-3.2 Single-Car and Multicar Installations. On single-car and multicar installations, equipment receiving electrical power from more than one source shall be provided with a disconnecting means for each source of electrical power. The disconnecting means shall be within sight of the equipment served.

4-3.3 Warning Sign for Multiple Disconnecting Means. Where multiple disconnecting means are used and parts of the controllers remain energized from a source other than the one disconnected, a warning sign shall be mounted on or next to the disconnecting means. The sign shall be clearly legible and shall read "WARNING — PARTS OF THE CONTROLLER ARE NOT DE-ENERGIZED BY THIS SWITCH."

4-3.4 Interconnection Multicar Controllers. Where interconnections between controllers are necessary for the operation of the system on multicar installations that remain energized from a source other than the one disconnected, a warning sign in accordance with 4-3.3 shall be mounted on or next to the disconnecting means.

4-3.5 Motor Controllers. Motor controllers shall be permitted outside the spaces herein specified, provided they are in enclosures with doors or removable panels capable of being locked in the closed position and the disconnecting means is located adjacent to or is an integral part of the motor controller. Motor controller enclosures for escalator or moving walks shall be permitted in the balustrade on the side located away from the moving steps or moving treadway. If the disconnecting means is an integral part of the motor controller, it shall be operable without opening the enclosure.

4-4 Electric Welders — Disconnecting Means.

4-4.1 Arc Welders. A disconnecting means shall be provided in the supply circuit for each arc welder that is not equipped with a disconnect mounted as an integral part of the welder.

The disconnecting means shall be a switch or circuit breaker, and its rating shall not be less than that necessary to accommodate overcurrent protection.

4-4.2 Resistance Welder. A switch or circuit breaker shall be provided by which each resistance welder and its control equipment can be disconnected from the supply circuit. The ampere rating of this disconnecting means shall not be less than the supply conductor ampacity. The supply circuit switch shall be permitted as the welder disconnecting means where the circuit supplies only one welder.

4-5 Information Technology Equipment — Disconnecting Means.

4-5.1 Disconnecting Means. A means shall be provided to disconnect power to all electronic equipment in the information technology equipment room. There shall also be a similar means to disconnect the power to all dedicated HVAC systems serving the room and cause all required fire/smoke dampers to close. The control for these disconnecting means shall be grouped and identified and shall be readily accessible at the principal exit doors. A single means to control both the electronic equipment and HVAC system shall be permitted.

4-6 X-Ray Equipment.

4-6.1 Disconnecting Means.

4-6.1.1 Disconnecting Means. A disconnecting means of adequate capacity for at least 50 percent of the input required for the momentary rating or 100 percent of the input required for the long-time rating of the X-ray equipment, whichever is greater, shall be provided in the supply circuit. The disconnecting means shall be operable from a location readily accessible from the X-ray control. For equipment connected to a 120-volt, nominal, branch circuit of 30 amperes or less, a grounding-type attachment plug cap and receptacle of proper rating shall be permitted to serve as a disconnecting means.

4-6.1.2 Independent Control. Where more than one piece of equipment is operated from the same high-voltage circuit, each piece or each group of equipment as a unit shall be provided with a high-voltage switch or equivalent disconnecting means. This disconnecting means shall be constructed, enclosed, or located so as to avoid contact by persons with its live parts.

4-6.2 Control — Industrial and Commercial Laboratory Equipment.

4-6.2.1 Radiographic and Fluoroscopic Types. All radiographic- and fluoroscopic-type equipment shall be effectively enclosed or shall have interlocks that de-energize the equipment automatically to prevent ready access to live current-carrying parts.

4-6.2.2 Diffraction and Irradiation Types. Diffraction- and irradiation-type equipment or installations not effectively enclosed or provided with interlocks to prevent access to live current-carrying parts during operation shall be provided with a positive means to indicate when they are energized. The indicator shall be a pilot light, readable meter deflection, or equivalent means.

4-7 Induction and Dielectric Heating.

4-7.1 Scope. Paragraphs 4-7.2 through 4-7.3 cover the construction and installation of induction and dielectric heating equipment and accessories for industrial and scientific applications, but not for medical or dental applications appliances, or line frequency pipelines and vessels heating.

4-7.2 Guarding, Grounding, and Labeling.

4-7.2.1 Enclosures. The converting apparatus (including the dc line) and high-frequency electric circuits (excluding the output circuits and remote-control circuits) shall be completely contained within an enclosure or enclosures of noncombustible material.

4-7.2.2 Panel Controls. All panel controls shall be of deadfront construction.

4-7.2.3 Access to Internal Equipment. Doors or detachable panels shall be employed for internal access. Where doors are used giving access to voltages from 500 to 1000 volts ac or dc, either door locks shall be provided or interlocks shall be installed. Where doors are used giving access to voltages of over 1000 volts ac or dc, either mechanical lockouts with a disconnecting means to prevent access until voltage is removed from the cubicle, or both door interlocking and mechanical door locks, shall be provided. Detachable panels not normally used for access to such parts shall be fastened in a manner that will make them inconvenient to remove.

4-7.2.4 Warning Labels or Signs. Warning labels or signs that read "DANGER — HIGH VOLTAGE — KEEP OUT" shall be attached to the equipment and shall be plainly visible where unauthorized persons might come in contact with energized parts, even when doors are open or when panels are removed from compartments containing over 250 volts ac or dc.

4-7.2.5 Work Applicator Shielding. Protective cages or adequate shielding shall be used to guard work applicators other than induction heating coils. Induction heating coils shall be permitted to be protected by insulation or refractory materials, or both. Interlock switches shall be used on all hinged access doors, sliding panels, or other easy means of access to the applicator. All interlock switches shall be connected in such a manner as to remove all power from the applicator when any one of the access doors or panels is open. Interlocks on access doors or panels shall not be required if the applicator is an induction heating coil at dc ground potential or operating at less than 150 volts ac.

4-7.2.6 Disconnecting Means. A readily accessible disconnecting means shall be provided by which each heating equipment can be isolated from its supply circuit. The ampere rating of this disconnecting means shall not be less than the nameplate current rating of the equipment. The supply circuit disconnecting means shall be permitted as a heating equipment disconnecting means where the circuit supplies only one equipment.

4-7.3 Remote Control.

4-7.3.1 Selector Switch. Where remote controls are used for applying power, a selector switch shall be provided and interlocked to provide power from only one control point at a time.

4-7.3.2 Foot Switches. Switches by foot pressure shall be provided with a shield over the contact button to avoid accidental closing of a switch.

4-8 Electrolytic Cells.

4-8.1 Scope. These provisions for electrolytic cells shall apply to the installation of the electrical components and accessory equipment of electrolytic cells, electrolytic cell lines, and process power supply for the production of aluminum, cadmium, chlorine, copper, fluorine, hydrogen peroxide, magnesium, sodium, sodium chlorate, and zinc.

These provisions do not cover cells used as a source of electric energy and for electroplating processes and cells used for the production of hydrogen.

4-8.2 Definitions Applicable to Section 4-8, Electrolytic Cells.

4-8.2.1 Cell, Electrolytic. A tank or vat in which electrochemical reactions are caused by applying energy for the purpose of refining or producing usable materials.

4-8.2.2 Cell Line. An assembly of electrically interconnected electrolytic cells supplied by a source of direct current power.

4-8.2.3 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 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.

4-8.2.4 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.

4-8.3 Application. Electrolytic cell lines shall comply with the provisions of Chapters 1 through 4 of Part I, except as follows:

(1) The electrolytic cell line conductors shall not be required to comply with the provisions of Chapter 1 and Sections 2-2 and 2-3 of Part I.

(2) Overcurrent protection of electrolytic cell dc process power circuits shall not be required to comply with the requirements of Section 2-5 of Part I.
(3) Equipment located or used within the electrolytic cell line working zone or associated with the cell line dc power circuits shall not be required to comply with the provisions of Section 2-6 of Part I.
(4) The electrolytic cells, cell line attachments, and the wiring of auxiliary equipments and devices within the cell line working zone shall not be required to comply with the provisions of Chapter 1 and Sections 2-2 and 2-3 of Part I.

4-8.4 Disconnecting Means.

4-8.4.1 More Than One Process Power Supply. Where more than one dc cell line process power supply serves the same cell line, a disconnecting means shall be provided on the cell line circuit side of each power supply to disconnect it from the cell line circuit.

4-8.4.2 Removable Links or Conductors. Removable links or removable conductors shall be permitted to be used as the disconnecting means.

4-8.5 Portable Electric Equipment.

4-8.5.1 Portable Electrical Equipment Not to Be Grounded. The frames and enclosures of portable electric equipment used within the cell line working zone shall not be grounded.

Exception No. 1: Where the cell line voltage does not exceed 200 volts dc, these frames and enclosures shall be permitted to be grounded.

Exception No. 2: These frames and enclosures shall be permitted to be grounded where guarded.

4-8.5.2 Marking. Ungrounded portable electric equipment shall be distinctively marked and shall employ plugs and receptacles of a configuration that prevents connection of this equipment to grounding receptacles and that prevents inadvertent interchange of ungrounded and grounded portable electrical equipments.

4-8.6 Power Supply Circuits and Receptacles for Portable Electric Equipment.

4-8.6.1 Isolated Circuits. Circuits supplying power to ungrounded receptacles for hand-held, cord-connected equipments shall be electrically isolated from any distribution system supplying areas other than the cell line working zone and shall be ungrounded. Power for these circuits shall be supplied through isolating transformers. Primaries of such transformers shall operate at not more than 600 volts between conductors and shall be provided with proper overcurrent protection. The secondary voltage of such transformers shall not exceed 300 volts between conductors, and all circuits supplied from such secondaries shall be ungrounded and shall have an approved overcurrent device of proper rating in each conductor.

4-8.6.2 Noninterchangeability. Receptacles and their mating plugs for ungrounded equipment shall not have provision for a grounding conductor and shall be of a configuration that prevents their use for equipment required to be grounded.

4-8.6.3 Marking. Receptacles on circuits supplied by an isolating transformer with an ungrounded secondary shall be a distinctive configuration, distinctively marked, and shall not be used in any other location in the plant.

4-8.7 Fixed and Portable Electrical Equipment.

4-8.7.1 Electrical Equipment Not Required to Be Grounded. AC systems supplying fixed and portable electric equipments within the cell line working zone shall not be required to be grounded.

4-8.7.2 Exposed Conductive Surfaces Not Required to Be Grounded. Exposed conductive surfaces, such as electric equipment housings, cabinets, boxes, motors, raceways, and the like, that are within the cell line working zone shall not be required to be grounded.

4-8.7.3 Wiring Methods. Auxiliary electrical equipment such as motors, transducers, sensors, control devices, and alarms, mounted on an electrolytic cell or other energized surface, shall be connected to premises wiring systems by any of the following means:

(a) Multiconductor hard usage cord

(b) Wire or cable in suitable raceways or metal or nonmetallic cable trays. If metal conduit, cable tray, armored cable, or similar metallic systems are used, they shall be installed with insulating breaks such that they will not cause a potentially hazardous electrical condition.

4-8.7.4 Circuit Protection. Circuit protection shall not be required for control and instrumentation that are totally within the cell line working zone.

4-8.7.5 Bonding. Bonding of fixed electric equipment to the energized conductive surfaces of the cell line, its attachments, or auxiliaries shall be permitted. Where fixed electric equipment is mounted on an energized conductive surface, it shall be bonded to that surface.

4-8.8 Auxiliary Nonelectric Connections. Auxiliary nonelectric connections, such as air hoses, water hoses, and the like, to an electrolytic cell, its attachments, or auxiliary equipments shall not have continuous conductive reinforcing wire, armor, braids, and the like. Hoses shall be of a nonconductive material.

4-8.9 Cranes and Hoists.

4-8.9.1 Conductive Surfaces to Be Insulated from Ground. The conductive surfaces of cranes and hoists that enter the cell line working zone shall not be required to be grounded. The portion of an overhead crane or hoist that contacts an energized electrolytic cell or energized attachments shall be insulated from ground.

4-8.9.2 Hazardous Electrical Conditions. Remote crane or hoist controls that may introduce hazardous electrical conditions into the cell line working zone shall employ one or more of the following systems:

(1) Isolated and ungrounded control circuit in accordance with 4-8.6.1
(2) Nonconductive rope operator
(3) Pendant pushbutton with nonconductive supporting means and having nonconductive surfaces or ungrounded exposed conductive surfaces
(4) Radio

4-9 Electrically Driven or Controlled Irrigation Machines.

4-9.1 Lightning Protection. If an irrigation machine has a stationary point, a grounding electrode system shall be connected to the machine at the stationary point for lightning protection.

4-9.2 Main Disconnecting Means. The main disconnecting means for the machine shall provide overcurrent protection and shall be at the point of connection of electrical power to the machine or shall be visible and not more than 50 ft (15.2 m) from the machine and shall be readily accessible and capable of being locked in the open position. The disconnecting means shall have a horsepower and current rating not less than required for the main controller.

4-10 Swimming Pools, Fountains, and Similar Installations.

4-10.1 Scope. Paragraphs 4-10.2 through 4-10.5 shall apply to the construction and installation of electric wiring for and equipment in or adjacent to all swimming, wading, therapeutic, and decorative pools, fountains, hot tubs, spas, and hydromassage bathtubs, whether permanently installed or storable, and to metallic auxiliary equipment, such as pumps, filters, and similar equipment. Therapeutic pools in health care facilities shall be exempt from these provisions.

4-10.2 Receptacles.

4-10.2.1 A receptacle(s) that provides power for a water-pump motor(s) for, or other loads directly related to the circulation and sanitation system, a permanently installed pool or fountain, shall be permitted between 5 ft (1.52 m) and 10 ft (3.05 m) from the inside walls of the pool or fountain, and, where so located, shall be single and of the locking and grounding types and shall be protected by a ground-fault circuit interrupter(s).

Other receptacles on the property shall be located at least 10 ft (3.05 m) from the inside walls of a pool or fountain.

4-10.2.2 Where a permanently installed pool is installed at a dwelling unit(s), at least one 125-volt, 15- or 20-ampere receptacle on a general-purpose branch circuit shall be located a minimum of 10 ft (3.05 m) and not more than 20 ft (6.08 m) from the inside wall of the pool. This receptacle shall be located not more than 6 ft 6 in. (1.98 m) above the floor, platform, or grade level serving the pool.

4-10.2.3 All 125-volt receptacles located within 20 ft (6.08 m) of the inside walls of a pool or fountain shall be protected by a ground-fault circuit interrupter.

NOTE: In determining the above dimensions, the distance to be measured is the shortest path the supply cord of an appliance connected to the receptacle would follow without piercing a floor, wall, ceiling, doorway with hinged or sliding door, window opening, or other effective permanent barrier.

4-10.3 Lighting Fixtures, Lighting Outlets, and Ceiling Suspended (Paddle) Fans.

4-10.3.1 In outdoor pool areas, lighting fixtures, lighting outlets, and ceiling-suspended (paddle) fans shall not be installed over the pool or over the area extending 5 ft (1.52 m) horizontally from the inside walls of a pool unless no part of the lighting fixture of ceiling-suspended (paddle) fan is less than 12 ft (3.66 m) above the maximum water level.

4-10.3.2 Existing lighting fixtures and lighting outlets located less than 5 ft (1.52 m) measured horizontally from the inside walls of a pool shall be at least 5 ft (1.52 m) above the surface of the maximum water level, shall be rigidly attached to the existing structure, and shall be protected by a ground-fault circuit interrupter.

4-10.3.3 In indoor pool areas, the limitations of 4-10.3.1 shall not apply if all of the following conditions are complied with:

(1) Fixtures are of a totally enclosed type.
(2) A ground-fault circuit interrupter is installed in the branch circuit supplying the fixture(s) or ceiling-suspended (paddle) fans.
(3) The distance from the bottom of the fixture or ceiling-suspended (paddle) fan to the maximum water level is not less than 7 ft 6 in. (2.29 m).

4-10.3.4 Lighting fixtures and lighting outlets installed in the area extending between 5 ft (1.52 m) and 10 ft (3.05 m) horizontally from the inside walls of a pool shall be protected by a ground-fault circuit interrupter unless installed 5 ft (1.52 m) above the maximum water level and rigidly attached to the structure adjacent to or enclosing the pool.

4-10.3.5 Cord-connected lighting fixtures shall meet the same specifications as other cord- and plug-connected equipment where installed within 16 ft (4.88 m) of any point on the water surface, measured radially.

4-10.4 Underwater Equipment.

4-10.4.1 The design of an underwater lighting fixture supplied from a branch circuit either directly or by way of a transformer shall be such that, where the fixture is properly installed without a ground-fault circuit interrupter, there is no shock hazard with any likely combination of fault conditions during normal use (not relamping).

In addition, a ground-fault circuit interrupter shall be installed in the branch circuit supplying fixtures operating at more than 15 volts, so that there is no shock hazard during relamping. The installation of the ground-fault circuit interrupter shall be such that there is no shock hazard with any likely fault-condition combination that involves a person in a conductive path from any ungrounded part of the branch circuit or the fixture to ground.

Compliance with this requirement shall be obtained by the use of a listed underwater lighting fixture and by installation of a listed ground-fault circuit interrupter in the branch circuit.

4-10.4.2 No lighting fixture shall be installed for operation on supply circuits over 150 volts between conductors.

4-10.4.3 Lighting fixtures mounted in walls shall be installed with the top of the fixture lens at least 18 in. (457 mm) below the normal water level of the pool, unless the lighting fixture is listed and identified for the use at a depth of not less than 4 in. (102 mm) below the normal water level of the pool.

4-10.4.4 A lighting fixture facing upward shall have the lens adequately guarded to prevent contact by any person.

4-10.4.5 Fixtures that depend on submersion for safe operation shall be inherently protected against the hazards of overheating when not submerged.

4-10.5 Fountains.

4-10.5.1 Ground-Fault Circuit Interrupter. A ground-fault circuit interrupter shall be installed in the branch circuit supplying fountain equipment unless the equipment is listed for operation at 15 volts or less and is supplied by a transformer.

4-10.6 Spas and Hot Tubs.

4-10.6.1 Protection. An outlet that supplies a self-contained spa or hot tub, or a packaged spa or hot tub equipment assembly, shall be protected by a ground-fault circuit interrupter.

4-11 Carnivals, Circuses, Fairs, and Similar Events.

4-11.1 General Requirements.

4-11.1.1 Scope. This section covers the installation of portable wiring and equipment for carnivals, circuses, exhibitions, fairs, traveling attractions, and similar functions, including wiring in or on all structures.

4-11.1.2 Portable Wiring and Equipment. Wherever the requirements of other chapters of Part I and Section 4-11 differ, the requirements of Section 4-11 shall apply to the portable wiring and equipment.

4-11.1.3 Protection of Electrical Equipment. Electrical equipment and wiring methods in or on rides, concessions, or other units shall be provided with mechanical protection where such equipment or wiring methods are subject to physical damage.

4-11.2 Installation.

4-11.2.1 Services.

4-11.2.1.1 Separately Derived Systems.

4-11.2.1.1.1 Generators and Transformers. Generators and transformers shall comply with applicable requirements of Part I of this standard.

4-11.2.1.1.2 Services. Services shall be installed in accordance with applicable requirements of Section 2-4 of Part I, and, in addition, shall comply with the following:

(1) *Guarding.* Service equipment shall not be installed in a location that is accessible to unqualified persons, unless the equipment is lockable.
(2) *Mounting and Location.* Service equipment shall be mounted on solid backing and be installed so as to be protected from the weather, unless of weatherproof construction.

4-11.2.2 Overhead Conductor Clearances.

4-11.2.2.1 Vertical Clearances. Conductors shall have a vertical clearance to ground in accordance with 2-3.2 of Part I. These clearances shall apply only to wiring installed outside of tents and concessions.

4-11.2.2.2 Clearance to Rides and Attractions. Amusement rides and amusement attractions shall be maintained not less than 15 ft (4.57 m) in any direction from overhead conductors operating at 600 volts or less, except for the conductors supplying the amusement ride or attraction. Amusement rides or attractions shall not be located under or within 15 ft (4.57 m) horizontally of conductors operating in excess of 600 volts.

4-11.2.3 Wiring Methods.

4-11.2.3.1 Type. Unless otherwise provided for in this standard, wiring methods shall comply with applicable requirements of Chapters 1 through 4 of Part I of this standard. Where flexible cords or cables are used and are not subject to physical damage, they shall be permitted to be listed for extra-hard usage. When used outdoors, flexible cords and cables shall also be listed for wet locations and shall be sunlight resistant.

4-11.2.3.2 Single Conductor. Single conductor cable shall be permitted only in size No. 2 or larger.

4-11.2.3.3 Open Conductors. Open conductors are prohibited except as part of a listed assembly or festoon lighting installed in accordance with Section 2-3 of Part I.

4-11.2.3.4 Splices. Flexible cords or cables shall be continuous without splice or tap between boxes or fittings. Cord connectors shall not be laid on ground unless listed for wet locations. Connectors and cable connections shall not be placed in audience traffic paths or within areas accessible to the public unless guarded.

4-11.2.3.5 Support. Wiring for an amusement ride, attraction, tent, or similar structure shall not be supported by another ride or structure unless specifically designed for the purpose.

4-11.2.3.6 Protection. Flexible cords or cables run on the ground, where accessible to the public, shall be covered with approved nonconductive mats. Cables and mats shall be arranged so as not to present a tripping hazard.

4-11.2.3.7 Inside Tents and Concessions. Electrical wiring for temporary lighting, where installed inside of tents and concessions, shall be securely installed, and, where subject to physical damage, shall be provided with mechanical protection. All temporary lamps for general illumination shall be protected from accidental breakage by a suitable fixture or lampholder with a guard.

4-11.2.4 Boxes and Fittings. A box or fitting shall be installed at each connection point, outlet, switchpoint, or junction point.

4-11.2.5 Portable Distribution or Termination Boxes. Portable distribution or termination boxes shall comply with 4-11.2.5.1 through 4-11.2.5.4.

4-11.2.5.1 Construction. Boxes shall be designed so that no live parts are exposed to accidental contact. Where installed outdoors the box shall be of weatherproof construction and mounted so that the bottom of the enclosure is not less 6 in. (152 mm) above the ground.

4-11.2.5.2 Busbars and Terminals. Busbars shall have an ampere rating not less than the overcurrent device supplying the feeder supplying the box. Where conductors terminate directly on busbars, busbar connectors shall be provided.

4-11.2.5.3 Receptacles and Overcurrent Protection. Receptacles shall have overcurrent protection installed within the box. The overcurrent protection shall not exceed the ampere rating of the receptacle, except as permitted in 3-10.4 of Part I for motor loads.

4-11.2.5.4 Single-Pole Connectors. Where single-pole connectors are used, they shall comply with the following:

(a) **General.** Where ac single-pole portable cable connectors are used, they shall be listed and of the locking type. Strain relief requirements and marking requirements other than those found in Section 4-11 of Part I, shall not apply to listed single-pole separable connections and single-conductor cable assemblies utilizing listed single-pole separable connectors. Where paralleled sets of current-carrying single-pole separable connectors are provided as input devices, they shall be prominently labeled with a warning indicating the presence of internal parallel connections. The use of single-pole separable connectors shall comply with at least one of the following conditions.

(1) Connection and disconnection of connectors are only possible where the supply connectors are interlocked to the source and it is not possible to connect or disconnect connectors when the supply is energized.

(2) Line connectors are of the listed sequential-interlocking type so that load connectors shall be connected in the following sequence:

a. Equipment grounding conductor connection
b. Grounded circuit-conductor connection, if provided
c. Ungrounded conductor connection, and that disconnection shall be in the reverse order

(3) A caution notice shall be provided adjacent to the line connectors indicating that plug connection shall be in the following order:

a. Equipment grounding conductor connectors
b. Grounded circuit-conductor connectors, if provided
c. Ungrounded conductor connectors, and that disconnection shall be in the reverse order

(b) **Interchangeability.** Single-pole separable connectors used in portable professional motion picture and television equipment shall be permitted to be interchangeable for ac or dc use or for different current ratings on the same premises provided they are listed for ac/dc use and marked in a suitable manner to identify the system to which they are connected.

4-11.2.6 Overcurrent Protection. Overcurrent protection of equipment and conductors shall be provided in accordance with Section 2-5 of Part I.

4-11.2.7 Motors. Motors and associated equipment shall be installed in accordance with 3-10.4.

4-11.2.8 Ground-Fault Circuit-Interrupter Protection for Personnel.

4-11.2.8.1 General-Use 15- and 20-Ampere, 125-Volt Receptacles. All 125-volt, single-phase, 15- and 20-ampere receptacle outlets that are in use by personnel shall have listed ground-fault circuit-interrupter protection for personnel. The ground-fault circuit interrupter shall be permitted to be an integral part of the attachment plug or located in the power-supply cord, within 12 in. (305 mm) of the attachment plug. For the purposes of this section, listed cord sets incorporating ground-fault circuit-interrupter protection for personnel shall be permitted. Egress lighting shall not be connected to the load side terminals of a ground-fault circuit-interrupter receptacle.

4-11.2.8.2 Appliance Receptacles. Receptacles supplying items, such as cooking and refrigeration equipment, which are incompatible with ground-fault circuit-interrupter devices shall not be required to have ground-fault circuit-interrupter protection.

4-11.2.8.3 Other Receptacles. Other receptacle outlets not covered in 4-11.2.8.1 and 4-11.2.8.2 shall be permitted to have ground-fault circuit-interrupter protection for personnel, or a written procedure shall be continuously enforced at the site by one or more designated persons to ensure the safety of equipment grounding conductors for all cord sets and receptacles.

4-11.3 Grounding and Bonding.

4-11.3.1 General. All system and equipment grounding shall be in accordance with Section 2-6 of Part I.

4-11.3.2 Equipment. The following equipment connected to the same source shall be bonded:

(1) Metal raceways and metal sheathed cable
(2) Metal enclosures of electrical equipment
(3) Metal frames and metal parts of rides, concessions, trailers, trucks, or other equipment that contain or support electrical equipment

4-11.3.3 Equipment Grounding Conductor. All equipment requiring grounding shall be grounded by an equipment grounding conductor. The equipment grounding conductor shall be bonded to the system grounded conductor at the service disconnecting means, or in the case of a separately derived system such as a generator, at the generator or first disconnecting means supplied by the generator. The grounded circuit conductor shall not be connected to the equipment grounding conductor on the load side of the service disconnecting means or on the load side of a separately derived system disconnecting means.

4-11.4 Disconnecting Means.

4-11.4.1 Type and Location. Each ride and concession shall be provided with a fused disconnect switch or circuit breaker located within sight and within 6 ft (1.83 m) of the operator's station. The disconnecting means shall be readily accessible to the operator, including when the ride is in operation. Where accessible to unqualified persons, the enclosure for the switch or circuit breaker shall be of the lockable type. A shunt trip device that opens the fused disconnect or circuit breaker when a switch located in the ride operator's console is closed shall be a permissible method of opening the circuit.

Chapter 5 Hazardous (Classified) Locations, Class I, II, and III, Divisions 1 and 2 and Class I, Zones 0, 1, and 2

5-1 Scope. This chapter shall cover the requirements for electric equipment and wiring in locations that are classified depending on the properties of the flammable vapors, liquids, or gases, or combustible dusts or fibers that might be present therein and the likelihood that a flammable or combustible concentration or quantity is present. Hazardous (classified) locations can be found in occupancies such as, but not limited to, aircraft hangars, gasoline dispensing and service stations, bulk storage plants for gasoline or other volatile flammable liquids, paint-finishing process plants, health care facilities, agricultural or other facilities where excessive combustible dusts might be present, marinas, boat yards, and petroleum and chemical processing plants. Each room, section, or area shall be considered individually in determining its classification. These classified locations shall be assigned six designations as follows.

5-1.1 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 ignitible mixtures. Class I locations include those specified in (a) and (b).

(a) **Class I, Division 1.** A Class I, Division 1 location is a location: (1) in which ignitible concentrations of flammable gases or vapors can exist under normal operating conditions; or (2) in which ignitible concentrations of such gases or vapors may exist frequently because of repair or maintenance operations or because of leakage; or (3) in which breakdown or faulty operation of equipment or processes might release ignitible concentrations of flammable gases or vapors, and might also cause simultaneous failure of electric equipment in such a way as to directly cause the electrical equipment to become a source of ignition.

NOTE 1: This classification usually includes the following locations: (1) Where volatile flammable liquids or liquefied flammable gases are transferred from one container to another; (2) interiors of spray booths and areas in the vicinity of spraying and painting operations where volatile flammable solvents are used; (3) locations containing open tanks or vats of volatile flammable liquids; (4) drying rooms or compartments for the evaporation of flammable solvents; (5) locations containing fat and oil extraction equipment using volatile flammable solvents; (6) portions of cleaning and dyeing plants where flammable liquids are used; (7) gas generator rooms and other portions of gas manufacturing plants where flammable gas may escape; (8) inadequately ventilated pump rooms for flammable gas or for volatile flammable liquids; (9) the interiors of refrigerators and freezers in which volatile flammable materials are stored in open, lightly stoppered, or easily ruptured containers; (10) and all other locations where ignitible concentrations of flammable vapors or gases are likely to occur in the course of normal operations.

NOTE 2: In some Division 1 locations, ignitible concentrations of flammable gases or vapors may be present continuously or for long periods of time. Examples include the following: (1) The inside of inadequately vented enclosures containing instruments normally venting flammable gases or vapors to the interior of the enclosure, (2) the inside of vented tanks containing volatile flammable liquids, (3) the area between the inner and outer roof sections of a floating roof tank containing volatile flammable fluids, (4) inadequately ventilated areas within spraying or coating operations using volatile flammable fluids, (5) and the interior of an exhaust duct that is used to vent ignitible concentrations of gases or vapors.

Experience has demonstrated the prudence of avoiding the installation of instrumentation or other electric equipment in these particular areas altogether or, where it cannot be avoided because it is essential to the process and other locations are not feasible using electric equipment or instrumentation approved for the specific application or consisting of intrinsically safe systems.

(b) **Class I, Division 2.** A Class I, Division 2 location is a location: (1) in which volatile flammable liquids or flammable gases are handled, processed, or used, but in which the liquids, vapors, or gases will normally be confined within closed containers or closed systems from which they can escape only in case of accidental rupture or breakdown of such containers or systems, or in case of abnormal operation of equipment; or (2) in which ignitible concentrations of gases or vapors are normally prevented by positive mechanical ventilation, and which might become hazardous through failure or abnormal operation of the ventilating equipment; or (3) that is adjacent to a Class I, Division 1 location, and to which ignitible 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 1: This classification usually includes locations where volatile flammable liquids or flammable gases or vapors are used but that, in the judgment of the authority having jurisdiction, 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.

NOTE 2: Piping without valves, checks, meters, and similar devices would not ordinarily introduce a hazardous condition even though used for flammable liquids or gases. Depending on factors such as the quantity and size of the containers and ventilation, locations used for the storage of flammable liquids or liquefied or compressed gases in sealed containers may either be considered hazardous (classified) or unclassified locations. See *Flammable and Combustible Liquids Code*, NFPA 30–1996, and *Liquefied Petroleum Gas Code*, NFPA 58–1998.

5-1.2 Class II Locations. Class II locations are those that are hazardous because of the presence of combustible dust. Class II locations include those specified in (a) and (b).

(a) **Class II, Division 1.** A Class II, Division 1 location is a location: (1) in which combustible dust is in the air under normal operating conditions in quantities sufficient to produce explosive or ignitible mixtures; or (2) where mechanical failure or abnormal operation of machinery or equipment might cause such explosive or ignitible mixtures to be produced, and might also provide a source of ignition through simultaneous failure of electric equipment, operation of protection devices, or from other causes; or (3) in which combustible dusts of an electrically conductive nature may be present in hazardous quantities.

NOTE: 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 woodflour, oil meal from beans and seed, dried hay, and other organic materials that may produce combustible dusts when processed or handled. Only Group E dusts are considered to be electrically conductive for classification purposes. Dusts containing magnesium or aluminum are particularly hazardous, and the use of extreme precaution will be necessary to avoid ignition and explosion.

(b) **Class II, Division 2.** A Class II, Division 2 location is a location where: (1) where combustible dust is not normally in the air in quantities sufficient to produce explosive or ignitible mixtures and dust accumulations are not normally 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 (2) where combustible dust accumulations on, in, or in the vicinity of the electrical equipment may be sufficient to interfere with the safe dissipation of heat from electrical equipment or may be ignitible by abnormal operation of failure of electrical equipment.

NOTE 1: The quantity of combustible dust that may be present and the adequacy of dust removal systems are factors that merit consideration in determining the classification and may result in an unclassified area.

NOTE 2: Where products such as seed are handled in a manner that produces low quantities of dust, the amount of dust deposited may not warrant classification.

5-1.3 Class III Locations. Class III locations are those that are hazardous because of the presence of easily ignitible 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 ignitible mixtures. Class III locations shall include those specified in (a) and (b).

(a) **Class III, Division 1.** A Class III, Division 1 location is a location in which easily ignitible fibers or materials producing combustible flyings are handled, manufactured, or used.

NOTE 1: Such locations usually include some parts of rayon, cotton, and other textile mills; combustible fiber manufacturing and processing plants; cotton gins and cottonseed mills; flax-processing plants; clothing manufacturing plants; woodworking plants; and establishments and industries involving similar hazardous processes or conditions.

NOTE 2: Easily ignitible 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.

(b) **Class III, Division 2.** A Class III, Division 2 location is a location in which easily ignitible fibers are stored or handled other than in the process of manufacture.

5-2 General.

5-2.1 Approval. Equipment shall be approved not only for the class of location but also for the ignitible or combustible properties of the specific flammable gases or vapors, combustible dust, or ignitible fibers or flyings that will be present.

NOTE: Chapter 5 of NFPA 70–1999, *National Electrical Code*, which is referenced in Appendix B, lists or defines flammable gases or vapors, and combustible dusts by "Groups" characterized by their ignitible or combustible properties.

5-2.2 Intrinsically Safe Equipment. Apparatus in which the circuits are not necessarily intrinsically safe themselves, but that affect the energy in the intrinsically safe circuits and are relied on to maintain intrinsic safety. Associated apparatus may be either of the following:

(1) Electrical apparatus that has an alternative-type protection for use in the appropriate hazardous (classified) location, or
(2) Electrical apparatus not so protected that shall not be used within a hazardous (classified) location

5-2.3 Conduits. All conduits shall be threaded and shall be made wrenchtight. Where it is impractical to make a threaded joint tight, a bonding jumper shall be utilized.

5-2.4 Marking. Approved equipment not covered in 5-2.4.1 through 5-2.4.5 shall be marked to show the class, group, and operating temperature or temperature range referenced to a 40°C ambient.

5-2.4.1 Equipment of the non-heat-producing type, such as junction boxes, conduit, and fittings, and equipment of the heat-producing type having a maximum temperature not more than 100°C (212°F), shall not be required to have a marked operating temperature or temperature range.

5-2.4.2 Fixed lighting fixtures marked for use in Class I, Division 2 or Class II, Division 2 locations only shall not be required to be marked to indicate the group.

5-2.4.3 Fixed general-purpose equipment in Class I locations, other than fixed lighting fixtures, that is acceptable for use in Class I, Division 2 locations shall not be required to be marked with the class, group, division, or operating temperature.

5-2.4.4 Fixed dusttight equipment other than fixed lighting fixtures that are acceptable for use in Class II, Division 2 and Class III locations shall not be required to be marked with class, group, division, or operating temperature.

5-2.4.5 Electric equipment suitable for ambient temperatures exceeding 40°C (104°F) shall be marked with both the maximum ambient temperature and the operating temperature or temperature range at that ambient temperature.

5-2.5 Equipment in Division 2 Locations. Equipment that has been approved for a Division 1 location shall be permitted in a Division 2 location of the same class and group.

NOTE: General-purpose equipment or equipment in general-purpose enclosures shall be permitted to be installed in Division 2 locations if the equipment does not constitute a source of ignition under normal operating conditions.

5-3 Electrical Installations. Equipment, wiring methods, and installations of equipment in a hazardous (classified) location shall be of a type and design that provides protection from the hazards arising from the combustibility and flammability of vapors, liquids, gases, dusts, or fibers.

NOTE: Chapter 5 of NFPA 70, *National Electrical Code*, which is referenced in Appendix B, contains guidelines that are appropriate for determining the type and design of equipment and installations that provide protection from the hazards arising from the combustibility and flammability of vapors, liquids, gases, dusts, or fibers. The guidelines in this referenced document address electric wiring and equipment and systems installed in hazardous (classified) locations and contain specific provisions for the following: wiring methods, wiring connections, conductor insulation, flexible cords, sealing and drainage, transformers, capacitors, switches, circuit breakers, fuses, motor controllers, receptacles, attachment plugs, meters, relays, instruments, resistors, generators, motors, lighting fixtures, storage battery charging equipment, electric cranes, electric hoists and similar equipment, utilization equipment, signaling systems, alarm systems, remote-control systems, local loudspeaker and communication systems, ventilating piping, live parts, lightning surge protection, and grounding.

5-4 Class I, Zone 0, 1, and 2 Locations.

5-4.1 Scope. This article covers the requirements for the zone classification system as an alternative to the division classification system for electrical and electronic equipment and wiring for all voltage in Class I, Zone 0, Zone 1, and Zone 2 hazardous (classified) locations where fire or explosion hazards may exist due to flammable gases, vapors, or liquids.

NOTE: For the requirements for electrical and electronic equipment and wiring for all voltages in Class I, Division 1 or Division 2; Class II, Division 1 or Division 2; and Class III, Division 1 or Division 2 hazardous (classified) locations where fire or explosion hazards may exist due to flammable gases or vapors, flammable liquids, or combustible dusts or fibers.

5-4.2 Other Articles. All other applicable rules contained in this standard shall apply to electrical equipment and wiring installed in hazardous (classified) locations.

Exception: As modified by this section.

5-4.3 Location and General Requirements.

5-4.3.1 Classification of Locations. Locations shall be classified depending on the properties of the flammable vapors, liquids, or gases that may be present and the likelihood that a flammable or combustible concentration or quantity is present. Where pyrophoric materials are the only materials used or handled, these locations shall not be classified.

Each room, section, or area shall be considered individually in determining its classification.

NOTE 1: See 5-4.6 for restrictions on area classification.

NOTE 2: Through the exercise of ingenuity in the layout of electrical installations for hazardous (classified) locations, it is frequently possible to locate much of the equipment in less hazardous or in nonhazardous locations and, thus, to reduce the amount of special equipment required.

5-4.3.2 Threading. All threaded conduit referred to herein shall be threaded with an NPT standard conduit cutting die that provides $^{3}/_{4}$-in. taper per foot. Such conduit shall be made wrenchtight to prevent sparking when fault current flows through the conduit system, and to ensure the explosionproof or flameproof integrity of the conduit system where applicable.

Equipment provided with threaded entries for field wiring connection shall be installed in accordance with (a) or (b).

(a) **Equipment Provided with Threaded Entries for NPT Threaded Conduit or Fittings.** For equipment provided with threaded entries for NPT threaded conduit or fittings, listed conduit, conduit fittings, or cable fittings shall be used.

(b) **Equipment Provided with Threaded Entries for Metric Threaded Conduit of Fittings.** For equipment with metric threaded entries, such entries shall be identified as being metric, or listed adaptors to permit connection to conduit of NPT-threaded fittings shall be provided with the equipment. Adapters shall be used for connection to conduit or NPT-threaded fittings. Listed cable fittings that have metric threads shall be permitted to be used.

NOTE: Threading specifications for metric threaded entries are located in *Metric Screw Threads*, ISO 965/1:1980, and *Metric Screw Threads*, ISO 965/3:1980.

5-4.4 Protection Techniques. The following shall be acceptable protection techniques for electrical and electronic equipment in hazardous (classified) locations.

NOTE: For additional information, see *Electrical Apparatus for Use in Class I, Zone 0, 1 Hazardous (Classified) Locations* — General Requirements, ISA S12.0.01-1997; *Electrical Equipment for Use in Class I, Zone 0, 1, and 2 Hazardous (Classified) Locations*, ANSI/UL 2279, 1997, and *Electrical apparatus for explosive gas atmospheres, part 0 — general requirements*, IEC 79-0-1983, Amendment No. 1 (1987), and Amendment No. 2 (1991).

(a) **Flameproof "d."** This protection technique shall be permitted for equipment in those Class I, Zone 1 locations for which it is approved.

NOTE 1: Flameproof is a type of protection of electrical equipment in which the enclosure will withstand an internal explosion of a flammable mixture that has penetrated into the interior, without suffering damage and without causing ignition, through any joints or structural openings in the enclosure, of an external explosive atmosphere consisting of one or more of the gases or vapors for which it is designed.

NOTE 2: For further information, see *Electrical Apparatus for Use in Class I, Zone 1 and 2 Hazardous (Classified) Locations, Type of Protection — Flameproof "d,"* ISA S 12.22.01-1996; *Electrical apparatus for explosive gas atmospheres, part 1 — construction and verification test of flameproof enclosures of electrical apparatus,* IEC 79-1-1990 and Amendment No. 1 (1993).

(b) **Purged and Pressurized.** This protection technique shall be permitted for equipment in those Class 1, Zone 1 or Zone 2 locations for which it is approved.

NOTE 1: In some cases, hazards may be reduced or hazardous (classified) locations limited or eliminated by adequate positive-pressure ventilation from a source of clean air in conjunction with effective safeguards against ventilation failure.

NOTE 2: For further information, see *Standard for Purged and Pressurized Enclosures for Electrical Equipment*, NFPA 496-1998.

NOTE 3: Pressurized "p" is a type of protection of electrical equipment that uses the technique of guarding against the ingress of the external atmosphere, which may be explosive, into an enclosure by maintaining a protective gas therein at a pressure above that of the external atmosphere. For further information, see *Electrical Apparatus for Explosive Gas Atmospheres — Part 2: Electrical Apparatus, Type of Protection "p,"* IEC 79-2-1983; and *Electrical Apparatus for Gas Atmospheres — Part 13: Construction and Use of Rooms or Buildings protected by pressurization*, IEC 79-13-1982.

(c) **Intrinsic Safety.** This protection technique shall be permitted for equipment in those Class I, Zone 0 or Zone 1 locations for which it is approved.

NOTE 1: Intrinsic Safety is designated type of protection "ia" by IEC 79-11 for use in Zone 0 locations. Intrinsic safety is designated type of protection "ib" by IEC 79-11 for use in Zone 1 locations.

NOTE 2: For further information, see *Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Hazardous Locations*, ANSI/UL 913-1997; *Electrical Apparatus for Explosive Gas Atmospheres, Part II — Instrinsic Safety "i,"* IEC 79-11-1991; and *Electrical apparatus for intrinsically safe circuits*, IEC 79-3-1990.

NOTE 3: Intrinsically safe associated apparatus, designated by [ia] or [ib], is connected to intrinsically safe equipment ("ia" or "ib" respectively), but is located outside the hazardous (classified) location unless also protected by another type of protection (such as flameproof).

(d) **Type of Protection "n."** This protection technique shall be permitted for equipment in those Class I, Zone 2 locations for which it is approved. Type of protection "n" is further subdivided into nA, nC, and nR.

NOTE 1: See Table 5-4.4(d) for the descriptions of subdivisions for type of protection "n."

NOTE 2: Type "n" protection is a type of protection applied to electrical equipment such that, in normal operation, the electrical equipment is not capable of igniting a surrounding explosive gas atmosphere and a fault capable of causing ignition is not likely to occur.

NOTE 3: For further information, see *Electrical apparatus for explosive gas atmospheres, part 15 — electrical apparatus with type of protection "n,"* IEC 79-15-1987.

(e) **Oil Immersion "o."** This protection technique shall be permitted for equipment in those Class I, Zone 1 locations for which it is approved.

NOTE 1: Oil immersion is a type of protection in which the electrical equipment or parts of the electrical equipment are immersed in a protective liquid in such a way that an explosive atmosphere that may be above the liquid or outside the enclosure cannot be ignited.

NOTE 2: For further information, see *Electrical Apparatus for Use in Class I, Zone 1 Hazardous (Classified) Locations, Type of Protection — Oil-Immersion "o,"* ISA S12.26.01 – 1996; and *Electrical apparatus for explosive gas atmospheres, part 6 — oil-immersion "o,"* IEC 79–6-1995.

Table 5-4.4(d) Types of Protection Designation

Designation	Technique	Zone*
d	Flameproof enclosure	1
e	Increased safety	1
ia	Intrinsic safety	0
ib	Intrinsic safety	1
[ia]	Intrinsically safe associated apparatus	Nonhazardous
[ib]	Intrinsically safe associated apparatus	Nonhazardous
m	Encapsulation	1
nA	Nonsparking equipment	2
nC	Sparking equipment in which the contacts are suitably protected other than by restricted breathing enclosure	2
nR	Restricted breathing enclosure	2
o	Oil immersion	1
p	Purged and pressurized	1 or 2
q	Powder filled	

*Does not address use where a combination of techniques is used.

(f) **Increased Safety "e."** This protection technique shall be permitted for equipment in those Class I, Zone 1 locations for which it is approved.

NOTE 1: Increased safety is a type of protection applied to electrical equipment that does not produce arcs or sparks in normal service and under specified abnormal conditions, in which additional measures are applied so as to give increased security against the possibility of excessive temperatures and of the occurrence of arcs or sparks.

NOTE 2: For further information, see *Electrical Apparatus for Use in Class I, Zone 1 Hazardous (Classified) Locations, Type of Protection — Increased Safety "e,"* ISA S12.16.01-1996; and *Electrical apparatus for explosive gas atmospheres, part 7 — increased safety "e,"* IEC 79-7-1990, Amendment No. 1 (1991) and Amendment No. 2 (1993).

(g) **Encapsulation "m."** This protection technique shall be permitted for equipment in those Class I, Zone 1 locations for which it is approved.

NOTE 1: Encapsulation is a type of protection in which the parts that could ignite an explosive atmosphere by either sparking or heating are enclosed in a compound in such a way that this explosive atmosphere cannot be ignited.

NOTE 2: For further information, see *Electrical Apparatus for Use in Class I, Zone 1 Hazardous (Classified) Locations, Type of Protection — Encapsulation "m,"* ISA S12.23.01-1996, and *Electrical apparatus for explosive gas atmospheres, part 18 — encapsulation "m,"* IEC 79-18-1992.

(h) **Powder Filling "q."** This protection technique shall be permitted for equipment in those Class I, Zone 1 locations for which it is approved.

NOTE 1: Powder filling is a type of protection in which the parts capable of igniting an explosive atmosphere are fixed in position and completely surrounded by filling material (glass or quartz powder) to prevent the ignition of an external explosive atmosphere.

NOTE 2: For further information, see *Electrical Apparatus for Use in Class I, Zone 1 Hazardous (Classified) Locations Type of Protection — Powder Filling "q,"* ISA S12.25.01-1996, and *Electrical Apparatus for Explosive Gas Atmospheres — Part 5: Powder Filling, Type of Protection "q,"* IEC 79-5-1967.

5-4.5 Reference Standards.

NOTE 1: It is important that the authority having jurisdiction be familiar with recorded industrial experience as well as with standards of the National Fire Protection Association, the American Petroleum Institute, and the International Society for Measurement and Control (ISA) that may be of use in the classification of various locations, the determination of adequate ventilation, and the protection against static electricity and lightning hazards.

NOTE 2: For further information on the classification of locations, see *Electrical Apparatus for Explosive Gas Atmospheres, Classification of Hazardous Areas*, IEC 79-10-1995; *Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, or Zone 2*, API RP 505-1996; *Electrical Apparatus for Explosive Gas Atmospheres, Classifications of Hazardous (Classified) Locations*, ISA S12.24.01-1997; and *Model Code of Safe Practice in the Petroleum Industry, Part 15: Area Classification Code for Petroleum Installations*, IP 15, The Institute of Petroleum, London.

NOTE 3: For further information on protection against static electricity and lightning hazards in hazardous (classified) locations, see *Recommended Practice on Static Electricity*, NFPA 77-1993; *Standard for the Installation of Lightning Protection Systems*, NFPA 780-1997; and *Protection Against Ignitions Arising Out of Static Lightning and Stray Currents*, API RP 2003-1991.

NOTE 4: For further information on ventilation, see *Flammable and Combustible Liquids Code*, NFPA 30-1996, and *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 or Division 2*, API RP 500-1997, Section 6.3.

NOTE 5: For further information on electrical systems for hazardous (classified) locations on offshore oil and gas-producing platforms, see Design and Installation of *Electrical Systems for Offshore Production Platforms*, ANSI/API RP 14F-1991.

NOTE 6: For further information on the installation of electrical equipment in hazardous (classified) locations in general, see *Electrical Apparatus for Explosive Gas Atmospheres* — Part 14: *Electrical Installations in Explosive Gas Atmospheres (Other than Mines)*, IEC 79-14-1996, and *Electrical Apparatus for Explosive Gas Atmospheres — Part 16: Artificial Ventilation for the Protection of Analyzer(s) Houses*, IEC 79-16-1990.

5-4.6 Special Precaution. Chapter 5 of Part I requires equipment construction and installation that will ensure safe performance under conditions of proper use and maintenance.

NOTE 1: It is important that inspection authorities and users exercise more than ordinary care with regard to the installation and maintenance of electrical equipment in hazardous (classified) locations.

NOTE 2: Low ambient conditions require special consideration. Electrical equipment depending on the protection techniques described by 5-4.4(a) may not be suitable for use at temperatures lower than –20°C (–13°F) unless they are approved for use at lower temperatures, flammable concentrations of vapors may exist in a location classified Class I, Zones 0, 1, or 2 at normal ambient temperature.

5-4.6.1 Supervision of Work. Classification of areas and selection of equipment and wiring methods shall be under the supervision of a qualified Registered Professional Engineer.

5-4.6.2 Dual Classification. In instances of areas within the same facility classified separately, Class I, Zone 2 locations shall be permitted to abut, but not overlap, Class I, Division 2 locations. Class I, Zone 0 or Zone 1 locations shall not abut Class I, Division 1 or Division 2 locations.

5-4.6.3 Reclassification Permitted. A Class I, Division 1 or Division 2 location shall be permitted to be reclassified as a Class I, Zone 0, Zone 1, or Zone 2 location provided all of the space that is classified because of a single flammable gas or vapor source is reclassified under the requirements of the section.

5-4.7 Grouping and Classification. For purposes of testing, approval, and area classification, various air mixtures (not oxygen enriched) shall be grouped as required in (a), (b), and (c).

NOTE: Group I is intended for use in describing atmospheres that contain firedamp (a mixture of gases, composed mostly of methane, found underground, usually in mines). This section does not apply to installations underground in mines.

Group II shall be subdivided into IIC, IIB, and IIA, as noted in (a), (b) and (c), according to the nature of the gas or vapor, for protection techniques "d," "ia," "ib," "[ia]," and "[ib]," and, where applicable, "n" and "o."

NOTE 1: The gas and vapor subdivision are described above is based on the maximum experimental safe gap (MESG), minimum igniting current (MIC), or both. Test equipment for determining the MESG is described in *Construction and Verification Test of Flameproof Enclosures of Electrical Apparatus*, IEC 79-1A -1975, Amendment No. 1 (1993) and *UL Technical Report No. 58* (1993). The test equipment for determining MIC is described in Spark-test apparatus for intrinsically safe circuits, IEC 79-3-1990. The classification of gases or vapors according to their maximum experimental safe gaps and minimum igniting currents is described in *Classification of mixtures of gases or vapors with air according to their maximum experimental safe gaps and minimum igniting currents*, IEC 79-12-1978.

NOTE 2: Verification of electrical equipment utilizing protection techniques "e," "m," "p," and "q," due to design technique, does not require tests involving MESG or MIC. Therefore, Group II is not required to be subdivided for these protection techniques.

NOTE 3: It is necessary that the meanings of the different equipment markings and Group II classifications be carefully observed to avoid confusion with Class I, Division 1 and 2, Groups A, B, C, and D.

(a) **Group IIC.** Atmospheres containing acetylene, hydrogen, or flammable gas, flammable liquid-produced vapor, or combustible liquid-produced vapor mixed with air that may burn or explode, having either a maximum experimental safe gap (MESG) value less than or equal to 0.50 mm or minimum igniting current ratio (MIC ratio) less than or equal to 0.45.

NOTE: Group IIC is equivalent to a combination of Class I, Group A, and Class I, Group B.

(b) **Group IIB.** Atmospheres containing acetaldehyde, ethylene, or flammable gas, flammable liquid-produced vapor, or combustible liquid-produced vapor mixed with air that may burn or explode, having either maximum experimental safe gap (MESG) values greater than 0.50 mm and less than or equal to 0.90 mm or minimum igniting current ratio (MIC ratio) greater than 0.45 and less than or equal to 0.80.

NOTE: Group IIB is equivalent to Class I, Group C.

(c) **Group IIA.** Atmospheres containing acetone, ammonia, ethyl alcohol, gasoline, methane, propane, or flammable gas, flammable liquid-produced vapor, or combustible liquid-produced vapor mixed with air that may burn or explode, having either a maximum experiment safe gap (MESG) value greater than 0.90 mm or minimum igniting current ratio (MIC ratio) greater than 0.80.

NOTE: Group IIA is equivalent to Class I, Group D.

(d) **Other.** Equipment shall be permitted to be listed for a specific gas or vapor, specific mixtures of gases or vapors, or any specific combination of gases or vapors.

NOTE: One common example is equipment marked for "IIB + H2."

5-4.8 Class I Temperature. The temperature marking specified in 5-4.10.2(c) shall not exceed the ignition temperature of the specific gas or vapor to be encountered.

NOTE: For information regarding ignition temperatures of gases and vapors, see *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*, NFPA 497-1997; *Guide to Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids*, NFPA 325-1994 (available in NFPA's *Fire Protection Guide to Hazardous Materials*); and *Electrical Apparatus for Explosive Gas Atmospheres, Data for Flammable Gases and Vapours, Relating to the Use of Electrical Apparatus*, IEC 79-20-1996.

5-4.9 Zone Classification. The classification into zones shall be in accordance with the following.

(a) **Class I, Zone 0.** A Class I, Zone 0 location is a location in which one of the following conditions exists:

(1) Ignitible concentrations of flammable gases or vapors are present continuously.
(2) Ignitible concentrations of flammable gases or vapors are present for long periods of time.

NOTE 1: 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 505-1996; *Electrical Apparatus for Explosive Gas Atmospheres, Classifications of Hazardous Areas*, IEC 79-10-1995; and *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.

NOTE 2: This classification includes locations inside vented tanks and vessels that contain volatile flammable liquids; inside inadequately vented spraying or coating enclosures, where volatile flammable solids are used; between the inner and outer roof sections of a floating roof tank containing volatile flammable liquids; inside open vessels, tanks and pits containing volatile flammable liquids; the interior of an exhaust duct that is used to vent ignitible concentrations of gases or vapors; and inside inadequately ventilated enclosures that contain normally venting instruments utilizing or analyzing flammable fluids and venting to the inside of the enclosures.

NOTE 3: It is not good practice to install electrical equipment in Zone 0 locations except when the equipment is essential to the process or when other locations are not feasible. (See 5-4.3.1, Note 2.) If it is necessary to install electrical systems in a Zone 0 location, it is good practice to install intrinsically safe systems.

(b) **Class I, Zone 1.** A Class I, Zone 1 location is a location in which one of the following conditions exists:

(1) Ignitible concentrations of flammable gases or vapors are likely to exist under normal operating conditions.
(2) Ignitible concentrations of flammable gases or vapors may exist frequently because of repair or maintenance operations or because of leakage.
(3) Equipment is operated or processes are carried on of such a nature that equipment breakdown or faulty operations could result in the release of ignitible concentrations of flammable gases or vapors and also cause simultaneous failure of electrical equipment in a mode to cause the electrical equipment to become a source of ignition.
(4) A location that is adjacent to a Class I, Zone 0 location from which ignitible 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.

NOTE 1: Normal operations is considered the situation when plant equipment is operating within its design parameters. Minor releases include the releases from mechanical packings on pumps. Failures that involve repair or shutdown (such as the breakdown of pump seats and flange gaskets, and spillage caused by accidents) are not considered normal operation.

NOTE 2: This classification usually includes locations where volatile flammable liquids or liquified flammable gases are transferred from one container to another, in areas in the vicinity of spraying and painting operations where flammable solvents are used; adequately ventilated drying rooms or compartments for the evaporation of flammable solvents; adequately ventilated locations containing fat and oil extraction equipment using volatile flammable solvents; portions of cleaning and dyeing plants where volatile flammable liquids are used; adequately ventilated 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 the open, lightly stoppered, or easily ruptuerd containers; and other loactions where ignitible concentrations of flammable vapors or gases or likely to occur in the course of normal operation, but not clasified Zone 0.

(c) **Class I, Zone 2.** A Class I, Zone 2 location is a location in which one of the following conditions exists:

(1) Ignitible 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.
(2) Volatile flammable liquids, flammable gases, or flammable vapors are handled, processed, or used, but in which the liquids, gases, or vapors 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.
(3) Ignitible 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.
(4) A location that is adjacent to a Class I, Zone 1 location, from which ignitible 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.

NOTE: The Zone 2 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.

5-4.10 Listing, Marking, and Documentation.

5-4.10.1 Listing. Equipment that is listed for a Zone 0 location shall be permitted in a Zone 1 or Zone 2 location of the same gas or vapor. Equipment that is listed for a Zone 1 location shall be permitted in a Zone 2 location of the same gas or vapor.

5-4.10.2 Marking. Equipment shall be marked in accordance with (a) or (b).

(a) **Division Equipment.** Equipment approved for Class I, Division 1 or Class I, Division 2 shall, in addition to being marked in accordance with 5-2.4, be permitted to be marked with all of the following:

(1) Class I, Zone 1 or Class I, Zone 2 (as applicable)
(2) Applicable gas classification group(s) in accordance with Table 5-4.10.2(b)(5)
(3) Temperature classification in accordance with 5-4.10.2(c).

(b) **Zone Equipment.** Equipment meeting one or more of the protection techniques described in 5-4.4 shall be marked with the following in the order shown:

(1) Class
(2) Zone
(3) Symbol "AEx"
(4) Protection technique(s) in accordance with Table 5-4.4(d)
(5) Applicable gas classification group(s) in accordance with Table 5-4.10.2(b)(5)
(6) Temperature classification in accordance with 5-4.10.2(c)

Exception: Intrinsically safe associated apparatus shall be required to be marked only with (b)(3), (b)(4), and (b)(5).

NOTE 1: An example of such a required marking is "Class I, Zone 0, AEx ia IIC T6." See Figure 5-4.10.2(a) for an explanation of this marking.

Electrical equipment of types of protection "e," "m," "p," or "q" shall be marked Group II. Electrical equipment of types of protection "d," "ia," "ib," "[ia]," or "[ib]" shall be marked Group IIA, or IIB, or IIC, or for a specific gas or vapor. Electrical equipment of types of protection "n" shall be marked Group II unless it contains enclosed-break devices, nonincendive components, or energy-limited equipment or circuits, in

which case it shall be marked Group IIA, IIB, or IIC, or a specific gas or vapor. Electrical equipment of other types of protection shall be marked Group II unless the type of protection utilized by the equipment requires that it shall be marked Group IIA, IIB, or IIC, or a specific gas or vapor.

NOTE 2: An explanation of the marking that is required follows.

FIGURE 5-4.10.2(a) Class I, Zone 0, AEx ia IIC T6

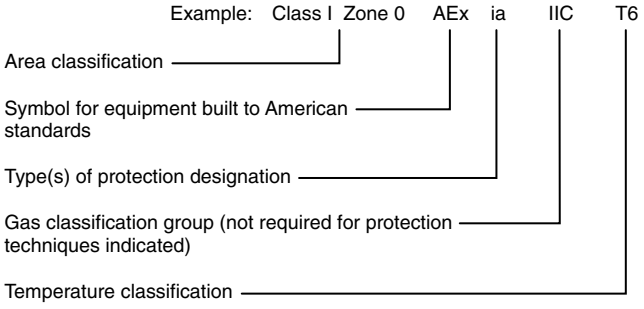


Table 5-4.10.2(b)(5) Gas Classification Groups

Gas Group	Comment
IIC	See 5-4.7(a)
IIB	See 5-4.7(b)
IIA	See 5-4.7(c)

(c) **Temperature Classifications.** Approved equipment shall be marked to show the operating temperature or temperature range referenced to a 40°C (104°F) ambient. The temperature range, if provided, shall be indicated in identification numbers, as shown in Table 5-4.10.2(c).

Table 5-4.10.2(c) Classification of Maximum Surface Temperature for Group II Electrical Equipment

Temperature Class	Maximum Surface Temperature (°C)
T1	≤450
T2	≤300
T3	≤200
T4	≤135
T5	≤100
T6	≤85

Electrical equipment designed for use in the ambient temperature range between –20°C and +40°C shall require no additional temperature marking.

Electrical equipment that is designed for use in a range of ambient temperatures other than –20°C and +40°C is considered to be special; and the ambient temperature range shall then be marked on the equipment, including either the symbol "Ta" or "Tamb" together with the special range of ambient temperatures. As an example, such a marking might be "–30°C Ta +40°C."

Electrical equipment suitable for ambient temperatures exceeding 40°C (104°F) shall be marked with both the maximum ambient temperature and the operating temperature or temperature range at that ambient temperature.

Exception No. 1: Equipment of the nonheat-producing type, such as conduit fittings, and equipment of the heat-producing type having a maximum temperature of not more than 100°C (212°F) shall not be required to have a marked operating temperature or temperature range.

Exception No. 2: Equipment approved for Class I, Division 1 or Division 2 locations as permitted by 5-4.12.2 and 5-4.12.3 shall be permitted to be marked.

(1) **Documentation for Industrial Occupancies.** All areas in industrial occupancies designated as hazardous (classified) locations shall be properly documented. This documentation shall be available to those authorized to design, install, inspect, maintain, or operate electrical equipment at the location.

NOTE: For examples of area classification drawings, see *Electrical Apparatus for Explosive Gas Atmospheres, Classification of Hazardous Areas,* IEC 79-10-1995; *Classification of Locations for Electrical Installations at 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 (Classified) Locations,* ISA S12.24.01-1997; *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 or Division 2,* API RP 500-1997, *Model Code of Safe Practice in the Petroleum Industry, Part 15 — Area Classification Code for Petroleum Installations,* IP 15, The Institute of Petroleum, London.

5-4.11 Wiring Methods.

5-4.11.1 Zone 0. In Class I, Zone 0 locations, only the following wiring methods shall be permitted.

(1) Intrinsically safe wiring

NOTE: Includes protection technique "ia."

(2) Seal shall be provided within 10 ft (3.05 m) of where a conduit leaves a Zone 0 location. There shall be no unions, couplings, boxes, or fittings, except reducers at the seal, in the conduit run between the seal and the point at which the conduit leaves the location.

Exception: A rigid unbroken conduit that passes completely through the Zone 0 location with no fittings less than 12 in. (305 mm) beyond each boundary shall not be required to be sealed, if the termination points of the unbroken conduit are in unclassified locations.

(3) Seals shall be provided on cables at the first point of termination after entry into the Zone 0 location.

(4) Seals shall not be required to be explosionproof or flameproof.

5-4.11.2 Zone 1. In Class I, Zone 1 locations, all wiring methods permitted for Class I, Division 1 locations shall be permitted.

Where Class I, Division 1 wiring methods are used, sealing and drainage shall be provided, except where the term "Division 1" is used, "Zone 1" shall be substituted.

An explosionproof seal shall be provided for each conduit entering an enclosure having type of protection "e" or "d," except where the type of protection "d" enclosure is marked to indicate that a seal is not required.

Wiring methods shall maintain the integrity of protection techniques.

NOTE 1: For example, equipment with type of protection "e" requires that conduit seals or cable fittings incorporate suitable methods to maintain the "ingress protection" (minimum IP54) of the enclosure; and, for conduit, serve to maintain the explosionproof integrity of the conduit system.

NOTE 2: Different electrical enclosures provide different degrees of "ingress protection." The measures applied to enclosures of electrical apparatus include

(a) The protection of persons against contact with or approach to live parts and against contact with moving parts (other than smooth rotating shafts and the like) inside the enclosure

(b) The protection of the apparatus inside the enclosure against ingress of solid foreign bodies; and

(c) The protection of the apparatus inside the enclosure against harmful ingress of water

5-4.11.3 Zone 2. In Class I, Zone 2 locations, all wiring methods permitted for Class I, Division 2 locations shall be permitted. Sealing and drainage shall be provided, except where the term "Division 2" is used, "Zone 2" shall be substituted and where the term "Division 1" is used, "Zone 1" shall be substituted.

Wiring methods shall maintain the integrity of protection techniques.

5-4.11.4 Solid Obstacles. Flameproof equipment with flanged joints shall not be installed such that the flange openings are closer than the distances shown in Table 5-4.11.4 to any solid obstacle that is not part of the equipment (such as steelworks, walls, weather guards, mounting brackets, pipes, or other electrical equipment) unless the equipment is listed for a smaller distance of separation.

Table 5-4.11.4 Minimum Distance of Obstructions from Flameproof "d" Flange Openings

	Minimum Distance	
Gas Group	in.	mm
IIC	$1^{37}/_{64}$	40
IIB	$1^{3}/_{16}$	30
IIA	$^{25}/_{64}$	10

5-4.12 Equipment.

5-4.12.1 Zone 0. In Class I, Zone 0 locations, only equipment specifically listed and marked as suitable for the location shall be permitted.

Exception: Intrinsically safe equipment listed for use in Class I, Division 1 locations for the same gas, or as permitted by 5-4.7(d), and with a suitable temperature rating shall be permitted.

5-4.12.2 Zone 1. In Class I, Zone 1 locations, only equipment specifically listed and marked as suitable for the location shall be permitted.

Exception: Equipment approved for use in Class I, Division 1 or listed for use in Class I, Zone 0 locations for the same gas, or as permitted by 5-4.7(d) and with a suitable temperature rating shall be permitted.

5-4.12.3 Zone 2. In Class I, Zone 2 locations, only equipment specifically listed and marked as suitable for the location shall be permitted.

Exception No. 1: Equipment listed for use in Class I, Zone 0 or 1 locations for the same gas, or as permitted by 5-4.7(d), and with a suitable temperature rating, shall be permitted.

Exception No. 2: Equipment approved for use in Class I, Division 1 or Division 2 locations for the same gas, or as permitted by 5-4.7(d), and with a suitable temperature rating shall be permitted.

Exception No. 3: In Class I, Zone 2 locations, the installation of open or nonexplosionproof or nonflameproof enclosed motors, such as squirrel-cage induction motors without brushes, switching mechanisms, or similar arc-producing devices that are not identified for use in a Class I, Zone 2 location shall be permitted.

NOTE 1: It is important to consider the temperature of internal and external surfaces that may be exposed to the flammable atmosphere.

NOTE 2: It is important to consider the risk of ignition due to currents arcing across discontinuities and overheating of parts in multisection enclosures of large motors and generators. Such motors and generators may need equipotential bonding jumpers across joints in the enclosure and from enclosure to ground. Where the presence of ignitible gases or vapors is suspected, clear air purging may be needed immediately prior to and during start-up periods.

5-4.12.4 Manufacturer's Instructions. Electrical equipment installed in hazardous (classified) locations shall be installed in accordance with the instructions (if any) provided by the manufacturer.

5-4.13 Increased Safety "e" Motors and Generators. In Class I, Zone 1 locations, increased safety "e" motors and generators of all voltage ratings shall be listed for Class I, Zone 1 locations, and shall comply with the following:

(a) Motors shall be marked with the current ratio (I_A/I_N) and time (t_E).

(b) Motors shall have controllers marked with model or identification number, output rating (horsepower or kilowatt), full-load amperes, starting current ratio (I_A/I_N), and time (t_E) of the motors that they are intended to protect; the controller marking shall also include the specific overload protection type (and setting, if applicable) that is listed with the motor or generator.

(c) Connections shall be made with the specific terminals listed with the motor or generator.

(d) Terminal housings shall be permitted to be of substantial, nonmetallic, nonburning material provided an internal grounding means between the motor frame and the equipment grounding connection is incorporated within the housing.

(e) Motor overload protection provisions according to NFPA 70, *National Electrical Code*, Article 430 Part C, shall apply regardless of the voltage rating of the motor.

(f) The motors shall be protected against overload by a separate overload device that is responsive to motor current. This device shall be selected to trip or shall be rated in accordance with the listing of the motor and its overload protection.

(g) Sections 430-34 and 430-44 of NFPA 70, *National Electrical Code*, shall not apply to such motors.

(h) The motor overload protection shall not be shunted or cut out during the starting period.

5-4.14 Grounding and Bonding. Grounding and bonding shall comply with Article 250 and Section 501-16 of NFPA 70, *National Electrical Code*.

Chapter 6 Special Systems

6-1 Systems Over 600 Volts, Nominal. Paragraphs 6-1.1 through 6-1.8 cover the general requirements for equipment operating at more than 600 volts, nominal.

6-1.1 Aboveground Wiring Methods. Aboveground conductors shall be installed in rigid metal conduit, in intermediate metal conduit, in electrical metallic tubing, in rigid nonmetallic conduit, in cable trays, as busways, as cablebus, in other identified raceways, or as open runs of metal-clad cable suitable for the use and purpose. In locations accessible to qualified persons only, open runs of Type MV cables, bare conductors, and bare busbars shall also be permitted. Busbars shall be permitted to be either copper or aluminum.

6-1.2 Braid-Covered Insulated Conductors — Open Installations. Open runs of braid-covered insulated conductors shall have a flame-retardant braid. If the conductors used do not have this protection, a flame-retardant saturant shall be applied to the braid covering after installation. This treated braid covering shall be stripped back a safe distance at conductor terminals, according to the operating voltage. This distance shall not be less than 1 in. (25.4 mm) for each kilovolt of the conductor-to-ground voltage of the circuit, where practicable.

6-1.3 Insulation Shielding. Metallic and semiconductor insulation shielding components of shielded cables shall be removed for a distance dependent on the circuit voltage and insulation. Stress reduction means shall be provided at all terminations of factory-applied shielding.

Metallic shielding components such as tapes, wires, or braids, or combinations thereof, and their associated conducting and semiconducting components shall be grounded.

6-1.4 Moisture or Mechanical Protection for Metal-Sheathed Cables. Where cable conductors emerge from a metal sheath and where protection against moisture or physical damage is necessary, the insulation of the conductors shall be protected by a cable sheath terminating device.

6-1.5 Circuit-Interrupting Devices.

6-1.5.1 Circuit Breakers. Circuit breakers installed indoors shall be mounted either in metal-enclosed units or fire-resistant cell-mounted units, or they shall be permitted to be open mounted in locations accessible to qualified persons only.

6-1.5.2 Power Fuses and Fuseholders — Use. Where fuses are used to protect conductors and equipment, a fuse shall be placed in each ungrounded conductor. Two power fuses shall be permitted to be used in parallel to protect the same load, if both fuses have identical ratings, and both fuses are installed in an identified common mounting with electrical connections that will divide the current equally. Power fuses of the vented type shall not be used indoors, underground, or in metal enclosures unless identified for the use.

6-1.5.3 Distribution Cutouts and Fuse Links — Expulsion Type.

6-1.5.3.1 Installation. Cutouts shall be located so that they may be readily and safely operated and re-fused, and so that the exhaust of the fuses will not endanger persons. Distribution cutouts shall not be used indoors, underground, or in metal enclosures.

6-1.5.3.2 Operation. Where fused cutouts are not suitable to interrupt the circuit manually while carrying full load, an approved means shall be installed to interrupt the entire load. Unless the fused cutouts are interlocked with the switch to prevent opening of the cutouts under load, a conspicuous sign shall be placed at such cutouts reading:

"WARNING — DO NOT OPERATE UNDER LOAD."

6-1.5.4 Oil-Filled Cutouts — Enclosure. Suitable barriers or enclosures shall be provided to prevent contact with nonshielded cables or energized parts of oil-filled cutouts.

6-1.5.5 Load Interrupters. Load interrupter switches shall be permitted if suitable fuses or circuits are used in conjunction with these devices to interrupt fault currents. Where these devices are used in combination, they shall be coordinated electrically so that they will safely withstand the effects of closing, carrying, or interrupting all possible currents up to the assigned maximum short-circuit rating.

Where more than one switch is installed with interconnected load terminals to provide for alternate connection to different supply conductors, each switch shall be provided with a conspicuous sign reading:

"WARNING — SWITCH MAY BE ENERGIZED BY BACKFEED."

6-1.6 Isolating Means. Means shall be provided to completely isolate an item of equipment. The use of isolating switches shall not be required where there are other ways of de-energizing the equipment for inspection and repairs, such as drawout-type metal-enclosed switchgear units and removable truck panels.

Isolating switches not interlocked with an approved circuit-interrupting device shall be provided with a sign warning against opening them under load.

A fuseholder and fuse, designed for the purpose, shall be permitted as an isolating switch.

6-1.7 Mobile and Portable Equipment.

6-1.7.1 Power Cable Connections to Mobile Machines. A metallic enclosure shall be provided on the mobile machine for enclosing the terminals of the power cable. The enclosure shall include provisions for a solid connection for the ground wire(s) terminal to effectively ground the machine frame. Ungrounded conductors shall be attached to insulators or be terminated in approved high-voltage cable couplers (which include ground wire connectors) of proper voltage and ampere rating. The method of cable termination used shall prevent any strain or pull on the cable from stressing the electrical connections. The enclosure shall have provision for locking so only authorized and qualified persons may open it and shall be marked "DANGER — HIGH VOLTAGE — KEEP OUT."

6-1.7.2 Enclosures. All energized switching and control parts shall be enclosed in effectively grounded metal cabinets or enclosures. These cabinets or enclosures shall be marked "DANGER — HIGH VOLTAGE — KEEP OUT" and shall be locked so that only authorized and qualified persons can enter. Circuit breakers and protective equipment shall have the operating means projecting through the metal cabinet or enclosure so these units can be reset without opening locked doors. With doors closed, reasonable safe access for normal operation of these units shall be provided.

6-1.8 Tunnel Installations.

6-1.8.1 General. The provisions of 6-1.8 shall apply to installation and use of high-voltage power distribution and utilization equipment that is portable and/or mobile, such as

substations, trailers, or cars, mobile shovels, draglines, hoists, drills, dredges, compressors, pumps, conveyors, underground excavators, and the like.

6-1.8.2 Conductors. High-voltage conductors in tunnels shall be installed in metal conduit or other metal raceway, Type MC cable, or other approved multiconductor cable. Multiconductor portable cable shall be permitted to supply mobile equipment.

6-1.8.3 Protection Against Physical Damage. Conductors and cables in tunnels shall be located above the tunnel floor and so placed or guarded to protect them from physical damage.

6-1.8.4 Equipment Grounding Conductors. An equipment grounding conductor shall be run with circuit conductors inside the metal raceway or inside the multiconductor cable jacket. The equipment grounding conductor shall be permitted to be insulated or bare.

6-1.8.5 Energized Parts. Bare terminals of transformers, switches, motor controllers, and other equipment shall be enclosed to prevent accidental contact with energized parts.

6-1.8.6 Enclosures. Enclosures for use in tunnels shall be dripproof, weatherproof, or submersible as required by the environmental conditions. Switch or contactor enclosures shall not be used as junction boxes or raceways for conductors feeding through or tapping off to other switches, unless special designs are used to provide adequate space for this purpose.

6-1.8.7 Disconnecting Means. A switching device, shall be installed at each transformer or motor location for disconnecting the transformer or motor. The switching device shall open all ungrounded conductors of a circuit simultaneously.

6-1.8.8 Grounded and Bonded. All noncurrent-carrying metal parts of electric equipment and all metal raceways and cable sheaths shall be effectively grounded and bonded to all metal pipes and rails at the portal and at intervals not exceeding 1000 ft (305 m) throughout the tunnel.

6-2 Emergency Systems.

6-2.1 Scope. The provisions of this section apply to emergency systems that consist of circuits and equipment intended to supply, distribute, and control electricity for illumination or power, or both, to required facilities when the normal electrical supply or system is interrupted.

Emergency systems are those systems legally required and classed as emergency by municipal, state, federal, or other codes, or by any governmental agency having jurisdiction. These systems are intended to automatically supply illumination of power, or both, to designated areas and equipment in the event of failure of the normal supply or in the event of accident to elements of a system intended to supply, distribute, and control power and illumination essential for safety to human life.

6-2.2 Wiring. Unless otherwise permitted in 6-2.2.1 through 6-2.2.4, wiring from an emergency source or emergency source distribution overcurrent protection to emergency loads shall be kept entirely independent of all other wiring and equipment. Wiring of two or more emergency circuits supplied from the same source shall be permitted in the same raceway, cable, box, or cabinet.

6-2.2.1 The normal power source wiring shall be permitted to be located in transfer equipment enclosures.

6-2.2.2 In exit or emergency lighting fixtures, wiring supplied from two sources shall be permitted.

6-2.2.3 In a common junction box, attached to exit or emergency lighting fixtures, wiring supplied from two sources shall be permitted.

6-2.2.4 The wiring within a common junction box attached to unit equipment containing only the branch circuit supplying the unit equipment and the emergency circuit supplied by the unit equipment shall be permitted.

6-2.3 Emergency Illumination. Emergency illumination shall include all required means of egress lighting, illuminated exit signs, and all other lights specified as necessary to provide required illumination.

Emergency lighting systems shall be designed and installed so that the failure of any individual lighting elements, such as the burning out of a light bulb, cannot leave in total darkness any space that requires emergency illumination.

Where high-intensity discharge lighting such as high- and low-pressure sodium, mercury vapor, and metal halide is used as the sole source of normal illumination, the emergency lighting system shall be required to operate until normal illumination has been restored.

Exception: Alternative means that ensure emergency lighting illumination level is maintained shall be permitted.

6-2.4 Signs.

6-2.4.1 Emergency Sources. A sign shall be placed at the service entrance equipment indicating type and location of on-site emergency power sources.

Exception: A sign shall not be required for individual unit equipment.

6-2.4.2 Grounding. Where the grounded circuit conductor connected to the emergency source is connected to a grounding electrode conductor at a location remote from the emergency source, there shall be a sign at the grounding location that shall identify all emergency and normal sources connected at that location.

6-3 Class 1, Class 2, and Class 3 Remote Control, Signaling, and Power-Limited Circuits.

6-3.1 Classification. Class 1, Class 2, or Class 3 remote control, signaling, or power-limited circuits shall be characterized by their usage and electrical power limitation, which differentiates them from light and power circuits. Class 1 circuits shall be classified in accordance with their respective voltage and power limitations as summarized in 6-3.1.1.

6-3.1.1 Class 1 Circuits.

6-3.1.1.1 Class 1 Power-Limited Circuits. These circuits shall be supplied from a source that has a rated output of not more than 30 volts and 1000 volt-amperes.

6-3.1.1.2 Class 1 Remote-Control and Signaling Circuits. These circuits shall not exceed 600 volts. The power output of the source shall not be required to be limited.

6-3.1.2 Power Sources for Class 2 and Class 3 Circuits.

6-3.1.2.1 Power Source. The power source for a Class 2 or a Class 3 circuit shall be as specified in (1) through (4).

(1) A listed Class 2 or 3 transformer
(2) A listed Class 2 or 3 power supply
(3) Other listed equipment marked to identify the Class 2 or Class 3 power source

Exception: Thermocouples shall not require listing as a Class 2 power source.

(4) Listed information technology (computer) equipment limited power circuits

6-3.1.2.2 A dry cell battery shall be considered an inherently limited Class 2 power source, provided the voltage is 30 volts or less and the capacity is equal to or less than that available from series connected No. 6 carbon zinc cells.

6-3.1.3 Installation of Conductors and Equipment.

6-3.1.3.1 Separation from Electric Light, Power, Class 1, Nonpower Limited Fire Alarm Circuit Conductors, and Medium Power Network-Powered Broadband Communications Cables.

6-3.1.3.1.1 In Cables, Compartments, Cable Trays, Enclosures, Manholes, Outlet Boxes, Device Boxes, and Raceways. Cables and conductors of Class 2 and Class 3 circuits shall not be placed in any cable, cable tray, compartment, enclosure, manhole, outlet box, device box, raceway, or similar fitting with conductors of electric light, power, Class 1, nonpower-limited fire alarm circuits, and medium power network-powered broadband communications cables.

6-4 Fire Alarm Systems.

6-4.1 Classifications. Fire alarm circuits shall be classified either as nonpower-limited or power-limited.

6-4.2 Power Sources. The power sources for use with fire alarm circuits shall be either power-limited or nonpower-limited as follows:

(a) **Nonpower-Limited Fire Alarm (NPLFA) Circuit Power Source Requirements.** The power source of nonpower-limited fire alarm circuits shall have an output voltage not more than 600 volts, nominal.

(b) **Power Sources for Power-Limited Fire Alarm (PLFA) Circuits.** The power source for a power-limited fire alarm circuit shall be as specified in (1) through (3).

(1) *Transformers.* A listed PLFA for Class 3 transformer

(2) *Power Supplies.* A listed PLFA for Class 3 power supply

(3) *Listed Equipment.* Listed equipment marked to identify the PLFA power source

6-4.3 Conductors of Different Circuits in Same Cable, Enclosure, or Raceway.

6-4.3.1 Class 1 with NPFLA Circuits. Class 1 and nonpower-limited fire alarm circuits shall be permitted to occupy the same cable, enclosure, or raceway without regard to whether the individual circuits are alternating current or direct current, provided all conductors are insulated for the maximum voltage of any conductor in the enclosure or raceway.

6-4.4 Installation of Conductors and Equipment.

6-4.4.1 In Cables, Compartments, Enclosures, Outlet Boxes, or Raceways. Power-limited circuit cables and conductors shall not be placed in any cable, cable tray, compartment, enclosure, outlet box, raceway, or similar fitting with conductors of electric light, power, Class 1, nonpower-limited fire alarm circuit conductors, or medium power network-powered broadband communications circuits.

6-4.4.2 Other Applications. Power-limited fire alarm circuit conductors shall be separated at least 2 in. (50.8 mm) from conductors of any electric light, power, Class 1, nonpower-limited fire alarm, or medium power network-powered broadband communications circuits.

6-4.4.3 Class 2 Circuits with PLFA Circuits. Conductors of one or more Class 2 circuits shall be permitted within the same cable, enclosure, or raceway with conductors of power-limited fire alarm circuits, provided that the insulation of the Class 2 circuit conductors in the cable, enclosure, or raceway is at least that required by the power-limited fire alarm circuits.

6-4.5 Fire Alarm Circuit Identification. Fire alarm circuits shall be identified at terminal and junction locations, in a manner that will prevent unintentional interference with the signaling circuit during testing and servicing.

6-5 Communications Systems.

6-5.1 Scope. These provisions for communications systems shall apply to telephone, telegraph (except radio), outside wiring for fire alarm and burglar alarm, and similar central station systems, and telephone systems not connected to a central station system but using similar types of equipment, methods of installation, and maintenance.

6-5.2 Protective Devices.

6-5.2.1 Application. A listed primary protector shall be provided on each circuit run partly or entirely in aerial wire or aerial cable not confined within a block. Also, a listed primary protector shall be provided on each circuit, aerial or underground, located within the block containing the building served so as to be exposed to accidental contact with electric light or power conductors operating at over 300 volts to ground. In addition, where there exists a lightning exposure, each interbuilding circuit on premises shall be protected by a listed primary protector at each end of the interbuilding circuit.

6-5.3 Conductor Location.

6-5.3.1 Outside of Buildings.

6-5.3.1.1 Lead-in Clearance. Lead-in or aerial-drop cables from a pole or other support, including the point of initial attachment to a building or structure, shall be kept away from electric light, power, Class 1, or nonpower-limited fire alarm circuit conductors so as to avoid the possibility of accidental contact.

6-5.3.1.2 Lightning Conductors. Where practicable, a separation of at least 6 ft (1.83 m) shall be maintained between communications wires and cables on buildings and lightning conductors.

6-5.3.2 Overhead Communications Wires and Cables.

6-5.3.2.1 On Poles and In-Span. Where communications wires and cables and electric light or power conductors are supported by the same pole or run parallel to each other in-span, the following conditions shall be met:

(a) **Relative Location.** Where practicable, the communications wires and cables shall be located below the electric light or power conductors.

(b) **Attachment to Crossarms.** Communications wires and cables shall not be attached to a crossarm that carries electric light or power conductors.

6-5.3.3 Other Applications. Communications wires and cables shall be separated at least 2 in. (50.8 mm) from conductors of any electric light, power, Class 1, nonpower-limited fire alarm, or medium power network-powered broadband communications circuits.

6-5.4 Grounding.

6-5.4.1 Lead-in Conductors. Where exposed to contact with electric light and power conductors, the metal sheath of aerial cables entering buildings shall be grounded or shall be interrupted close to the entrance to the building by an insulating joint or equivalent device. Where protective devices are used, they shall be grounded in an approved manner.

6-5.4.2 Antenna Structures. Masts and metal structures supporting antennas shall be permanently and effectively grounded without splice or connection in the grounding conductor.

6-5.4.3 Equipment Enclosures. Transmitters shall be enclosed in a metal frame or grille or separated from the operating space by a barrier or other equivalent means, all metallic parts of which are effectively connected to ground. All external metal handles and controls accessible to the operating personnel shall be effectively grounded. Unpowered equipment and enclosures shall be considered grounded where connected to an attached coaxial cable whose metallic shield is effectively grounded.

6-6 Solar Photovoltaic Systems.

6-6.1 These provisions cover solar photovoltaic systems that can be interactive with other electric power production sources or can stand alone, with or without electrical energy storage such as batteries. These systems shall be permitted to have ac or dc output for utilization.

6-6.2 Conductors of Different Systems. Photovoltaic source circuits and photovoltaic output circuits shall not be contained in the same raceway, cable tray, cable, outlet box, junction box, or similar fitting as feeders or branch circuits of other systems, unless the conductors of the different systems are separated by a partition or are connected together.

6-6.3 Disconnecting Means.

6-6.3.1 All Conductors. Means shall be provided to disconnect all current-carrying conductors of a photovoltaic power source from all other conductors in a building or other structure. Where a circuit grounding connection is not designed to be automatically interrupted as part of the ground-fault protection system, a switch or circuit breaker used as disconnecting means shall not have a pole in the grounded conductor.

6-6.3.2 Marking. Where all terminals of the disconnecting means may be energized in the open position, a warning sign shall be mounted on or adjacent to or on the disconnecting means. The sign shall be clearly legible and shall read substantially "WARNING — ELECTRIC SHOCK HAZARD — DO NOT TOUCH TERMINALS — TERMINALS ON BOTH THE LINE AND LOAD SIDES MAY BE ENERGIZED IN OPEN POSITION."

6-7 Integrated Electrical Systems.

6-7.1 Scope. This section shall cover integrated electrical systems, other than unit equipment, in which orderly shutdown is necessary to ensure safe operation. An integrated electrical system as used in this section shall be is a unitized segment of an industrial wiring system where all of the following conditions are met:

(1) An orderly shutdown is required to minimize personnel hazard and equipment damage.
(2) The conditions of maintenance and supervision ensure that qualified persons will service the system.
(3) Effective safeguards, acceptable to the authority having jurisdiction, are established and maintained.

6-7.2 Location of Overcurrent Devices in or on Premises. Location of overcurrent devices that are critical to integrated electrical systems shall be permitted to be accessible, with mounting heights permitted to ensure security from operation by nonqualified personnel.

Part II SAFETY-RELATED WORK PRACTICES

Chapter 1 General

1-1 Scope. Part II covers electrical safety-related work practices and procedures for employees who work on or near exposed energized electrical conductors or circuit parts in workplaces that are included in the scope of this standard. Electric circuits and equipment not included in the scope of this standard might present a hazard to employees not qualified to work near such facilities. Requirements have been included in Part II to protect unqualified employees from such hazards.

1-2 Purpose. These practices and procedures are intended to provide for employee safety relative to electrical hazards in the workplace.

1-3 Responsibility. The safety-related work practices contained in Part II shall be implemented by employees. The employer shall provide the safety-related work practices. He or she shall also train the employee who shall then implement them.

1-4 Organization. Part II of this standard is divided into five chapters. Chapter 1 applies to employee training and qualifications. Chapter 2 includes details of limits of approach to live parts and contains specific work practices. Chapter 3 applies to specifying and maintaining personal and other protective equipment. Chapter 4 covers the use of specific safety-related equipment and work practices. Chapter 5 covers the general requirements for a lockout/tagout procedure.

1-5 Training Requirements.

1-5.1 Safety Training. The training requirements contained in this section shall apply to employees who face a risk of electrical hazard that is not reduced to a safe level by the electrical installation requirements of Part I. Such employees shall be trained to understand the specific hazards associated with electrical energy. They shall be trained in safety-related work practices and procedural requirements as necessary to provide protection from the electrical hazards associated with their respective job or task assignments. Employees shall be trained to identify and understand the relationship between electrical hazards and possible injury.

1-5.2 Type of Training. The training required by this section shall be classroom or on-the-job type, or a combination of the two. The degree of training provided shall be determined by the risk to the employee.

1-5.3 Emergency Procedures. Employees working on or near exposed energized electrical conductors or circuit parts shall be trained in methods of release of victims from contact with

exposed energized conductors or circuit parts. They shall be regularly instructed in methods of first aid and emergency procedures, such as approved methods of resuscitation, if their duties warrant such training.

1-5.4 Employee Training.

1-5.4.1 Qualified Persons. A qualified person shall be trained and knowledgeable of the construction and operation of equipment or a specific work method, and be trained to recognize and avoid the electrical hazards that might be present with respect to that equipment or work method. Such persons shall also be familiar with the proper use of special precautionary techniques, personal protective equipment, insulating and shielding materials, and insulated tools and test equipment. A person can be considered qualified with respect to certain equipment and methods but still be unqualified for others. Such persons permitted to work within limited approach of exposed energized conductors and circuit parts shall, at a minimum, be additionally trained in all of the following:

(a) The skills and techniques necessary to distinguish exposed energized parts from other parts of electric equipment

(b) The skills and techniques necessary to determine the nominal voltage of exposed energized parts

(c) The approach distances specified in Table 2-1.3.4 of Part II and the corresponding voltages to which the qualified person will be exposed

(d) The decision-making process necessary to determine the degree and extent of the hazard and the personal protective equipment and job planning necessary to perform the task safely

NOTE: 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 shall be considered to be a qualified person for the performance of those duties.

1-5.4.2 Unqualified Persons.

1-5.4.2.1 Unqualified persons shall be trained in and be familiar with any of the electrical safety-related practices that might not be addressed specifically by Part II, but are necessary for their safety.

Chapter 2 General Requirements for Electrical Work Practices

2-1 Working On or Near Electrical Conductors or Circuit Parts.

2-1.1 General. Safety-related work practices shall be used to safeguard employees from injury while they are working on or near exposed electric conductors or circuit parts that are or can become energized. The specific safety-related work practice shall be consistent with the nature and extent of the associated electric hazards.

2-1.1.1 Live parts to which an employee might be exposed shall be put into an electrically safe work condition before an employee works on or near them, unless the employer can demonstrate that deenergizing introduces additional or increased hazards or is infeasible due to equipment design or operational limitations. Energized parts that operate at less than 50 volts to ground are not required to be deenergized if there will be no increased exposure to electrical burns or to explosion due to electric arcs.

NOTE 1: Examples of increased or additional hazards include, but are not limited to, interruption of life support equipment, deactivation of emergency alarm systems, shutdown of hazardous location ventilation equipment, or removal of illumination for an area.

NOTE 2: Examples of work that may be performed on or near exposed energized electrical conductors or circuit parts because of infeasibility due to equipment design or operational limitations include performing diagnostics and testing (e.g., start-up or troubleshooting) of electric circuits that can only be performed with the circuit energized and work on circuits that form an integral part of a continuous process that would otherwise need to be completely shut down in order to permit work on one circuit or piece of equipment.

2-1.1.2 Only qualified persons shall be permitted to work on electrical conductors or circuit parts that have been put into an electrically safe work condition.

2-1.1.3 An electrically safe work condition shall be achieved when performed in accordance with the procedures of 2-1.2 of Part II and verified by the following process:

(a) Determine all possible sources of electrical supply to the specific equipment. Check applicable up-to-date drawings, diagrams, and identification tags.

(b) After properly interrupting the load current, open the disconnecting device(s) for each source.

(c) Where it is possible, visually verify that all blades of the disconnecting devices are fully open or that drawout type circuit breakers are withdrawn to the fully disconnected position.

(d) Apply lockout/tagout devices in accordance with a documented and established policy.

(e) Use an adequately rated voltage detector to test each phase conductor or circuit part to verify they are deenergized. Before and after each test, determine that the voltage detector is operating satisfactorily.

(f) Where the possibility of induced voltages or stored electrical energy exists, ground the phase conductors or circuit parts before touching them. Where it could be reasonably anticipated that the conductors or circuit parts being deenergized could contact other exposed energized conductors or circuit parts, apply ground connecting devices rated for the available fault duty.

2-1.2 Working On or Near Deenergized Electrical Conductors or Circuit Parts that Have Lockout/Tagout Devices Applied. Each employer shall identify, document, and implement lockout/tagout procedures conforming to Chapter 5 to safeguard employees from exposure to electrical hazards while they are working on or near deenergized electrical conductors or circuit parts that are likely to result in injury from inadvertent or accidental contact or equipment failure. The lockout/tagout procedure shall be appropriate for the experience and training of the employees and conditions as they exist in the workplace.

2-1.3 Working On or Near Exposed Electrical Conductors or Circuit Parts that Are or Might Become Energized.

2-1.3.1 Where working on live parts that have not had lockout/tagout devices applied in accordance with 2-1.1.3 and Chapter 5 of Part II, 2-1.3.2 through 2-1.3.5 of Part II shall apply to the work.

2-1.3.2 If the live parts are not placed in electrically safe work conditions, other safety-related work practices shall be used to protect employees who might be exposed to the electrical hazards involved. Such work practices shall protect each employee from arc flash and from contact with live parts directly with any part of the body or indirectly through some other conductive object. 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 live parts.

2-1.3.3 Flash Hazard Analysis. Flash hazard analysis shall be done before a person approaches any exposed electrical conductor or circuit part that has not been placed in an electrically safe work condition.

2-1.3.3.1 General. In certain instances, the flash protection boundary might be a greater distance than the limited approach boundary and the greater distance shall be utilized to trigger the need for personal protective equipment.

2-1.3.3.2 Flash Protection Boundary. For systems which are 600 volts and below, the flash protection boundary shall be 4.0 ft, based upon the product of clearing times of 6 cycles (0.1 second) and available bolted fault current of 50 kA or any combination not exceeding 300 kA cycles (5000 ampere seconds). For clearing times and bolted fault currents other than 300 kA cycles, or under engineering supervision, the flash protection boundary shall alternatively be permitted to be calculated in accordance with the following general formula.

$$D_c = [2.65 \times MVA_{bf} \times t]^{1/2}$$

or

$$D_c = [53 \times MVA \times t]^{1/2}$$

where:

D_c = distance of person from an arc source for a just curable burn in feet

MVA_{bf} = bolted fault *MVA* at point involved

MVA = *MVA* rating of transformer. For transformers with *MVA* ratings below 0.75 *MVA*, multiply the transformer *MVA* rating by 1.25

t = time of arc exposure in seconds

At voltage levels above 600 volts, the flash protection boundary is the distance at which the incident energy level equals 1.2 cal/cm^2. For situations where fault clearing time is 0.1 second (or faster), the flash protection boundary is the distance at which the incident energy level equals 1.5 cal/cm^2.

2-1.3.3.3 Protective Clothing and Personal Protective Equipment for Application with a Flash Hazard Analysis. Where it has been determined that work will be performed within the flash protection boundary by 2-1.3.3.2 of Part II, the flash hazard analysis shall determine, and the employer shall document, the incident energy exposure of the worker (in calories per square centimeter). This incident energy exposure level shall be based on the working distance of the employee's face and chest areas from a prospective arc source for the specific task to be performed. Flame Resistant (FR) Clothing and Personal Protective Equipment (PPE) shall be used by the employee based upon the incident energy exposure associated with the specific task. As an alternative, the PPE requirements of 3-3.9 of Part II shall be permitted to be used in lieu of the detailed flash hazard analysis approach described in 2-1.3.3.2 of Part II.

NOTE: For information on estimating the incident energy exposure on 600 volt systems, see Appendix B-5 of Part II.

2-1.3.4 Approach Boundaries to Live Parts. No qualified person shall approach or take any conductive object closer to live parts than the restricted approach boundary set forth in Table 2-1.3.4 of Part II, unless:

(a) The qualified person is insulated or guarded from the live parts (insulating gloves or insulating gloves and sleeves are considered insulation only with regard to the energized parts upon which work is being performed), and no uninsulated part of the qualified person's body enters the prohibited space set forth in Table 2-1.3.4 of Part II, or

(b) The live part is insulated from the qualified person and from any other conductive object at a different potential, or

(c) The qualified person is insulated from any other conductive object as during live-line bare-hand work.

2-1.3.5 Unqualified Persons.

2-1.3.5.1 Unqualified persons shall not be permitted to enter spaces that are required under 1-8.2 or Section 1-9 of Part I to be accessible to qualified employees only, unless the electric conductors and equipment involved are in an electrically safe work condition.

2-1.3.5.2 Where an unqualified person(s) is (are) working at or close to the limited approach boundary, the designated person in charge of the work space where the electrical hazard exists shall cooperate with the designated person in charge of the unqualified person(s) to ensure that all work can be done safely. This shall include advising the unqualified person(s) of the electrical hazard and warning him or her to stay outside of the limited approach boundary.

2-2 Work On or Near Uninsulated Overhead Lines.

2-2.1 Uninsulated and Energized. Where work is performed in locations containing uninsulated energized overhead lines that are not guarded or isolated, precautions shall be taken to prevent employees from contacting such lines directly with any unguarded parts of their body or indirectly through conductive materials, tools, or equipment. Where the work to be performed is such that contact with uninsulated energized overhead lines is possible, the lines shall be deenergized and visibly grounded at the point of work, or suitably guarded.

2-2.2 Deenergizing or Guarding. If the lines are to be deenergized, arrangements shall be made with the person or organization that operates or controls the lines to deenergize them and visibly ground them at the point of work. If arrangements are made to use protective measures, such as guarding, isolating, or insulation, these precautions shall prevent each employee from contacting such lines directly with any part of his or her body or indirectly through conductive materials, tools, or equipment.

Table 2-1.3.4 Approach Boundaries to Live Parts for Shock Protection.
(All dimensions are distance from live part to employee.)

(1)	(2)	(3)	(4)	(5)
	Limited Approach Boundary[1]		Restricted Approach Boundary[1]; Includes Inadvertent Movement Adder	
Nominal System Voltage Range, Phase to Phase	Exposed Movable Conductor	Exposed Fixed Circuit Part		Prohibited Approach Boundary[1]
0 to 50	Not specified	Not specified	Not specified	Not specified
51 to 300	10 ft 0 in.	3 ft 6 in.	Avoid contact	Avoid contact
301 to 750	10 ft 0 in.	3 ft 6 in.	1 ft 0 in.	0 ft 1 in.
751 to 15 kV	10 ft 0 in.	5 ft 0 in.	2 ft 2 in.	0 ft 7 in.
15.1 kV to 36 kV	10 ft 0 in.	6 ft 0 in.	2 ft 7 in.	0 ft 10 in.
36.1 kV to 46 kV	10 ft 0 in.	8 ft 0 in.	2 ft 9 in.	1 ft 5 in.
46.1 kV to 72.5 kV	10 ft 0 in.	8 ft 0 in.	3 ft 3 in.	2 ft 1 in.
72.6 kV to 121 kV	10 ft 8 in.	8 ft 0 in.	3 ft 2 in.	2 ft 8 in.
138 kV to 145 kV	11 ft 0 in.	10 ft 0 in.	3 ft 7 in.	3 ft 1 in.
161 kV to 169 kV	11 ft 8 in.	11 ft 8 in.	4 ft 0 in.	3 ft 6 in.
230 kV to 242 kV	13 ft 0 in.	13 ft 0 in.	5 ft 3 in.	4 ft 9 in.
345 kV to 362 kV	15 ft 4 in.	15 ft 4 in.	8 ft 6 in.	8 ft 0 in.
500 kV to 550 kV	19 ft 0 in.	19 ft 0 in.	11 ft 3 in.	10 ft 9 in.
765 kV to 800 kV	23 ft 9 in.	23 ft 9 in.	14 ft 11 in.	14 ft 5 in.

Notes:
For SI units: 1 in. = 25.4 mm; 1 ft = 0.3048 m.
For flash protection boundary, see 2-1.3.3.2.
1. See definitions in the Introduction and text in 2-1.3.5 and Appendix A of Part II for elaboration.

2-2.3 Employer and Employee Responsibility. The employer and employee shall be responsible to ensure that guards or protective measures are satisfactory for the conditions. Employees shall comply with established work methods and the use of protective equipment.

2-2.4 Approach Distances for Unqualified Persons. When employees without electrical training are working on the ground or in an elevated position near overhead lines, the location shall be such that the employee and the longest conductive object the employee might contact cannot come closer to any unguarded, energized overhead power line than the limited approach boundary. If the voltage on the line exceeds 50 kV, the distance shall be 10 ft plus 4 in. for every 10 kV over 50 kV.

NOTE: Objects that are not insulated for the voltage involved shall be considered to be conductive.

2-2.5 Vehicular and Mechanical Equipment.

2-2.5.1 Where any vehicle or mechanical equipment structure will be elevated near energized overhead lines, they shall be operated so that the limited approach boundary distance of Table 2-1.3.4 of Part II, Column 2, is maintained. However, under any of the following conditions, the clearances shall be permitted to be reduced:

(a) If the vehicle is in transit with its structure lowered, the limited approach boundary to overhead lines in Table 2-1.3.4 of Part II, Column 2, shall be permitted to be reduced by 6 ft (1.83 m).

(b) If insulated barriers, rated for the voltages involved, are installed, and they are not part of an attachment to the vehicle, the clearance shall be permitted to be reduced to the design working dimensions of the insulating barrier.

(c) If the equipment is an aerial lift insulated for the voltage involved, and if the work is performed by a qualified person, the clearance (between the uninsulated portion of the aerial lift and the power line) shall be permitted to be reduced to the restricted approach boundary given in Table 2-1.3.4 of Part II, Column 4.

2-2.5.2 Employees standing on the ground shall not contact the vehicle or mechanical equipment or any of its attachments, unless:

(a) The employee is using protective equipment rated for the voltage; or

(b) The equipment is located so that no uninsulated part of its structure (that portion of the structure that provides a conductive path to employees on the ground) can come closer to the line than permitted in 2-2.5.1 of Part II.

2-2.5.3 If any vehicle or mechanical equipment capable of having parts of its structure elevated near energized overhead lines is intentionally grounded, employees working on the ground near the point of grounding may not stand at the grounding location whenever there is a possibility of overhead line contact. Additional precautions, such as the use of barricades or insulation, shall be taken to protect employees from hazardous ground potentials (step and touch potential), which can develop within a few feet or more outward from the grounded point.

2-3 Electrical Safety Program.

2-3.1 General. The employer shall implement an overall electrical safety program that directs activity appropriate for the voltage, energy level, and circuit conditions.

NOTE: Safety-related work practices are just one component of an overall electrical safety program.

2-3.1.1 Awareness and Self Discipline. The electrical safety program shall be designed to provide an awareness of the potential electrical hazards to the employees who might from time to time work in an environment influenced by the presence of electrical energy. The program shall be developed to provide the required self-discipline to the employees who occasionally must perform work on or near exposed energized electrical conductors and circuit parts. The program shall instill safety principles and controls.

2-3.1.2 Electrical Safety Program Principles. An electrical safety program shall identify the principles upon which it is based.

NOTE: For examples of typical electrical safety program principles, see Appendix C of Part II.

2-3.1.3 Electrical Safety Program Controls. An electrical safety program shall identify the controls by which it is measured and monitored.

NOTE: For examples of typical electrical safety program controls, see Appendix C of Part II.

2-3.1.4 Electrical Safety Program Procedures. An electrical safety program shall identify the procedures for working on or near live parts before work is started.

NOTE: For an example of a typical electrical safety program procedure, see Appendix C of Part II.

2-3.1.5 Hazard/Risk Evaluation Procedure. An electrical safety program shall identify a hazard/risk evaluation procedure to be used before work is started on or near live parts.

NOTE: For an example of a hazard risk procedure, see Appendix D of Part II.

2-3.1.6 Job Briefing. Before starting each job, the employee in charge shall conduct a job briefing with the employees involved. The briefing shall cover such subjects as hazards associated with the job, work procedures involved, special precautions, energy source controls, and personal protective equipment requirements.

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

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

(a) The work is complicated or particularly hazardous, or

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

2-3.2 Alertness.

2-3.2.1 Employees shall be instructed to be alert at all times when they are working near live parts and in work situations where unexpected electrical hazards might exist.

2-3.2.2 Employees shall not knowingly be permitted to work in areas containing live parts or other electrical hazards while their alertness is recognizably impaired due to illness, fatigue, or other reasons.

2-3.3 Blind Reaching. Employees shall be instructed not to reach blindly into areas that might contain live parts.

2-3.4 Illumination.

2-3.4.1 Employees shall not enter spaces containing live parts unless illumination is provided that enables the employees to perform the work safely.

2-3.4.2 Where lack of illumination or an obstruction precludes observation of the work to be performed, employees shall not perform any task near live parts.

2-3.5 Conductive Articles Being Worn. Conductive articles of jewelry and clothing (such as watchbands, bracelets, rings, key chains, necklaces, metalized aprons, cloth with conductive thread, metal headgear, or unrestrained metal frame glasses) shall not be worn where they present an electrical contact hazard with live parts, unless such articles are rendered nonconductive by covering, wrapping, or other insulating means.

2-3.6 Conductive Materials, Tools, and Equipment Being Handled.

2-3.6.1 Conductive materials, tools, and equipment that are in contact with any part of an employee's body shall be handled in a manner that will prevent accidental contact with live parts. Such materials and equipment include but are not limited to long conductive objects, such as ducts, pipes and tubes, conductive hose and rope, metal-lined rules and scales, steel tapes, pulling lines, metal scaffold parts, structural members, bull floats, and chains.

2-3.6.2 Means shall be employed to ensure that conductive materials approach live parts no closer than that permitted by Table 2-1.3.4 of Part II.

2-3.7 Insulated Tools and Equipment. Employees shall use insulated tools and/or handling equipment when working inside the limited approach boundary of live parts where tools or handling equipment might make accidental contact. Insulated tools shall be protected from damage to the insulating material.

NOTE: See 2-1.3.4 of Part II for working on live parts.

2-3.7.1 Fuse or fuse holder handling equipment, insulated for the circuit voltage, shall be used to remove or install a fuse if the fuse terminals are energized.

2-3.7.2 Ropes and handlines used near live parts shall be nonconductive.

2-3.8 Protective Shields. Protective shields, protective barriers, or insulating materials shall be used to protect each employee from shock, burns, or other electrically related injuries while that employee is working near live parts which might be accidentally contacted or where dangerous electric 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.

2-3.9 Portable Ladders. Portable ladders shall have nonconductive side rails if they are used where the employee or the ladder could contact live parts.

2-3.10 Confined or Enclosed Work Spaces. When an employee works in a confined or enclosed space (such as a manhole or vault) that contains live parts, the employer shall provide, and the employee shall use protective shields, protective barriers, or insulating materials as necessary to avoid inadvertent contact with these parts. Doors, hinged panels, and the like shall be secured to prevent their swinging into an employee and causing the employee to contact live parts.

2-3.11 Safety Interlocks. Only a qualified person following the requirements for working inside the restricted approach boundary as covered by 2-1.3.4 of Part II shall be permitted to defeat or bypass an electrical safety interlock over which the person has sole control, and then only temporarily while the qualified person is working on the equipment. The safety interlock system shall be returned to its operable condition when the work is completed.

2-3.12 Housekeeping Duties. Where live parts present an electrical contact hazard, employees shall not perform housekeeping duties inside the limited approach boundary where there is a possibility of contact, unless adequate safeguards (such as insulating equipment or barriers) are provided to prevent contact. Electrically conductive cleaning materials (including conductive solids such as steel wool, metalized cloth, and silicone carbide, as well as conductive liquid solutions) shall not be used inside the limited approach boundary unless procedures to prevent electrical contact are followed.

2-3.13 Occasional Use of Flammable Materials. Where flammable materials are present only occasionally, electric equipment capable of igniting them may not be used, unless measures are taken to prevent hazardous conditions from developing. Such materials include, but are not limited to: flammable gases, vapors, or liquids; combustible dust; and ignitible fibers or flyings.

NOTE: Electrical installation requirements for locations where flammable materials are present on a regular basis are contained in Chapter 5 of Part I.

2-3.14 Overcurrent Protection Modification. Overcurrent protection of circuits and conductors shall not be modified, even on a temporary basis, beyond that permitted by 2-5.1 and 2-5.2 of Part I.

2-3.15 Anticipating Failure. When there is evidence that electric equipment could fail and injure employees, the electric equipment shall be deenergized unless the employer can demonstrate that deenergizing introduces additional or increased hazards or is infeasible due to equipment design or operational limitation. Until the equipment is deenergized or repaired, employees shall be protected from hazards associated with the impending failure of the equipment.

Chapter 3 Personal and Other Protective Equipment

3-1 General. Employees working in areas where there are electrical hazards shall be provided with, and shall use, protective equipment that is designed and constructed for the specific part of the body to be protected and for the work to be performed.

NOTE: Personal protective equipment requirements are contained in 3-3.8 and 3-4.11 of Part II.

3-2 Care of Equipment. Protective equipment shall be maintained in a safe, reliable condition. The protective equipment shall be visually inspected before each use.

NOTE 1: Specific requirements for periodic testing of electrical protective equipment are given in 3-3.8 and 3-4.11 of Part II.

NOTE 2: Requirements relating to the use of leather protectors over rubber insulating gloves are given in 3-3.8 and 3-3.9.5.3 of Part II.

3-3 Personal Protective Equipment.

3-3.1 General. When an employee is working within the flash protection boundary he/she shall wear protective clothing and other personal protective equipment in accordance with 2-1.3.3.3 of Part II.

3-3.2 Movement and Visibility. When flame-resistant, flame-retardant, or treated clothing is worn to protect an employee, it shall cover all ignitible clothing and shall allow for movement and visibility.

3-3.3 Head, Face, Neck, and Chin Protection. Employees shall wear nonconductive head protection wherever there is a danger of head injury from electric shock or burns due to

contact with live parts or from flying objects resulting from an electrical explosion.

3-3.4 Eye Protection. Employees shall wear protective equipment for the eyes whenever there is danger of injury from electric arcs, flashes, or from flying objects resulting from electrical explosion.

3-3.5 Body Protection. Employees shall wear clothing resistant to flash flame wherever there is possible exposure to an electric arc flash.

NOTE: Such clothing can be provided as shirt and trousers, or as coveralls, or as a combination of jacket and trousers, or, for maximum protection, as coveralls and jacket. Various weight fabrics of 4 oz, 6 oz, or 10 oz are available. The higher degree of protection is provided by heavier weight fabrics or by layering combinations of natural fiber clothing resistant to electric arc flash.

3-3.6 Hand and Arm Protection. Employees shall wear rubber insulating gloves where there is danger of hand and arm injury from electric shock and burns due to contact with live parts. Hand and arm protection shall be worn where there is possible exposure to arc flash burn. Arm protection shall be accomplished by apparel described in 3-3.5 of Part II.

3-3.7 Foot and Leg Protection. Where insulated footwear is used as protection against step and touch potential, dielectric overshoes shall be required.

NOTE: Insulated soles are not intended to be used as primary electrical protection.

3-3.8 Standards for Personal Protective Equipment. Personal protective equipment shall conform to the standards given in Table 3-3.8.

3-3.9 Selection of Personal Protective Equipment.

3-3.9.1 Personal Protective Equipment Required for Various Tasks. Listed in Table 3-3.9.1 of Part II are a number of common work tasks with the respective Hazard/Risk Category associated with each task. Once the Hazard/Risk Category has been identified, refer to Table 3-3.9.2 of Part II. The assumed "normal" short circuit current capacities and fault clearing times for various tasks conducted on low-voltage (600 V, and below) equipment are listed in the notes to Table 3-3.9.1 of Part II. For tasks not listed, or for power systems of greater than the assumed "normal" short circuit current capacity or for longer than assumed fault clearing times (for the assumed current and time values, see the Notes to Table 3-3.9.1 of Part II), a flash hazard analysis is required in accordance with 2-1.3.3 of Part II.

NOTE: Energized parts that operate at less than 50 volts are not required to be de-energized to satisfy an "electrically safe work condition." Consideration should be given to the capacity of the source, any overcurrent protection between the energy source and the worker, and whether the work task related to the source operating at less than 50 volts increases exposure to electrical burns or to explosion from an electric arc.

3-3.9.2 Protective Clothing and Personal Protective Equipment Matrix. Once the Hazard/Risk Category has been identified, refer to Table 3-3.9.2. Table 3-3.9.2 lists the requirements for protective clothing and other protective equipment based on Hazard/Risk Category numbers 0 through 4. This clothing and equipment shall be used when working on or near energized equipment within the Flash Protection Boundary.

NOTE 1: See Appendix F of Part II for a suggested simplified approach to assure adequate PPE for electrical workers within facilities with large and diverse electrical systems.

NOTE 2: The PPE requirements of this section are intended to protect a person from arc-flash and shock hazards. While some situations may result in burns to the skin, even with the protection described in Table 3-3.9.2, any burn injury should be relatively minor and survivable. Due to the explosive effect of some arc events, physical trauma injuries may occur. The PPE requirements of this section do not provide protection against physical trauma.

Table 3-3.8 Standards on Protective Equipment

Subject	Number and Title
Head protection	ANSI Z89.1, *Requirements for Protective Headwear for Industrial Workers,* 1997
Eye and face protection	ANSI Z87.1, *Practice for Occupational and Educational Eye and Face Protection,* 1989
Gloves	ASTM D 120, *Standard Specification for Rubber Insulating Gloves,* 1995
Sleeves	ASTM D 1051, *Standard Specification for Rubber Insulating Sleeves,* 1995
Gloves and sleeves	ASTM F 496, *Standard Specification for In-Service Care of Insulating Gloves and Sleeves,* 1997
Leather protectors	ASTM F 696, *Standard Specification for Leather Protectors for Rubber Insulating Gloves and Mittens,* 1997
Footwear	ASTM F 1117, *Standard Specification for Dielectric Overshoe Footwear,* 1993
	ANSI Z41, *Standard for Personnel Protection, Protective Footwear,* 1991
Visual inspection	ASTM F 1236, *Standard Guide for Visual Inspection of Electrical Protective Rubber Products,* 1996
Apparel	ASTM F 1506, *Standard Specification for Protective Wearing Apparel for Use by Electrical Workers When Exposed to Momentary Electric Arc and Related Thermal Hazards,* 1998

ANSI – American National Standards Institute
ASTM – American Society for Testing and Materials

Table 3-3.9.1 Hazard Risk Category Classifications

Task (Assumes Equipment Is Energized, and Work Is Done Within the Flash Protection Boundary)	Hazard/ Risk Category	V-rated Gloves	V-rated Tools
Panelboards rated 240 V and below – Notes 1 and 3	—	—	—
Circuit breaker (CB) or fused switch operation with covers on	0	N	N
CB or fused switch operation with covers off	0	N	N
Work on energized parts, including voltage testing	1	Y	Y
Remove/install CBs or fused switches	1	Y	Y
Removal of bolted covers (to expose bare, energized parts)	1	N	N
Opening hinged covers (to expose bare, energized parts)	0	N	N
Panelboards or Switchboards rated >240 V and up to 600 V (with molded case or insulated case circuit breakers) — Notes 1 and 3	—	—	—
CB or fused switch operation with covers on	0	N	N
CB or fused switch operation with covers off	1	N	N
Work on energized parts, including voltage testing	2*	Y	Y
600 V Class Motor Control Centers (MCCs) – Notes 2 (except as indicated) and 3	—	—	—
CB or fused switch or starter operation with enclosure doors closed	0	N	N
Reading a panel meter while operating a meter switch	0	N	N
CB or fused switch or starter operation with enclosure doors open	1	N	N
Work on energized parts, including voltage testing	2*	Y	Y
Work on control circuits with energized parts 120 V or below, exposed	0	Y	Y
Work on control circuits with energized parts >120 V exposed	2*	Y	Y
Insertion or removal of individual starter "buckets" from MCC — Note 4	3	Y	N
Application of safety grounds, after voltage test	2*	Y	N
Removal of bolted covers (to expose bare, energized parts)	2*	N	N
Opening hinged covers (to expose bare, energized parts)	1	N	N
600 V Class Switchgear (with power circuit breakers or fused switches) — Notes 5 and 6	—	—	—
CB or fused switch operation with enclosure doors closed	0	N	N
Reading a panel meter while operating a meter switch	0	N	N

(Sheet 1 of 4)

Table 3-3.9.1 Hazard Risk Category Classifications *(Continued)*

Task (Assumes Equipment Is Energized, and Work Is Done Within the Flash Protection Boundary)	Hazard/ Risk Category	V-rated Gloves	V-rated Tools
CB or fused switch operation with enclosure doors open	1	N	N
Work on energized parts, including voltage testing	2*	Y	Y
Work on control circuits with energized parts 120 V or below, exposed	0	Y	Y
Work on control circuits with energized parts >120 V exposed	2*	Y	Y
Insertion or removal (racking) of CBs from cubicles, doors open	3	N	N
Insertion or removal (racking) of CBs from cubicles, doors closed	2	N	N
Application of safety grounds, after voltage test	2*	Y	N
Removal of bolted covers (to expose bare, energized parts)	3	N	N
Opening hinged covers (to expose bare, energized parts)	2	N	N
Other 600 V Class (277 V through 600 V, nominal) Equipment — Note 3	—	—	—
Lighting or small power transformers (600 V, maximum)	—	—	—
Removal of bolted covers (to expose bare, energized parts)	2*	N	N
Opening hinged covers (to expose bare, energized parts)	1	N	N
Work on energized parts, including voltage testing	2*	Y	Y
Application of safety grounds, after voltage test	2*	Y	N
Revenue meters (kW-hour, at primary voltage and current)	—	—	—
Insertion or removal	2*	Y	N
Cable trough or tray cover removal or installation	1	N	N
Miscellaneous equipment cover removal or installation	1	N	N
Work on energized parts, including voltage testing	2*	Y	Y
Application of safety grounds, after voltage test	2*	Y	N
NEMA E2 (fused contactor) Motor Starters, 2.3 kV through 7.2 kV	—	—	—
Contactor operation with enclosure doors closed	0	N	N
Reading a panel meter while operating a meter switch	0	N	N
Contactor operation with enclosure doors open	2*	N	N
Work on energized parts, including voltage testing	3	Y	Y

(Sheet 2 of 4)

Table 3-3.9.1 Hazard Risk Category Classifications ***(Continued)***

Task (Assumes Equipment Is Energized, and Work Is Done Within the Flash Protection Boundary)	Hazard/ Risk Category	V-rated Gloves	V-rated Tools
Work on control circuits with energized parts 120 V or below, exposed	0	Y	Y
Work on control circuits with energized parts >120 V, exposed	3	Y	Y
Insertion or removal (racking) of starters from cubicles, doors open	3	N	N
Insertion or removal (racking) of starters from cubicles, doors closed	2	N	N
Application of safety grounds, after voltage test	3	Y	N
Removal of bolted covers (to expose bare, energized parts)	4	N	N
Opening hinged covers (to expose bare, energized parts)	3	N	N
Metal Clad Switchgear, 1 kV and above	—	—	—
CB or fused switch operation with enclosure doors closed	2	N	N
Reading a panel meter while operating a meter switch	0	N	N
CB or fused switch operation with enclosure doors open	4	N	N
Work on energized parts, including voltage testing	4	Y	Y
Work on control circuits with energized parts 120 V or below, exposed	2	Y	Y
Work on control circuits with energized parts >120 V, exposed	4	Y	Y
Insertion or removal (racking) of CBs from cubicles, doors open	4	N	N
Insertion or removal (racking) of CBs from cubicles, doors closed	2	N	N
Application of safety grounds, after voltage test	4	Y	N
Removal of bolted covers (to expose bare, energized parts)	4	N	N
Opening hinged covers (to expose bare, energized parts)	3	N	N
Opening voltage transformer or control power transformer compartments	4	N	N
Other Equipment 1 kV and above	—	—	—
Metal clad load interrupter switches, fused or unfused	—	—	—
Switch operation, doors closed	2	N	N
Work on energized parts, including voltage testing	4	Y	Y
Removal of bolted covers (to expose bare, energized parts)	4	N	N

(Sheet 3 of 4)

Table 3-3.9.1 Hazard Risk Category Classifications ***(Continued)***

Task (Assumes Equipment Is Energized, and Work Is Done Within the Flash Protection Boundary)	Hazard/ Risk Category	V-rated Gloves	V-rated Tools
Opening hinged covers (to expose bare, energized parts)	3	N	N
Outdoor disconnect switch operation (hookstick operated)	3	Y	Y
Outdoor disconnect switch operation (gang-operated, from grade)	2	N	N
Insulated cable examination, in manhole or other confined space	4	Y	N
Insulated cable examination, in open area	2	Y	N

(Sheet 4 of 4)

Legend:
V-rated Gloves are gloves rated and tested for the maximum line-to-line voltage upon which work will be done.
V-rated Tools are tools rated and tested for the maximum line-to-line voltage upon which work will be done.
2* means that a double-layer switching hood and hearing protection are required for this task in addition to the other Hazard/Risk Category 2 requirements of Table 3-3.9.2 of Part II.
Y = yes (required)
N = no (not required)
Notes:
1. 25 kA short circuit current available, 0.03 second (2 cycle) fault clearing time.
2. 65 kA short circuit current available, 0.03 second (2 cycle) fault clearing time.
3. For < 10 kA short circuit current available, the Hazard/Risk Category required may be reduced by one Number.
4. 65 kA short circuit current available, 0.33 second (20 cycle) fault clearing time.
5. 65 kA short circuit current available, up to 1.0 second (60 cycle) fault clearing time.
6. For < 25 kA short circuit current available, the Hazard/Risk Category required may be reduced by one Number.

Table 3-3.9.2 Protective Clothing and Personal Protective Equipment (PPE) Matrix

Protective Clothing & Equipment	Protective Systems for Hazard/Risk Category					
Hazard/Risk Category Number	**–1** (Note 3)	**0**	**1**	**2**	**3**	**4**
Untreated Natural Fiber	—	—	—	—	—	—
a. T-shirt (short-sleeve)	X			X	X	X
b. Shirt (long-sleeve)		X				
c. Pants (long)	X	X	X (Note 4)	X (Note 6)	X	X
FR Clothing (Note 1)	—	—	—	—	—	—
a. Long-sleeve shirt			X	X	X (Note 9)	X
b. Pants			X (Note 4)	X (Note 6)	X (Note 9)	X
c. Coverall			(Note 5)	(Note 7)	X (Note 9)	(Note 5)
d. Jacket, parka, or rainwear			AN	AN	AN	AN
FR Protective Equipment	—	—	—	—	—	—
a. Flash suit jacket (2-layer)						X
b. Flash suit pants (2-layer)						X
Head protection	—	—	—	—	—	—
a. Hard hat			X	X	X	X
b. FR hard hat liner					X	X
Eye protection		—	—	—	—	—
a. Safety glasses	X	X	X	AL	AL	AL
b. Safety goggles				AL	AL	AL
Face protection double-layer switching hood				AR (Note 8)	X	X
Hearing protection (ear canal inserts)				AR (Note 8)	X	X

(Sheet 1 of 2)

Table 3-3.9.2 Protective Clothing and Personal Protective Equipment (PPE) Matrix *(Continued)*

Protective Clothing & Equipment	Protective Systems for Hazard/Risk Category					
Hazard/Risk Category Number	**–1** (Note 3)	**0**	**1**	**2**	**3**	**4**
Leather gloves (Note 2)			AN	X	X	X
Leather work shoes			AN	X	X	X

(Sheet 2 of 2)

Legend:
AN = As needed
AL = Select one in group
AR = As required
X = Minimum required

Notes:
1. See Table 3-3.9.3. (ATPV is the Arc Thermal Performance Exposure Value for a garment in cal/cm^2.)
2. If voltage-rated gloves are required, the leather protectors worn external to the rubber gloves satisfy this requirement.
3. Class –1 is only defined if determined by Notes 3 or 6 of Table 3-3.9.1 of Part II.
4. Regular weight (minimum 12 oz/yd^2 fabric weight), untreated, denim cotton blue jeans are acceptable in lieu of FR pants. The FR pants used for Hazard/Risk Category 1 shall have a minimum ATPV of 5.
5. Alternate is to use FR coveralls (minimum ATPV of 5) instead of FR shirt and FR pants.
6. If the FR pants have a minimum ATPV of 8, long pants of untreated natural fiber are not required beneath the FR pants.
7. Alternate is to use FR coveralls (minimum ATPV of 5) over untreated natural fiber pants and T-shirt.
8. A double-layer switching hood and hearing protection are required for the tasks designated 2* in Table 3-3.9.1 of Part II.
9. Alternate is to use two sets of FR coveralls (each with a minimum ATPV of 5) over untreated natural fiber clothing, instead of FR coveralls over FR shirt and FR pants over untreated natural fiber clothing.

3-3.9.3 Protective Clothing Characteristics. Table 3-3.9.3 lists the characteristics and degree of protection for various clothing. The protective clothing selected for the corresponding Hazard/Risk Category Number shall have an arc thermal performance exposure value (ATPV) of at least the value listed in the last column of Table 3-3.9.3.

NOTE: The ATPV for a particular clothing system may be obtained from the FR clothing manufacturer.

3-3.9.4 Factors in Selection of Protective Clothing. Protective clothing includes shirts, pants, coveralls, jackets, and parkas worn routinely by workers who, under normal working conditions, are exposed to momentary electric arc and related thermal hazards. Arc and flame resistant rainwear worn in inclement weather are included in this category of clothing.

Clothing and equipment that maximize worker protection shall be utilized. Clothing and equipment required by the degree of exposure shall be permitted to be worn alone or be integrated with normal apparel. It shall cover associated parts of the body and all normal apparel that is not flash-flame resistant, while allowing movement and visibility. All personal protective equipment shall be maintained in a sanitary and reliable condition. Individual protection items will normally be used in conjunction with one another as a system to provide appropriate protection.

3-3.9.4.1 Layering. FR and natural fiber garments shall be permitted to be used for a layered system for added protection. A typical layering system may include an undershirt, a shirt and trouser and coverall. Specific tasks may call for specific protection systems.

3-3.9.4.2 Outer Layers. Garments worn as outer layers over FR clothing, such as jackets or rainwear, shall also be made from FR material.

3-3.9.4.3 Underlayers. Meltable synthetic fibers shall be avoided in fabric underlayers next to the skin. Garments worn as underlayers (underwear) that neither ignite nor melt and drip in the course of an exposure to the electric arc and related thermal hazard may provide additional thermal protection.

3-3.9.4.4 Coverage. Clothing shall cover potentially exposed areas as completely as possible.

3-3.9.4.5 Fit. Tight-fitting clothing shall be avoided. Loose fitting clothing provides additional thermal insulation due to air spaces. FR apparel shall fit properly such that it does not interfere with the work task.

3-3.9.4.6 Interference. The garment selected shall result in the least interference with the task, but still provide the necessary protection. The work method, location, and task may influence the protective equipment selected.

Table 3-3.9.3 Protective Clothing Characteristics

Typical Protective Clothing Systems			
Hazard Risk Category	**Clothing Description (Number of clothing layers is given in parentheses)**	**Total Weight oz/yd^2**	**Minimum Arc Thermal Performance Exposure Value (ATPV)* or Breakopen Threshold Energy (E_{BT})* Rating of PPE cal/cm^2**
0	Untreated cotton (1)	4.5 – 7	N/A
1	FR shirt and FR pants (1)	4.5 – 8	5
2	Cotton underwear plus FR shirt and FR pants (2)	9 – 12	8
3	Cotton underwear plus FR shirt and FR pants plus FR coverall (3)	16 – 20	25
4	Cotton underwear plus FR shirt and FR pants plus double layer switching coat and pants (4)	24 – 30	40

*ATPV is defined in the ASTM P S58 standard arc test method for flame resistant (FR) fabrics as the incident energy that would just cause the onset of a second degree burn (1.2 cal/cm^2). E_{BT} is reported according to ASTM P S58 and is defined as the highest incident energy which did not cause FR fabric breakopen and did not exceed the second-degree burn criteria. E_{BT} is reported when ATPV cannot be measured due to FR fabric breakopen.

3-3.9.5 Arc Flash Protective Equipment.

3-3.9.5.1 Flash Suits. Flash suits and their closure design shall permit easy and rapid removal. The entire flash suit, including the window, shall have energy absorbing characteristics that are suitable for the arc-flash exposure.

3-3.9.5.2 Face Protection. Face shields made of polycarbonate material are more appropriate for use in situations with relatively low radiation exposure. Safety glasses and goggles provide lesser protection, but in low risk tasks they may be justified if the task involves substantial physical work in combination with good visual requirements. Eye protection (safety glasses or goggles) shall always be worn under face shields or hoods.

3-3.9.5.3 Hand Protection. Gloves made from layers of flame resistant material provide the highest level of hand protection. Heavy-duty leather gloves also provide good protection. Where voltage-rated gloves are used, leather protectors shall be worn over the rubber gloves. The leather protectors also provide good arc-flash protection for the hands.

3-3.9.5.4 Foot Protection. Heavy-duty leather work shoes normally provide a significant degree of protection to the feet. They are recommended for all tasks and shall be used for incident energy exposure levels 5 cal/cm^2, and higher (Hazard/Risk Category 2, and higher).

3-3.9.6 Care and Maintenance of FR Clothing and FR Flash Suits.

3-3.9.6.1 Inspection. FR apparel shall be inspected before each use. Work clothing or flash suits that are contaminated, greasy, worn, or damaged to the extent their protective qualities are impaired, shall be cleaned, repaired or replaced. Protective items that become soiled with grease or flammable liquids shall be removed from service and cleaned.

3-3.9.6.2 Manufacturer's Instructions. The garment manufacturer's instructions for care and maintenance of FR apparel shall be followed.

3-3.9.7 Clothing Material Characteristics.

NOTE: Flame-retardant treated cotton, meta-aramid, para-aramid, and poly-benzimidazole (PBI) fibers provide thermal protection. Para-aramid adds strength to a fabric to prevent the fabric from breaking open due to the blast energy of the arc.

3-3.9.7.1 Melting. Synthetic materials, such as polyester, nylon, and synthetic-cotton blends shall not be used. These materials will melt into the skin when exposed to high temperatures and aggravate the burn injury.

3-3.9.7.2 Flammability. Cotton and polyester-cotton, silk, wool, and nylon fabrics are flammable. Flame-retardant treated cotton, meta-aramid, para-aramid, and PBI fabrics may ignite but will not continue to burn after the ignition source is removed. Clothing made from natural materials, such as cotton, wool, or silk shall be considered acceptable if it is determined by flash hazard analysis that the fabric will not ignite and continue to burn under the arc conditions to which it will be exposed.

NOTE: The weight of the fabric is a factor in meeting this requirement.

3-3.9.8 Clothing Not Permitted. Clothing made from synthetic materials such as acetate, nylon, polyester, rayon, either alone or in blends with cotton, shall not be worn.

NOTE: Some flame-resistant fabrics, like non-FR modacrylic and non-durable flame-retardant treatments of cotton, are not recommended for industrial electrical or utility applications.

3-4 Other Protective Equipment.

3-4.1 Insulated Tools.

3-4.1.1 Qualifications for Insulated Tools.

3-4.1.1.1 Insulated tools shall be rated for the voltages on which they are used.

3-4.1.1.2 Insulated tools shall be designed and constructed for the environment to which they are exposed and the manner in which they are used.

3-4.1.2 Fiberglass-Reinforced Plastic Rods. Fiberglass-reinforced plastic rod and tube used for live line tools shall meet the requirements of ASTM F 711.

3-4.2 Temporary Protective Grounding Equipment.

3-4.2.1 Temporary protective grounds shall be placed at such locations and arranged in such a manner as to prevent each employee from being exposed to hazardous differences in electrical potential.

3-4.2.2 Temporary protective grounds shall be capable of conducting the maximum fault current that could flow at the point of grounding for the time necessary to clear the fault.

3-4.2.3 Temporary protective grounding equipment shall meet the requirements of ASTM F 855.

3-4.2.4 Temporary protective grounds shall have an impedance low enough to cause immediate operation of protective devices in case of accidental energizing of the electric conductors or circuit parts.

3-4.3 Nonconductive Ladders. Nonconductive ladders shall meet the requirements of ANSI standards for ladders given in Table 3-4.11 of Part II.

3-4.4 Rubber Insulating Equipment. Rubber insulating equipment used for protection from accidental contact with live parts shall meet the requirements of the ASTM standards given in Table 3-4.11 of Part II.

3-4.5 Voltage Rated Plastic Guard Equipment. Plastic guard equipment for protection of employees from accidental contact with live parts, or to protect the employee or energized equipment or material from contact with ground, shall meet the requirements of the ASTM standards given in Table 3-4.11 of Part II.

3-4.6 Physical or Mechanical Barriers. Physical or mechanical (field fabricated) barriers shall be installed no closer than the restricted approach distance given in Table 2-1.3.4 of Part II.

NOTE: The restricted approach distance specified in Table 2-1.3.4 of Part II shall be maintained, or the live parts must be placed in an electrically safe working condition while the barrier is being installed.

3-4.7 Safety Signs and Tags. Safety signs, safety symbols, or accident prevention tags shall be used where necessary to warn employees about electrical hazards that might endanger them. Such signs and tags shall meet the requirements of ANSI Standard Z535 given in Table 3-4.11 of Part II.

3-4.8 Barricades. Barricades shall be used in conjunction with safety signs where it is necessary to prevent or limit employee access to work areas containing live parts. Conductive barricades shall not be used where it might cause an electrical hazard. Barricades shall be placed no closer than the limited approach boundary give in Table 2-1.3.4 of Part II.

Table 3-4.11 Standards on Other Protective Equipment

Subject	Number and Title
Ladders	ANSI A14.1, *Safety Requirements for Portable Wood Ladders,* 1994
	ANSI A14.3, *Safety Requirements for Fixed Ladders,* 1984
	ANSI A14.4, *Safety Requirements for Job-Made Ladders,* 1992
	ANSI A14.5, *Safety Requirement for Portable Reinforced Plastic Ladders,* 1992
Safety signs and tags	ANSI Z535, *Series of Standards for Safety Signs and Tags,* 1998
Blankets	ASTM D 1048, *Standard Specification for Rubber Insulating Blankets,* 1998
Covers	ASTM D 1049, *Standard Specification for Rubber Covers,* 1998
Line hoses	ASTM D 1050, *Standard Specification for Rubber Insulating Line Hoses,* 1990
Line hoses and covers	ASTM F 478, *Standard Specification for In-Service Care of Insulating Line Hose and Covers,* 1992
Blankets	ASTM F 479, *Standard Specification for In-Service Care of Insulating Blankets,* 1995
Fiberglass tools/ ladders	ASTM F 711, *Standard Specification for Fiberglass-Reinforced Plastic (FRP) Rod and Tube Used; in Line Tools,* 1989 (R 1997)
Plastic guards	ASTM F 712, *Standard Test Methods for Electrically Insulating Plastic Guard Equipment for Protection of Workers,* 1988 (R 1995)
Temporary grounding	ASTM F 855, *Standard Specification for Temporary Protective Grounds to Be Used on De-energized Electric Power Lines and Equipment,* 1997
Insulated hand tools	ASTM F 1505, *Standard Specification for Insulated and Insulating Hand Tools,* 1994

ASTM - American Society for Testing and Materials
ANSI - American National Standards Institute

3-4.9 Alternate Alerting Techniques — 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. The primary duty and responsibility of an attendant providing manual signaling and alerting

shall be to keep unqualified employees outside a work area where the unqualified employee might be exposed to electrical hazards. An attendant shall remain in the area as long as there is a potential for employees to be exposed to the electrical hazards.

3-4.10 Test Instruments and Equipment.

3-4.10.1 Test instruments, equipment, and their accessories shall be rated for circuits and equipment to which they will be connected.

3-4.10.2 Test instruments, equipment, and their accessories shall be designed for the environment to which they will be exposed, and for the manner in which they will be used.

3-4.11 Standards for Other Protective Equipment. Other protective equipment required in Section 3-4 of Part II shall conform to the standards given in Table 3-4.11 of Part II.

Chapter 4 Use of Specific Safety-Related Equipment and Work Practices

4-1 Test Instruments and Equipment Use. Only qualified persons shall perform testing work on or near live parts operating at 50 volts or more.

4-1.1 Visual Inspection. Test instruments and equipment and all associated test leads, cables, power cords, probes, and connectors shall be visually inspected for external defects and damage before the equipment is used on any shift. If there is a defect or evidence of damage that might expose an employee to injury, the defective or damaged item shall be removed from service, and no employee shall use it until repairs and tests necessary to render the equipment safe have been made.

4-2 Energizing and Deenergizing Electrical Power Circuits.

4-2.1 Routine Opening and Closing of Circuits. Load-rated switches, circuit breakers, or other devices specifically designed as disconnecting means shall be used for the opening, reversing, or closing of circuits under load conditions. Cable connectors not of the load-break type, fuses, terminal lugs, and cable splice connections shall not be permitted to be used for such purposes, except in an emergency.

4-2.2 Reclosing Circuits after Protective Device Operation. After a circuit is deenergized by a circuit protective device, the circuit shall not be manually reenergized until it has been determined that the equipment and circuit can be safely energized. The repetitive manual reclosing of circuit breakers or reenergizing circuits through replaced fuses is prohibited. When it is determined from the design of the circuit and the overcurrent devices involved that the automatic operation of a device was caused by an overload rather than a fault condition, examination of the circuit or connected equipment shall not be required before the circuit is reenergized.

4-3 Portable Electric Equipment. This section applies to the use of cord- and plug-connected equipment, including cord sets (extension cords).

4-3.1 Handling. Portable equipment shall be handled in a manner that will not cause damage. Flexible electric cords connected to equipment shall not be used for raising or lowering the equipment. Flexible cords shall not be fastened with staples or hung in such a fashion as could damage the outer jacket or insulation.

4-3.2 Grounding-type Equipment.

4-3.2.1 A flexible cord used with grounding-type utilization equipment shall contain an equipment grounding conductor.

4-3.2.2 Attachment plugs and receptacles shall not be connected or altered in a manner that would interrupt continuity of the equipment grounding conductor at the point where plugs are attached to receptacles. Additionally, these devices shall not be altered to allow the grounding pole of a plug to be inserted into slots intended for connection to the current-carrying conductors.

4-3.2.3 Adapters that interrupt the continuity of the equipment grounding conductor shall not be used.

4-3.3 Visual Inspection of Portable Cord- and Plug-Connected Equipment and Flexible Cord Sets.

4-3.3.1 Frequency of Inspection. Before use on any shift, portable cord- and plug-connected equipment shall be visually inspected for external defects (such as loose parts, deformed and missing pins) and for evidence of possible internal damage (such as pinched or crushed outer jacket).

Exception: Cord- and plug-connected equipment and flexible cord sets (extension cords) that remain connected once they are put in place and are not exposed to damage shall not be required to be visually inspected until they are relocated.

4-3.3.2 Defective Equipment. If there is a defect or evidence of damage that might expose an employee to injury, the defective or damaged item shall be removed from service, and no employee shall use it until repairs and tests necessary to render the equipment safe have been made.

4-3.3.3 Proper Mating. When an attachment plug is to be connected to a receptacle, the relationship of the plug and receptacle contacts shall first be checked to ensure that they are of mating configurations.

4-3.4 Conductive Work Locations. Portable electric equipment used in highly conductive work locations (such as those inundated with water or other conductive liquids) or in job locations where employees are likely to contact water or conductive liquids shall be approved for those locations. In job locations where employees are likely to contact or be drenched with water or conductive liquids, ground-fault circuit-interrupter protection for personnel shall also be used.

4-3.5 Connecting Attachment Plugs.

4-3.5.1 Employees' hands shall not be wet when plugging and unplugging flexible cords and cord- and plug-connected equipment, if energized equipment is involved.

4-3.5.2 Energized plug and receptacle connections shall be handled only with insulating protective equipment if the condition of the connection could provide a conductive path to the employee's hand (if, for example, a cord connector is wet from being immersed in water).

4-3.5.3 Locking-type connectors shall be secured after connection.

Chapter 5 Lockout/Tagout Practices and Devices

5-1 General. All electrical circuit conductors and circuit parts shall be considered energized until the source(s) of energy is (are) removed, at which time they shall be considered deenergized. All electrical circuit conductors and circuit parts shall not be considered to be in an electrically safe condition until all sources of energy are removed, the disconnecting means is under lockout/tagout, the absence of voltage is verified by an approved voltage testing device, and, where exposure to energized facilities exist, are temporarily grounded *(see 2-1.1.3 of Part II for the six-step procedure to establish an electrically safe work condition).* Electrical conductors and circuit parts that have been disconnected, but not under lockout/tagout, tested, and grounded (where appropriate) shall not be considered to be in an electrically safe work condition, and safe work practices appropriate for the circuit voltage and energy level shall be used. Lockout/tagout requirements shall apply to fixed permanently installed equipment, temporarily installed equipment, and to portable equipment.

5-1.1 Principles of Lockout/Tagout Execution.

5-1.1.1 Each person who could be exposed directly or indirectly to a source of electrical energy shall be involved in the lockout/tagout process.

NOTE: An example of direct exposure is the qualified electrician who is to work on the motor starter control, or power circuits, or the motor. An example of indirect exposure is the person who is to work on the coupling between the motor and compressor.

5-1.1.2 All persons who could be exposed shall be trained to understand the established procedure to control the energy and their responsibility in executing the procedure. New (or reassigned) employees shall be trained (or retrained) to understand the lockout/tagout procedure as related to their new assignment.

5-1.1.3 A plan shall be developed based on the existing electrical equipment and system and shall utilize up-to-date diagrammatic drawing representation(s).

5-1.1.4 All sources of electrical energy shall be controlled in such a way as to minimize employee exposure to electrical hazards.

5-1.1.5 The lockout/tagout device shall be unique and readily identifiable as a lockout/tagout device.

5-1.1.6 Voltage shall be removed and absence of voltage verified.

5-1.1.7 The established electrical lockout/tagout procedure shall be coordinated with all of the employer's procedures associated with lockout/tagout of other energy sources. The lockout/tagout procedure shall be audited for execution and completeness on an annual basis.

5-1.2 Responsibility. The employer shall establish lockout/tagout procedures for the organization, provide training to employees, provide equipment necessary to execute the details of the procedure, audit execution of the procedures to ensure employee understanding/compliance, and audit the procedure for improvement opportunity and completeness.

There are three forms of hazardous electrical energy control that shall be permitted: individual employee control, simple lockout/tagout, and complex lockout/tagout. *(See 5-1.3 of Part II.)* For the individual employee control and the simple lockout/tagout, the qualified person shall be in charge. For the complex lockout/tagout, the person in charge shall have overall responsibility. *(See Appendix D of Part II for a sample lockout/tagout procedure.)*

5-1.2.1 Audit. An audit shall be conducted at least annually by a qualified person and shall cover at least one lockout/tagout in progress and the procedure details. The audit shall be designed to correct deficiencies in the procedure or in employee understanding.

5-1.3 Hazardous Electrical Energy Control Procedures.

5-1.3.1 Individual Qualified Employee Control Procedure. The individual qualified employee control procedure shall be permitted when equipment with exposed conductors and circuit parts are deenergized for minor maintenance, servicing, adjusting, cleaning, inspection, operating conditions, and the like. The work shall be permitted to be performed without the placement of lockout/tagout devices on the disconnecting means, provided the disconnecting means is adjacent to the conductor, circuit parts, and equipment on which the work is performed, the disconnecting means is clearly visible to the individual qualified employee involved in the work, and the work does not extend beyond one shift.

5-1.3.2 Simple Lockout/Tagout Procedure. All lockout/tagout procedures that are not under individual qualified employee control *(see 5-1.3.1 of Part II)* or complex lockout/tagout *(see 5-1.3.3 of Part II)* shall be considered to be simple lockout/tagout procedures. All lockout/tagout procedures that involve only a qualified person(s) deenergizing one set of conductors or circuit part source for the sole purpose of performing work on or near electrical equipment shall be considered to be a simple lockout/tagout. Simple lockout/tagout plans shall not be required to be written for each application. Each worker shall be responsible for his or her own lockout/tagout.

5-1.3.3 Complex Lockout/Tagout Procedure. A complex lockout/tagout plan shall be permitted where one or more of the following exist:

(a) Multiple energy sources
(b) Multiple crews
(c) Multiple crafts
(d) Multiple locations
(e) Multiple employers
(f) Different disconnecting means
(g) Particular sequences
(h) Continues for more than one work period

There shall be a person in charge of a complex lockout/tagout procedure. The person in charge of a lockout/tagout shall be a qualified person who is specifically appointed with overall responsibility to ensure that all energy sources are under lockout/tagout and to account for all persons working on the job/task.

The procedure shall identify the person in charge. In this (these) instance(s), the person in charge shall be permitted to install locks/tags, or direct their installation, on behalf of other employees. The person-in-charge shall be held accountable for safe execution of the complex lockout/tagout. The complex lockout/tagout procedure shall address all the concerns of employees who might be exposed. All complex lockout/tagout procedures shall require a written plan of execution that identifies the person in charge. All complex lockout/tagout plans identify the method to account for all persons who might be exposed to electrical hazards in the course of the lockout/tagout.

5-1.4 Coordination.

5-1.4.1 The established electrical lockout/tagout procedure shall be coordinated with all other employer's procedures for control of exposure to electrical energy sources such that all employer's procedural requirements are adequately addressed on a site basis.

5-1.4.2 The procedure for control of exposure to electrical hazards shall be coordinated with other procedures for control of other hazardous energy sources such that they are based on similar/identical concepts.

5-1.4.3 The electrical lockout/tagout procedure shall always include voltage testing requirements where there might be direct exposure to electrical energy hazards.

5-1.4.4 Electrical lockout/tagout devices shall be permitted to be similar to lockout/tagout devices for control of other hazardous energy sources, such as pneumatic, hydraulic, thermal, and mechanical, provided such devices are used only for control of hazardous energy and for no other purpose.

5-2 Training and Retraining. Each employer shall provide training as required to ensure employees' understanding of the lockout/tagout procedure content and their duty in executing such procedures.

5-3 Equipment.

5-3.1 Lock/Tag Application. Energy isolation devices for machinery or equipment installed after January 2, 1990, shall be capable of accepting a lockout/tagout device.

5-3.2 Lockout/Tagout Device. Each employer shall supply and employees shall use lockout/tagout devices and equipment necessary to execute the requirements of Section 5-3. Locks and tags used for control of exposure to electrical energy hazards shall be unique, shall be readily identifiable as lockout/tagout devices, and shall be used for no other purpose.

5-3.3 Lockout Device.

5-3.3.1 A lockout device includes a lock (either keyed or combination).

5-3.3.2 The lockout device shall include a method of identifying the individual who installed the lockout device.

5-3.3.3 A lockout device shall be permitted to be only a lock, provided the lock is readily identifiable as a lockout device, in addition to a means of identifying the person who installed the lock.

5-3.3.4 Lockout devices shall be attached to prevent operation of the disconnecting means without resorting to undue force or the use of tools.

5-3.3.5 The tag used in conjunction with a lockout device shall contain a statement prohibiting unauthorized operation of the disconnecting means or unauthorized removal of the device.

5-3.3.6 Lockout devices shall be suitable for the environment and for the duration of the lockout.

5-3.3.7 Whether keyed or combination locks are used, the key or combination shall remain in the possession of the individual installing the lock or the person in charge, when provided by the established procedure.

5-3.4 Tagout Device.

5-3.4.1 A tagout device shall include a tag together with an attachment means.

5-3.4.2 The tagout device shall be readily identifiable as a tagout device and suitable for the environment and duration of the tagout.

5-3.4.3 A tagout device attachment means shall be capable of withstanding at least 50 pounds of force (222.4 N) exerted at a right angle to the disconnecting means surface. The tag attachment means shall be nonreusable, attachable by hand, self-locking, and nonreleasable, equal to an all-environmental tolerant nylon cable tie.

Exception: A "hold card tagging tool" on an overhead conductor in conjunction with a hotline tool to install the tagout device safely on a disconnect that is isolated from the worker(s).

5-3.4.4 Tags shall contain a statement prohibiting unauthorized operation of the disconnecting means or removal of the tag.

5-3.5 Electrical Circuit Interlocks. Up-to-date diagrammatic drawings shall be consulted to ensure that no electrical circuit interlock operation can result in reenergizing the circuit being worked on.

5-3.6 Control Devices. Locks/tags shall only be installed on circuit disconnecting means. Control devices, such as pushbuttons or selector switches, shall not be used as the primary isolating device.

5-4 Procedures. The employer shall maintain a copy of the procedures required by this section and shall make the procedures available to all employees.

5-4.1 Planning. The procedure shall require planning, including 5-4.1.1 through 5-4.2.14 of Part II.

5-4.1.1 Locating Sources. Up-to-date single-line drawings shall be considered a primary reference source for such information. When up-to-date drawings are not available, the employer shall be responsible to ensure that an equally effective means of locating sources of energy is employed.

5-4.1.2 Exposed Persons. The plan shall identify persons that might be exposed to an electrical hazard during the execution of the job or task.

5-4.1.3 Person In Charge. The plan shall identify the person in charge and his or her responsibility in the lockout/tagout.

5-4.1.4 Individual Qualified Employee Control. Individual qualified employee control shall be in accordance with 5-1.3.1 of Part II.

5-4.1.5 Simple Lockout/Tagout. Simple lockout/tagout procedure shall be in accordance with 5-1.3.2 of Part II.

5-4.1.6 Complex Lockout/Tagout. Complex lockout/tagout procedure shall be in accordance with 5-1.3.3 of Part II.

5-4.2 Elements of Control. The procedure shall identify elements of control.

5-4.2.1 Deenergizing Equipment (Shutdown). The procedure shall establish the person who performs the switching and where and how to deenergize the load.

5-4.2.2 Stored Energy. The procedure shall include requirements for releasing stored electric or mechanical energy that might endanger personnel. All capacitors shall be discharged, and high capacitance elements shall also be short-circuited and

grounded before the associated equipment is touched or worked on. Springs shall be released or physical restraint shall be applied when necessary to immobilize mechanical equipment and pneumatic and hydraulic pressure reservoirs. Other sources of stored energy shall be blocked or otherwise relieved.

5-4.2.3 Disconnecting Means. The procedure shall identify how to verify that the circuit is deenergized (open).

5-4.2.4 Responsibility. The procedure shall identify the person who is responsible to verify that the lockout/tagout procedure is implemented and who is responsible to ensure that the task is completed prior to removing locks/tags. A mechanism to accomplish lockout/tagout for multiple (complex) jobs/tasks where required, including the person responsible for coordination, shall be included.

5-4.2.5 Verification. The procedure shall verify that equipment cannot be restarted. The equipment operating controls, such as pushbuttons, selector switches, and electrical interlocks, shall be operated or otherwise shall be verified that the equipment cannot be restarted.

5-4.2.6 Testing. The procedure shall establish: what voltage detector will be used and who will use it to verify that the voltage has been removed; a requirement to verify proper operation of the voltage detector before and after use; a requirement to retest for absence of voltage when circuit conditions change or when the job location has been left unattended; and, where there are no accessible exposed points to take voltage measurements, planning considerations shall include methods of verification.

5-4.2.7 Grounding. Grounding requirements for the circuit shall be established, including whether the grounds shall be installed for the duration of the task or temporarily are established by the procedure. Grounding needs or requirements shall be permitted to be covered in other work rules and might not be part of the lockout/tagout procedure.

5-4.2.8 Shift Change. A method shall be identified in the procedure to transfer responsibility for lockout/tagout to another person or person in charge when the job or task extends beyond one shift.

5-4.2.9 Coordination. The procedure shall establish how coordination is accomplished with other jobs or tasks in progress, including related jobs or tasks at remote locations, including the person responsible for coordination.

5-4.2.10 Accountability for Personnel. A method shall be identified in the procedure to account for all persons who could be exposed to hazardous energy during the lockout/tagout.

5-4.2.11 Lockout/Tagout Application. The procedure shall clearly identify when and where lockout applies, in addition to when and where tagout applies.

(a) Lockout is defined as installing a lockout device on all sources of hazardous energy such that operation of the disconnecting means is prohibited, and forcible removal of the lock is required to operate the disconnect means.

(b) Tagout is defined as installing a tagout device on all sources of hazardous energy, such that operation of the disconnect means is prohibited. The tagout device shall be installed in the same position available for the lockout device.

(c) Where it is not possible to attach a lock to existing disconnecting means, the disconnecting means shall not be used as the only means to put the circuit in an electrically safe work condition.

(d) Where tagout is employed, at least one additional safety measure shall be employed. The procedure shall clearly establish responsibilities and accountability for each person that might be exposed to electrical hazards. The employer shall establish that tagout provides equivalent safety as a lockout.

5-4.2.12 Removal of Lockout/Tagout Devices. The procedure shall identify the details for removing locks or tags when the installing individual is unavailable. When locks or tags are removed by other than the installer, the employer shall attempt to locate the person prior to removing the lock or tag. When the lock or tag is removed because the installer is unavailable, the installer shall be informed prior to return to work.

5-4.2.13 Release for Return to Service. The procedure shall identify steps to be taken when the job or task requiring lockout/tagout is completed. Before electric circuits or equipment are reenergized, appropriate tests and visual inspections shall be conducted to verify that all tools, mechanical restraints and electrical jumpers, shorts, and grounds have been removed, so that the circuits and equipment are in a condition to be safely energized. Where appropriate, the employees responsible for operating the machines or process shall be notified when circuits and equipment are ready to be energized, and such employees shall provide assistance as necessary to safely energize the circuits and equipment. The procedure shall contain a statement requiring the area to be inspected to ensure that nonessential items have been removed.

One such step shall ensure that all personnel are clear of exposure to dangerous conditions resulting from reenergizing the service and that blocked mechanical equipment or grounded equipment is cleared and prepared for return to service.

5-4.2.14 Temporary Release for Testing/Positioning. The procedure shall clearly identify the steps and qualified persons' responsibilities when the job or task requiring lockout/tagout is to be interrupted temporarily for testing or positioning of equipment; then the steps shall be identical to the steps for return to service. See 3-4.10 and Section 4-1 of Part II for requirements when using test instruments and equipment.

Part II, Appendix A, Limits of Approach

This appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.

References

Introduction I-2, Definitions

Part II, Chapter 2, Section 2-1, Working On or Near Electrical Conductors or Circuit Parts

A-1 Preparation for Approach. Observing a safe approach distance from exposed energized electrical conductors or circuit parts is an effective means of maintaining electrical safety. As the distance between a person and the exposed energized conductors or circuit parts is decreased, the potential for electrical accident increases.

A-1-1 Unqualified Persons, Safe Approach Distance. Unqualified persons are safe when they maintain a distance from the exposed energized conductors or circuit parts, including the longest conductive object being handled, so that they cannot contact or enter a specified air insulation distance to the exposed energized electrical conductors or circuit parts. This safe approach distance is the limited approach boundary. Further, persons must not cross the flash protection boundary unless they are wearing appropriate personal protective clothing and are under the close supervision of a qualified person.

A-1-2 Qualified Persons, Safe Approach Distance.

A-1-2.1 Determine the flash protection boundary and, if the boundary is to be crossed, appropriate flash-flame protection equipment shall be utilized.

A-1-2.2 For a person to cross the limited approach boundary and enter the limited space, he or she must be qualified to perform the job/task.

A-1-2.3 To cross the restricted approach boundary and enter the restricted space, the qualified person must:

(a) Have a plan that is documented and approved by authorized management

(b) Use personal protective equipment appropriate for working near exposed energized conductors or circuit parts, and rated for the voltage and energy level involved

(c) Be certain that no part of the body shall enter the prohibited space

(d) Minimize the risk due to inadvertent movement by keeping as much of the body out of the restricted space, using only protected body parts in the space as necessary to accomplish the work

A-1-2.4 To cross the prohibited approach boundary and enter the prohibited space is considered the same as making contact with exposed energized conductors or circuit parts. The qualified person must:

(a) Have specified training to work on energized conductors or circuits parts

(b) Have a documented plan justifying the need to work that close

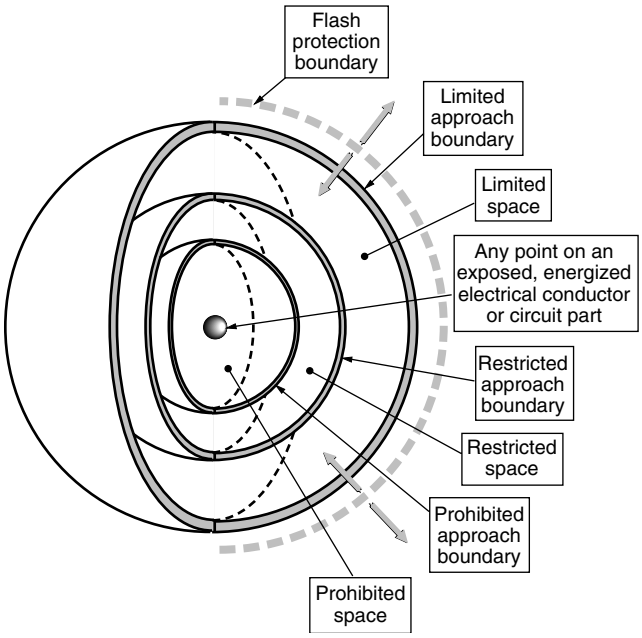
(c) Perform a risk analysis

(d) Have (b) and (c) approved by authorized management

(e) Use personal protective equipment appropriate for working on exposed energized conductors or circuit parts, and rated for the voltage and energy level involved

See Figure A-1-2.4.

FIGURE A-1-2.4 Limits of approach.



A-2 Basis for Distance Values in Table 2-1.3.4 of Part II.

A-2-1 General Statement. Columns 1 through 5 of Table 2-1.3.4 all show various distances from the exposed energized electrical conductors or circuit part. They include dimensions that are added to a basic minimum air insulation distance. That basic minimum air insulation distance for voltages 72.5 kV and under are based on ANSI/IEEE 4-1995, *Standard Techniques for High-Voltage Testing*, Appendix 2B; and for voltages over 72.5 kV, are based on ANSI/IEEE 516-1995, *Guide for Maintenance Methods on Energized Power Lines*. These minimum air insulation distances required to avoid flashover are:

300 V and less — 0 ft 0.03 in.

Over 300 V, not over 750 V — 0 ft 0.07 in.

Over 750 V not over 2 kV — 0 ft 0.19 in.

Over 2 kV, not over 15 kV — 0 ft 1.5 in.

Over 15 kV, not over 36 kV — 0 ft 6.3 in.

Over 36 kV, not over 48.3 kV — 0 ft 10.0 in.

Over 48.3 kV, not over 72.5 kV — 1 ft 3.0 in

Over 72.5 kV, not over 121 kV — 2 ft 1.2 in.

Over 138 kV, not over 145 kV — 2 ft 6.6 in.

Over 161 kV, not over 169 kV — 3 ft 0.0 in.

Over 230 kV, not over 242 kV — 4 ft 2.4 in.

Over 345 kV, not over 362 kV — 7 ft 5.8 in.

Over 500 kV, not over 550 kV — 10 ft 2.5 in.

Over 765 kV, not over 800 kV — 13 ft 10.3 in.

Column No. 1: The voltage ranges have been selected to group voltages that require similar approach distances based on the sum of the electrical withstand distance and an inadvertent movement factor. The value of the upper limit for a range is the maximum voltage for highest nominal voltage in the range based on ANSI C84.1-1995, *Electric Power systems and Equipment — Voltage Ratings (60 Hertz)*. For single-phase systems, select the range that is equal to the system's maximum phase-to-ground voltage times 1.732.

Column No. 2: The distances in this column are based on OSHA's rule for unqualified persons to maintain a 10 ft (3.05 m) clearance for all voltages up to 50 kV (voltage-to-ground), plus 0.4 in. (102 mm) for each 1 kV over 50 kV.

Column No. 3: The distances are based on the following:

750 V and lower, use *NEC* Table 110-26(a) Working Clearances, Condition 2 for 151 – 600 V range.

For over 750 V, but not over 145 kV, use *NEC* Table 110-34(a) Working Space, Condition 2.

Over 145 kV, use OSHA's 10 ft (3.05 m) rules as used in Column No. 2.

Column No. 4: The distances are based on adding to the flashover dimensions shown above the following inadvertent movement distance:

300 V and less, avoid contact.

Based on experience and precautions for household 120/240 V systems.

Over 300 V and not over 750 V, add 1 ft 0 in. inadvertent movement.

These values have been found to be adequate over years of use in ANSI C2, *National Electrical Safety Code*, in the approach distances for communication workers.

Over 72.5 kV, add 1 ft 0 in. inadvertent movement.

These values have been found to be adequate over years of use in the *National Electrical Safety Code* in the approach distances for supply workers.

Column No. 5: The distances are based on the following:

300 V and less, avoid contact.

Over 300 but less than 750 V, use *NEC* Table 230-51(c), Clearances.

Between open conductors and surfaces, 600 V not exposed to weather.

Over 750 V but not over 2.0 kV, value selected that fits in with adjacent values.

Over 2 kV but not over 72.5 kV, use *NEC* Table 490-24, Minimum Clearance of Live Parts, outdoor phase-to-ground values.

Over 72.5 kV, add 0 ft 6 in. inadvertent movement.

These values have been found to be adequate over years of use where there has been a hazard/risk analysis, either formal or informal, of a special work procedure that allows closer approach than that permitted by the restricted approach boundary distance.

Part II, Appendix B, Sample Calculation of Flash Protection Boundary

This appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.

Existing knowledge about arc flash exposure at voltage levels above 600 volts is limited. Other methods of calculating such exposure exist and may be used. Commercial and shareware programs are available for calculating these values. It is important to investigate the limitations of any programs to be used. For example some only calculate for single phase conditions and others have current limitations.

The following example is conservative at voltage levels above 600 volts. Experience suggests that the example is conservative and becomes more conservative as the voltage increases. It should be noted that all present methods of calculating incident energy at higher voltage levels have limitations.

See Chapter 2, 2-1.3.3 of Part II.

B-1 Development of Arc Energy and Temperature Rise on a Person's Exposed Skin. The following provides an explanation of the development of the arc energy and temperature rise on a person's exposed skin due to various strengths of electrical arc blasts at various distances from the involved person. The formulae used in this explanation are from Ralph Lee's paper, "The Other Electrical Hazard: Electrical Arc Blast Burns," IEEE Trans. Industrial Applications, Vol 1A-18. No. 3, Page 246, May/June 1982. The calculations are based on the worst case arc impedance. See Table B-1.

Table B-1 Flash Burn Hazards at Various Levels in a Large Petrochemical Plant

Bus Nominal Voltage Levels	System *MVA*	Transformer *MVA*	System or Transformer % *Z*	Short Circuit Symmetrical Amperes	Arc MW	Clearing Time of Fault Cycles	Distance from Arc to Limit Skin Temperature to a Curable Skin Burn [Less than 80°C (176°F) on Skin] in Free Flash Protection Boundary Typical Distance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
230 kV	9000		1.11	23,000	4000	6.0	46.0
13.8 kV	750		9.4	31,300	374	6.0	14.1
Load side of all 13.8 kV fuses	750		9.4	31,300	374	1.0	5.8
4.16 kV		10	5.5	25,000	91	6.0	7.3
4.16 kV		5	5.5	12,600	45	6.0	5.5
Line side of incoming 600 V fuse		2.5	5.5	44,000	23	6.0	3.7
600 V bus		2.5	5.5	44,000	23	0.25	0.74
600 V bus		1.5	5.5	26,000	27	6.0	2.8
600 V bus		1.0	5.57	17,000	17	6.0	2.3

B-2 Basic Equations for Calculating Flash Protection Boundary Distances.

B-2-1 The short-circuit symmetrical amperes from a bolted 3-phase fault at the transformer terminals is calculated with the following formula:

$$I_{sc} = \{[MVA\ \text{Base} \times 10^6] \div [1.732 \times V]\} \times \{100 \div \%Z\}$$

where I_{sc} is in amperes, V is in volts, and $\%Z$ is based on the transformer *MVA*.

B-2-2 A typical value for the maximum power (in MW) in a 3-phase arc can be calculated using the following formula:

$$P = [\text{maximum bolted fault in } MVA_{bf}] \times 0.707^2$$

B-2-3 The flash protection boundary distance is calculated in accordance with the following formulae.

B-2-3.1 $P = 1.732 \times V \times I_{sc} \times 10^{-6} \times 0.707^2$

B-2-3.2 $D_c = [2.65 \times MVA_{bf} \times t]^{1/2}$ or

B-2-3.3 $D_c = [53 \times MVA \times t]^{1/2}$

where:

D_c = distance in feet of person from arc source for a just curable burn (i.e., skin temperature remains less than 80 degrees)

MVA_{bf} = bolted fault *MVA* at point involved

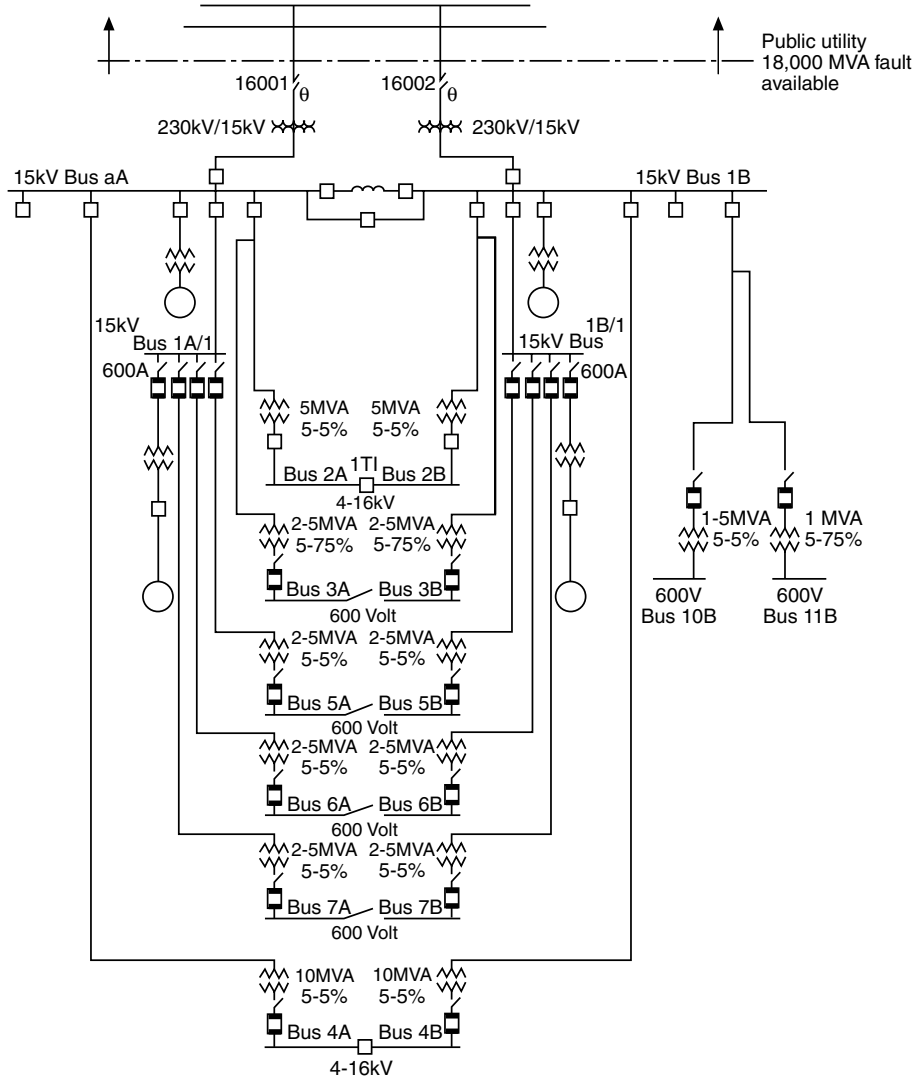
MVA = *MVA* rating of transformer. For transformers with *MVA* ratings below 0.75 *MVA*, multiply the transformer *MVA* rating by 1.25.

t = time of arc exposure in seconds

The clearing time for a current limiting fuse is approximately $^1/_4$ cycle or 0.004 sec. The clearing time of a 5 kV and 15 kV circuit breaker is approximately 0.1 sec or 6 cycles. This can be broken down as follows: actual breaker time (approximately 2.0 cycles), plus relay operating time of approximately 1.74 cycles, plus an additional safety margin of 2 cycles, giving a total time of approximately 6 cycles.

B-3 Single Line Diagram of a Typical Petrochemical Complex. The single line diagram *(see Figure B-3)* illustrates the complexity of a distribution system in a typical petrochemical plant.

FIGURE B-3 Single line diagram of a typical petrochemical complex.



B-4 Sample Calculation. Many of the electrical characteristics of the systems and equipment are provided in Table B-1. The sample calculation is made on the 4160-volt bus 4A or 4B. Table B-1 tabulates the results of calculating the flash protection boundary for each part of the system.

B-4-1 Calculation is on a 4160-volt bus.

B-4-2 Transformer MVA (and base MVA) = 10 MVA.

B-4-3 Transformer impedance on 10 MVA base = 5.5%.

B-4-4 Circuit breaker clearing time = 6 cycles.

B-4-5 Based on equation B-2-1, calculate the short-circuit current:

$$I_{sc} = \{[MVA\ \text{Base} \times 10^6] \div [1.732 \times V]\} \times \{100 \div \%\ Z\}$$
$$= \{[10 \times 10^6] \div [1.732 \times 4160]\} \times \{100 \div 5.5\}$$
$$= (25{,}000\ \text{amperes})$$

B-4-6 Based on the equation in B-2-2, calculate the power in the arc:

$$P = 1.732 \times 4160 \times 25{,}000 \times 10^{-6} \times 0.707^2$$

$$P = 91\ \text{MW}$$

B-4-7 Based on the equation in B-2-3.2, calculate the curable burn distance:

$$D_c = \{2.65 \times [1.732 \times 25{,}000 \times 4160 \times 10^{-6}] \times 0.1\}^{1/2}$$

$$D_c = 6.9 \text{ or } 7.00 \text{ feet}$$

Or, using B-2-3.3, calculate the curable burn distance using an alternate method:

$$D_c = [53 \times 10 \times 0.1]^{1/2}$$

$$D_c = 7.28 \text{ feet}$$

B-5 Calculation of Incident Energy Exposure for a Flash Hazard Analysis. The following equations can be used to predict the incident energy produced by a three-phase arc on systems rated 600 volts and below. The parameters required to make the calculation are:

(a) The maximum "bolted fault" three-phase short circuit current available at the equipment

(b) The total protective device clearing time (upstream of the prospective arc location) at the maximum short circuit current

(c) The distance of the worker from the prospective arc for the task to be performed.

B-5.1 Arc in Open Air. The estimated incident energy for an arc in open air is

$$E_{MA} = 5271 D_A^{-1.9593} t_A [0.0016F^2 - 0.0076F + 0.8938]$$

where:

E_{MA} = maximum open arc incident energy, cal/cm^2
D_A = distance from arc electrodes, inches (for distances 18 in. and greater)
t_A = arc duration, seconds
F = bolted fault short circuit current, kA (for the range of 16 to 50 kA)

B-5.2 Arc in a Cubic Box. The estimated incident energy for an arc in cubic box (20 in. on each side, open on one end) is given in the following equation. This equation is applicable to arc flashes emanating from within switchgear, motor control centers, or other electrical equipment enclosures.

$$E_{MB} = 1038.7 D_B^{-1.4738} t_A [0.0093F^2 - 0.3453F + 5.9675]$$

where:

E_{MB} = maximum 20 in. cubic box incident energy, cal/cm^2
D_B = distance from arc electrodes, inches (for distances 18 in. and greater)
t_A = arc duration, seconds
F = bolted fault short circuit current, kA (for the range of 16 to 50 kA)

B-5.3 Reference. The equations for this section were derived in the IEEE paper by R. L. Doughty, T. E. Neal, and H. L. Floyd, II, "Predicting Incident Energy to Better Manage the Electric Arc Hazard on 600 V Power Distribution Systems," *Record of Conference Papers IEEE IAS 45th Annual Petroleum and Chemical Industry Conference*, September 28-30, 1998.

Part II, Appendix C, Electrical Safety Program

This appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.

See Section 2-3 of Part II.

C-1 Typical Electrical Safety Program Principles. Electrical safety program principles can include, but are not limited to, the following:

(a) Inspect/evaluate the electrical equipment
(b) Maintain the electrical equipment's insulation and enclosure integrity
(c) Plan every job and document first-time procedures
(d) Deenergize, if possible *(see 2-1.1.3)*
(e) Anticipate unexpected events
(f) Identify and minimize the hazard
(g) Protect the employee from shock, burn, and blast, and other hazards that are due to the working environment
(h) Use the right tools for the job
(i) Assess people's abilities
(j) Audit these principles

C-2 Typical Electrical Safety Program Controls. Electrical safety program controls can include, but are not limited to, the following:

(a) Every electrical conductor or circuit part is considered energized until proven otherwise.
(b) No bare-hand contact is to be made with exposed energized electrical conductors or circuit parts above 50 volts to ground, unless the "bare-hand method" is properly used.
(c) Deenergizing an electrical conductor or circuit part and making it safe to work on is in itself a potentially hazardous task.
(d) Employer develops programs, including training, and employees apply them.
(e) Use procedures as "tools" to identify the hazards and develop plans to eliminate/control the hazards.
(f) Train employees to qualify them for working in an environment influenced by the presence of electrical energy.
(g) Identify/categorize tasks to be performed on or near exposed energized electrical conductors and circuit parts.
(h) Use a logical approach to determine potential hazard of task.
(i) Identify and use precautions appropriate to the working environment.

C-3 Typical Electrical Safety Program Procedures. Electrical safety program procedures can include, but are not limited to, the following:

(a) Purpose of task
(b) Qualifications and number of employees to be involved
(c) Hazardous nature and extent of task
(d) Limits of approach
(e) Safe work practices to be utilized
(f) Personal protective equipment involved
(g) Insulating materials and tools involved
(h) Special precautionary techniques
(i) Electrical diagrams
(j) Equipment details
(k) Sketches/pictures of unique features
(l) Reference data

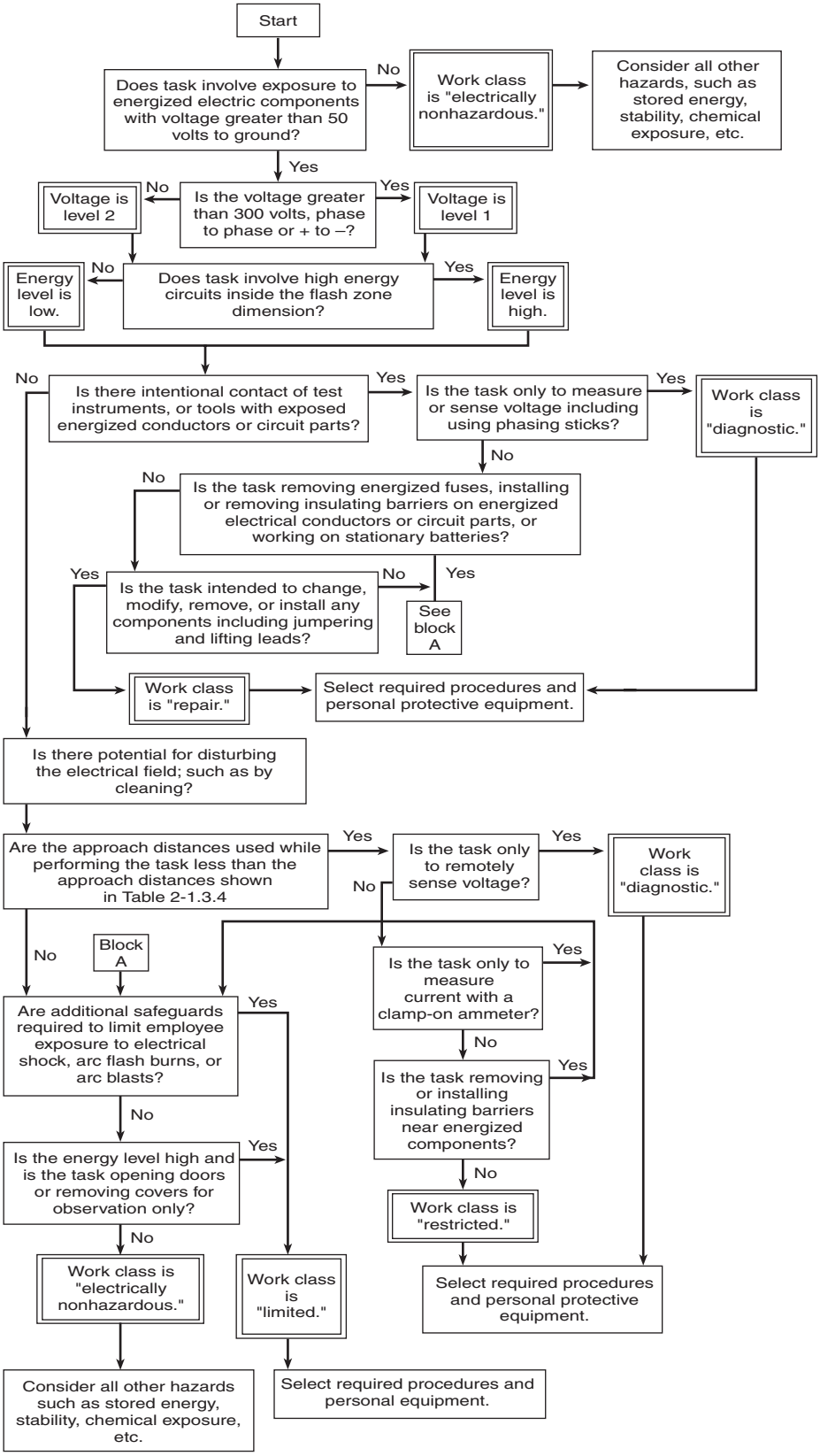
Part II, Appendix D, Hazard/Risk Evaluation Procedure

This appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.

See 2-3.1.5 of Part II.

Figure D-1 illustrates the steps of a hazard/risk analysis evaluation procedure flow chart.

FIGURE D-1 Hazard/risk analysis evaluation procedure flow chart.



Part II, Appendix E, Sample Lockout/Tagout Procedure

This appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.

Lockout is the preferred method of controlling personnel exposure to electrical energy hazards. Tagout is an alternate method that is available to employers. To assist employers in developing a procedure that meets the requirement of NFPA 70E, Chapter 5 of Part II, the following sample procedure is provided for use in lockout or tagout programs. This procedure can be used for an individual employee control, a simple lockout/tagout, or as part of a complex lockout/tagout. Where a job/task is under the control of one person, the individual employee control procedure can be used in lieu of a lockout/tagout procedure. A more comprehensive plan will need to be developed, documented, and utilized for the complex lockout/tagout.

LOCKOUT PROCEDURE FOR _____ COMPANY

OR

TAGOUT PROCEDURE FOR _____ COMPANY

E-1 Purpose. This procedure establishes the minimum requirements for lockout (tagout) of electrical energy sources. It is to be used to ensure that conductors and circuit parts are disconnected from sources of electrical energy, locked (tagged), and tested before work begins where employees could be exposed to dangerous conditions. Sources of stored energy, such as capacitors or springs, shall be relieved of their energy. A mechanism shall be engaged to prevent reaccumulation of energy.

E-2 Responsibility. All employees shall be instructed in the safety significance of the lockout (tagout) procedure. All new or transferred employees and all other persons whose work operations are or might be in the area shall be instructed in the purpose and use of this procedure _____ [include the name(s) of person(s) or job title(s) of employees with responsibility] shall ensure that appropriate personnel receive instructions on their roles and responsibilities. All persons installing a lockout (tagout) device shall sign their names and the date on the tag (or state how the name of the individual or person in charge will be available).

E-3 Preparation for Lockout (Tagout).

E-3-1 Review current diagrammatic drawings (or other equally effective means), tags, labels, and signs to identify and locate all disconnecting means to determine that power is interrupted by a physical break and not deenergized by a circuit interlock. Make a list of disconnecting means to be locked (tagged).

E-3-2 Review disconnecting means to determine adequacy of their interrupting ability. Determine if it will be possible to verify a visible open point, or if other precautions will be necessary.

E-3-3 Review other work activity to identify where and how other personnel might be exposed to sources of electrical energy hazards. Review other energy sources in the physical area to determine employee exposure to sources of other types of energy. Establish energy control methods for control of other hazardous energy sources in the area.

E-3-4 Provide an adequately rated voltage detector to test each phase conductor or circuit part to verify that they are deenergized. *(See E-12-3.)* Provide a method to determine that the voltage detector is operating satisfactorily.

E-3-5 Where the possibility of induced voltages or stored electrical energy exists, call for grounding the phase conductors or circuit parts before touching them. Where it could be reasonably anticipated that contact with other exposed energized conductors or circuit parts is possible, call for applying ground connecting devices.

E-4 Individual Employee Control Procedure. The individual employee control procedure can be used when equipment with exposed conductors and circuit parts are deenergized for minor maintenance, servicing, adjusting, cleaning, inspection operating corrections, and the like, and the work shall be permitted to be performed without the placement of lockout/tagout devices on the disconnecting means, provided the disconnecting means is adjacent to the conductor, circuit parts, and equipment on which the work is performed, the disconnecting means is clearly visible to all employees involved in the work, and the work does not extend beyond the work shift.

E-5 Simple Lockout/Tagout. The simple lockout/tagout procedure will involve paragraphs E-1 through E-3, E-5 through E-9, and E-11 through E-13.

E-6 Sequence of Lockout (Tagout) System Procedures.

E-6-1 The employees shall be notified that a lockout (tagout) system is going to be implemented and the reason therefore. The qualified employee implementing the lockout (tagout) shall know the disconnecting means location for all sources of electrical energy and the location of all sources of stored energy. The qualified person shall be knowledgeable of hazards associated with electrical energy.

E-6-2 If the electrical supply is energized, the qualified person shall deenergize and disconnect the electric supply and relieve all stored energy.

E-6-3 Lockout (tagout) all disconnecting means with lockout (tagout) devices.

NOTE: For tagout, one additional safety measure must be employed, such as opening, blocking, or removing an additional circuit element.

E-6-4 Attempt to operate the disconnecting means to determine that operation is prohibited.

E-6-5 A voltage-detecting instrument shall be used. *(See E-12-3.)* Inspect the instrument for visible damage. Do not proceed if there is an indication of damage to the instrument until an undamaged device is available.

E-6-6 Verify proper instrument operation and then test for absence of voltage.

E-6-7 Verify proper instrument operation after testing for absence of voltage.

E-6-8 Where required, install grounding equipment/conductor device on the phase conductors or circuit parts, to eliminate induced voltage or stored energy, before touching them. Where it has been determined that contact with other exposed energized conductors or circuit parts is possible, apply ground connecting devices rated for the available fault duty.

E-6-9 The equipment and/or electrical source is now locked out (tagged out).

E-7 Restoring the equipment and/or electrical supply to normal condition.

E-7-1 After the job/task is complete, visually verify that the job/task is complete.

E-7-2 Remove all tools, equipment, and unused materials and perform appropriate housekeeping.

E-7-3 Remove all grounding equipment/conductor/devices.

E-7-4 Notify all personnel involved with the job/task that the lockout (tagout) is complete, that the electrical supply is being restored, and to remain clear of the equipment and electrical supply.

E-7-5 Perform any quality control tests/checks on the repaired/replaced equipment and/or electrical supply.

E-7-6 Remove lockout (tagout) devices by the person who installed them.

E-7-7 Notify the equipment and/or electrical supply owner that the equipment and/or electrical supply is ready to be returned to normal operation.

E-7-8 Return the disconnecting means to their normal condition.

E-8 Procedure Involving More Than One Person. For a simple lockout/tagout and where more than one person is involved in the job/task, each person shall install his/her own personal lockout (tagout) device.

E-9 Procedure Involving More Than One Shift. When the lockout (tagout) extends for more than one day, the lockout (tagout) shall be verified to be still in place at the beginning of the next day. Where the lockout (tagout) is continued on successive shifts, the lockout (tagout) is considered to be a complex lockout (tagout).

For complex lockout (tagout), the person-in-charge shall identify the method for transfer of the lockout (tagout) and of communication with all employees.

E-10 Complex Lockout (Tagout). A complex lockout/tagout plan is required where one or more of the following exist:

(a) Multiple energy sources (more than one)
(b) Multiple crews
(c) Multiple crafts
(d) Multiple locations
(e) Multiple employers
(f) Unique disconnecting means
(g) Complex or particular switching sequences
(h) Continues for more than one shift, that is, new workers

E-10-1 All complex lockout/tagout procedures shall require a written plan of execution. The plan will include the requirements in E-1 through E-3, E-6, E-7, and E-9 through E-13.

E-10-2 A person in charge shall be involved with a complex lockout/tagout procedure. At this location _____ shall be the person in charge.

E-10-3 The person in charge shall develop a written plan of execution and communicate that plan to all persons engaged in the job/task. The person in charge shall be held accountable for safe execution of the complex lockout/tagout plan. The complex lockout/tagout plan must address all the concerns of employees who might be exposed, and they must understand how electrical energy is controlled. The person in charge shall ensure that each person understands the hazards to which they are exposed and the safety-related work practices they are to use.

E-10-4 All complex lockout/tagout plans identify the method to account for all persons who might be exposed to electrical hazards in the course of the lockout/tagout.

Select which of the following methods is to be used:

(a) Each individual will install his or her own personal lockout or tagout device.

(b) The person in charge shall lock his/her key in a "lock box"

(c) The person in charge shall maintain a sign in/out log for all personnel entering the area.

(d) Another equally effective methodology.

E-10-5 The person in charge can install locks/tags, or direct their installation on behalf of other employees.

E-10-6 The person in charge can remove locks/tags or direct their removal on behalf of other employees, only after all personnel are accounted for and ensured to be clear of potential electrical hazards.

E-10-7 Where the complex lockout (tagout) is continued on successive shifts, the person in charge shall identify the method for transfer of the lockout and of communication with all employees.

E-11 Discipline.

E-11-1 Knowingly violating this procedure will result in _____ (state disciplinary actions that will be taken).

E-11-2 Knowingly operating a disconnecting means with an installed lockout device (tagout device) will result in _____ (state disciplinary actions to be taken).

E-12 Equipment.

E-12-1 Locks shall be _____ (state type and model of selected locks).

E-12-2 Tags shall be _____ (state type and model to be used).

E-12-3 Voltage detecting device(s) to be used shall be _____ (state type and model).

E-13 Review. This procedure was last reviewed on _____, and is scheduled to be reviewed again on _____ (not more than one year from the last review).

E-14 Lockout/Tagout Training. Recommended training can include, but is not limited to, the following:

(a) Recognizing lockout/tagout devices
(b) Installing lockout/tagout devices
(c) Duty of employer in writing procedures
(d) Duty of employee in executing procedures
(e) Duty of person-in-charge
(f) Authorized and unauthorized removal of locks/tags
(g) Enforcing execution of lockout/tagout procedures
(h) Individual employee control of energy
(i) Simple lockout/tagout
(j) Complex lockout/tagout
(k) Using single line and diagrammatic drawings to identify sources of energy
(l) Use of tags and warning signs
(m) Release of stored energy
(n) Personnel accounting methods
(o) Grounding needs/requirements
(p) Safe use of voltage detecting instruments

Part II, Appendix F, Simplified, Two-Category, Flame-Resistant (FR) Clothing System.

F-1 Use of Simplified Approach. The use of Table F-1 is suggested as a simplified approach to assure adequate PPE for electrical workers within facilities with large and diverse electrical systems. The clothing listed in Table F-1 fulfills the minimum FR clothing requirements of Tables 3-3.9.1 and 3-3.9.2. The clothing systems listed in this table should be used with the other PPE appropriate for the Hazard/Risk Category. See Table 3-3.9.2.

Table F-1 Simplified, Two-Category, Flame-Resistant Clothing System.

CLOTHING*	APPLICABLE TASKS
Everyday Work Clothing:	All Hazard/Risk Category 1 and 2 tasks listed in Table 3-3.9.1.
FR long-sleeve shirt (minimum ATPV of 5) worn over an untreated cotton T-shirt with FR pants (minimum ATPV of 8) *or* FR coveralls (minimum ATPV of 5) worn over an untreated cotton T-shirt (or an untreated natural fiber long-sleeve shirt) with untreated natural fiber pants.	On systems operating at less than 1000 volts, these tasks include work on all equipment *except* • Insertion or removal of low-voltage motor starter "buckets," • Insertion or removal of power circuit breakers with the switchgear doors open, or • Removal of bolted covers from switchgear. On systems operating at 1000 volts or greater, tasks also include the operation, insertion, or removal of switching devices *with equipment enclosure doors closed.*
Electrical "Switching" Clothing:	All Hazard/Risk Category 3 and 4 tasks listed in Table 3-3.9.1.
Double-layer FR flash jacket and FR bib overalls worn over either FR coveralls (minimum ATPV of 5) or FR long-sleeve shirt and FR pants (minimum ATPV of 5), worn over untreated natural fiber long-sleeve shirt and pants, worn over an untreated cotton T-shirt *or* Insulated FR coveralls (with a minimum ATPV of 25, independent of other layers) worn over untreated natural fiber long-sleeve shirt with untreated denim cotton blue jeans ("regular weight," minimum 12 oz/yd^2 fabric weight), worn over an untreated cotton T-shirt.	On systems operating at 1000 volts or greater, these tasks include work on exposed energized parts of all equipment. On systems of less than 1000 volts, tasks include insertion or removal of low-voltage motor starter MCC "buckets," insertion or removal of power circuit breakers with the switchgear enclosure doors open, and removal of bolted covers from switchgear.

*Note other PPE required for the specific tasks listed in Tables 3-3.9.1 and 3-3.9.2, which include double-layer FR flash hoods, FR hardhat liners, safety glasses or safety goggles, hard hat, hearing protection, leather gloves, voltage-rated gloves, and voltage-rated tools.

Part III SAFETY-RELATED MAINTENANCE REQUIREMENTS

Chapter 1 Introduction

1-1 General. Part III shall cover practical safety-related maintenance requirements for electrical equipment and installations in workplaces as included in the scope of NFPA 70E. These requirements shall identify only that maintenance directly associated with employee safety.

Part III does not prescribe specific maintenance methods or testing procedures. It is left to the employer to choose from the various maintenance methods available to satisfy the requirements of Part III.

For the purpose of Part III, maintenance shall be defined as preserving or restoring the condition of electrical equipment and installations, or parts of either, for the safety of employees who work on, near, or with such equipment. Repair or replacement of individual portions or parts of equipment shall be permitted without requiring modification or replacement of other portions or parts that are in a safe condition.

NOTE: Refer to NFPA 70B, *Recommended Practice for Electrical Equipment Maintenance*, for specific maintenance methods and tests.