**Chapter 6 Special Equipment**

Article 600 Electric Signs and Outline Lighting

Part I General

600.1 Scope

This article covers the installation of conductors, equipment, and field wiring for electric signs, retrofit kits, and outline lighting, regardless of voltage. All installations and equipment using neon tubing, such as signs, decorative elements, skeleton tubing, or art forms, are covered by this article.

Informational Note: Sign and outline lighting illumination systems include, but are not limited to, cold cathode neon tubing, high-intensity discharge lamps (HID), fluorescent or incandescent lamps, light-emitting diodes (LEDs), and electroluminescent and inductance lighting.

600.2 Definitions

The definitions in this section shall apply only within this article.

Host Sign. A sign or outline lighting system already installed in the field that is designated for field conversion of the illumination system with a retrofit kit.

LED Sign Illumination System. A complete lighting system for use in signs and outline lighting consisting of light-emitting diode (LED) light sources, power supplies, wire, and connectors to complete the installation.

Neon Tubing. Electric-discharge luminous tubing, including cold cathode luminous tubing, that is manufactured into shapes to illuminate signs, form letters, parts of letters, skeleton tubing, outline lighting, other decorative elements, or art forms and filled with various inert gases.

Photovoltaic (PV) Powered Sign. A complete sign powered by solar energy consisting of all components and subassemblies for installation either as an off-grid stand-alone, on-grid interactive, or non-grid interactive system.

Retrofit Kit, General Use. A kit consisting of primary parts, which does not include all the parts for a complete subassembly but includes a list of required parts and installation instructions to complete the subassembly in the field.

Retrofit Kit, Sign Specific. A kit consisting of the necessary parts and hardware to allow for field installation in a host sign, based on the included installation instructions.

Section Sign. A sign or outline lighting system, shipped as subassemblies, that requires field-installed wiring between the subassemblies to complete the overall sign. The subassemblies are either physically joined to form a single sign unit or are installed as separate remote parts of an overall sign.

Sign Body. A portion of a sign that may provide protection from the weather but is not an electrical enclosure.

Skeleton Tubing. Neon tubing that is itself the sign or outline lighting and is not attached to an enclosure or sign body.

Subassembly. Component parts or a segment of a sign, retrofit kit, or outline lighting system that, when assembled, forms a complete unit or product.

600.3 Listing

Fixed, mobile, or portable electric signs, section signs, outline lighting, photovoltaic (PV) powered signs, and retrofit kits, regardless of voltage, shall be listed and labeled, provided with installation instructions, and installed in conformance with that listing, unless otherwise approved by special permission.

(A) Field-Installed Skeleton Tubing

Field-installed skeleton tubing shall not be required to be listed where installed in conformance with this Code.

(B) Outline Lighting

Outline lighting shall not be required to be listed as a system when it consists of listed luminaires wired in accordance with Chapter 3.

600.4 Markings

(A) Signs and Outline Lighting Systems

Signs and outline lighting systems shall be listed and labeled; marked with the manufacturer's name, trademark, or other means of identification; and input voltage and current rating.

(B) Signs With a Retrofitted Illumination System

Signs with a retrofitted illumination system shall contain the following:

The sign shall be marked that the illumination system has been replaced.

The marking shall include the kit providers and installer's name, logo, or unique identifier.

Signs equipped with tubular light-emitting diode lamps powered by the existing sign sockets shall include a label alerting the service personnel that the sign has been modified. The label shall meet the requirements of 110.21(B). The label shall also include a warning not to install fluorescent lamps and shall also be visible during relamping.

(C) Signs With Lampholders for Incandescent Lamps

Signs and outline lighting systems with lampholders for incandescent lamps shall be marked to indicate the maximum allowable lamp wattage per lampholder. The markings shall be permanently installed, in letters at least 6 mm (1/4 in.) high, and shall be located where visible during relamping.

(D) Visibility

The markings required in 600.4(A) and listing labels shall be visible after installation and shall be permanently applied in a location visible prior to servicing. The marking shall be permitted to be installed in a location not viewed by the public.

(E) Durability

Marking labels shall be permanent, durable and, when in wet locations, weatherproof.

(F) Installation Instructions

All signs, outline lighting, skeleton tubing systems, and retrofit kits shall be marked to indicate that field wiring and installation instructions are required.

Exception: Portable, cord-connected signs are not required to be marked.

600.5 Branch Circuits

(A) Required Branch Circuit

Each commercial building and each commercial occupancy accessible to pedestrians shall be provided with at least one outlet in an accessible location at each entrance to each tenant space for sign or outline lighting system use. The outlet(s) shall be supplied by a branch circuit rated at least 20 amperes that supplies no other load. A sign or outline lighting outlet shall not be required at entrances for deliveries, service corridors, or service hallways that are intended to be used only by service personnel or employees.

(B) Marking

A disconnecting means for a sign, outline lighting system, or controller shall be marked to identify the sign, outline lighting system, or controller it controls.

Exception: An external disconnecting means that is mounted on the sign body, sign enclosure, sign pole, or controller shall not be required to identify the sign or outline lighting system it controls.

(C) Rating

Branch circuits that supply signs shall be rated in accordance with 600.5(C)(1) or (C)(2) and shall be considered to be continuous loads for the purposes of calculations.

(1) Neon Signs

Branch circuits that supply neon tubing installations shall not be rated in excess of 30 amperes.

(2) All Other Signs

Branch circuits that supply all other signs and outline lighting systems shall be rated not to exceed 20 amperes.

(D) Wiring Methods

Wiring methods used to supply signs shall comply with 600.5(D)(1), (D)(2), and (D)(3).

(1) Supply

The wiring method used to supply signs and outline lighting systems shall terminate within a sign, an outline lighting system enclosure, a suitable box, a conduit body, or panelboard.

(2) Enclosures as Pull Boxes

Transformer enclosures shall be permitted to be used as pull or junction boxes for conductors supplying other adjacent signs, outline lighting systems, or floodlights that are part of a sign and shall be permitted to contain both branch and secondary circuit conductors, provided the sign disconnecting means de-energizes all current-carrying conductors in these enclosures.

(3) Metal or Nonmetallic Poles

Metal or nonmetallic poles used to support signs shall be permitted to enclose supply conductors, provided the poles and conductors are installed in accordance with 410.30(B).

600.6 Disconnects

Each sign and outline lighting system, feeder conductor(s), or branch circuit(s) supplying a sign, outline lighting system, or skeleton tubing shall be controlled by an externally operable switch or circuit breaker that opens all ungrounded conductors and controls no other load. The switch or circuit breaker shall open all ungrounded conductors simultaneously on multi-wire branch circuits in accordance with 210.4(B). Signs and outline lighting systems located within fountains shall have the disconnect located in accordance with 680.13.

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.

Informational Note: The location of the disconnect is intended to allow service or maintenance personnel and first responders complete and local control of the disconnecting means.

(A) Location

The disconnecting means shall be permitted to be located in accordance with 600.6(A)(1), (A)(2), (A)(3), and (A)(4):

(1) At Point of Entry to a Sign

The disconnect shall be located at the point the feeder circuit or branch circuit(s) supplying a sign or outline lighting system enters a sign enclosure, a sign body, or a pole in accordance with 600.5(D)(3). The disconnect shall open all ungrounded conductors where it enters the enclosure of the sign or pole.

Exception No. 1: A disconnect shall not be required for branch circuit(s) or feeder conductor(s) passing through the sign where not accessible and enclosed in a Chapter 3 listed raceway or metal-jacketed cable identified for the location.

Exception No. 2: A disconnect shall not be required at the point of entry to a sign enclosure or sign body for branch circuit(s) or feeder conductor(s) that supply an internal panelboard(s) in a sign enclosure or sign body. The conductors shall be enclosed where not accessible in a Chapter 3 listed raceway or metal-jacketed cable identified for the location. A field-applied permanent warning label that is visible during servicing shall be applied to the raceway at or near the point of entry into the sign enclosure or sign body. The warning label shall comply with 110.21(B) and state the following: "Danger. This raceway contains energized conductors." The marking shall include the location of the disconnecting means for the energized conductor(s). The disconnecting means shall be capable of being locked in the open position in accordance with 110.25.

(2) Within Sight of the Sign

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 is able to be energized, the disconnecting means shall be lockable in accordance with 110.25. A permanent field-applied marking identifying the location of the disconnecting means shall be applied to the sign in a location visible during servicing. The warning label shall comply with 110.21(B).

(3) Within Sight of the Controller

The following shall apply for signs or outline lighting systems operated by electronic or electromechanical controllers located external to the sign or outline lighting system:

The disconnecting means shall be 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.

The disconnecting means shall be designed such that no pole can be operated independently and shall be lockable in accordance with 110.25.

Exception: Where the disconnecting means is not located within sight of the controller, a permanent field-applied marking identifying the location of the disconnecting means shall be applied to the controller in a location visible during servicing. The warning label shall comply with 110.21(B).

(4) Remote Location

The disconnecting means, if located remote from the sign, sign body, or pole, shall be mounted at an accessible location available to first responders and service personnel. The location of the disconnect shall be marked with a label at the sign location and marked as the disconnect for the sign or outline lighting system. The label shall comply with 110.21(B).

(B) Control Switch Rating

Switches, flashers, and similar devices controlling transformers and electronic power supplies shall be rated for controlling inductive loads or have a current rating not less than twice the current rating of the transformer or the electronic power supply.

600.7 Grounding and Bonding

(A) Grounding

(1) Equipment Grounding

Metal equipment of signs, outline lighting, and skeleton tubing systems shall be grounded by connection to the equipment grounding conductor of the supply branch circuit(s) or feeder using the types of equipment grounding conductors specified in 250.118.

Exception: Portable cord-connected signs shall not be required to be connected to the equipment grounding conductor where protected by a system of double insulation or its equivalent. Double insulated equipment shall be distinctively marked.

(2) Size of Equipment Grounding Conductor

The equipment grounding conductor size shall be in accordance with 250.122.

(3) Connections

Equipment grounding conductor connections shall be made in accordance with 250.130 and in a method specified in 250.8.

(4) Auxiliary Grounding Electrode

Auxiliary grounding electrode(s) shall be permitted for electric signs and outline lighting systems covered by this article and shall meet the requirements of 250.54.

(5) Metal Building Parts

Metal parts of a building shall not be permitted as a secondary return conductor or an equipment grounding conductor.

(B) Bonding

(1) Bonding of Metal Parts

Metal parts and equipment of signs and outline lighting systems shall be bonded together and to the associated transformer or power-supply equipment grounding conductor of the branch circuit or feeder supplying the sign or outline lighting system and shall meet the requirements of 250.90.

Exception: Remote metal parts of a section sign or outline lighting system only supplied by a remote Class 2 power supply shall not be required to be bonded to an equipment grounding conductor.

(2) Bonding Connections

Bonding connections shall be made in accordance with 250.8.

(3) Metal Building Parts

Metal parts of a building shall not be permitted to be used as a means for bonding metal parts and equipment of signs or outline lighting systems together or to the transformer or power-supply equipment grounding conductor of the supply circuit.

(4) Flexible Metal Conduit Length

Listed flexible metal conduit or listed liquidtight flexible metal conduit that encloses the secondary circuit conductor from a transformer or power supply for use with neon tubing shall be permitted as a bonding means if the total accumulative length of the conduit in the secondary circuit does not exceed 30 m (100 ft).

(5) Small Metal Parts

Small metal parts not exceeding 50 mm (2 in.) in any dimension, not likely to be energized, and spaced at least 19 mm (3/4 in.) from neon tubing shall not require bonding.

(6) Nonmetallic Conduit

Where listed nonmetallic conduit is used to enclose the secondary circuit conductor from a transformer or power supply and a bonding conductor is required, the bonding conductor shall be installed separate and remote from the nonmetallic conduit and be spaced at least 38 mm (11/2 in.) from the conduit when the circuit is operated at 100 Hz or less or 45 mm (13/4 in.) when the circuit is operated at over 100 Hz.

(7) Bonding Conductors

Bonding conductors shall comply with (1) and (2).

Bonding conductors shall be copper and not smaller than 14 AWG.

Bonding conductors installed externally of a sign or raceway shall be protected from physical damage.

(8) Signs in Fountains

Signs or outline lighting installed inside a fountain shall have all metal parts bonded to the equipment grounding conductor of the branch circuit for the fountain recirculating system. The bonding connection shall be as near as practicable to the fountain and shall be permitted to be made to metal piping systems that are bonded in accordance with 680.58(4).

Informational Note: Refer to 600.32(J) for restrictions on length of high-voltage secondary conductors.

600.8 Enclosures

Live parts, other than lamps, and neon tubing shall be enclosed. Transformers and power supplies provided with an integral enclosure, including a primary and secondary circuit splice enclosure, shall not require an additional enclosure.

(A) Strength

Enclosures shall have ample structural strength and rigidity.

(B) Material

Sign and outline lighting system enclosures shall be constructed of metal or shall be listed.

(C) Minimum Thickness of Enclosure Metal

Sheet copper or aluminum shall be at least 0.51 mm (0.020 in.) thick. Sheet steel shall be at least 0.41 mm (0.016 in.) thick.

(D) Protection of Metal

Metal parts of equipment shall be protected from corrosion.

600.9 Location

(A) Vehicles

Sign or outline lighting system equipment shall be at least 4.3 m (14 ft) above areas accessible to vehicles unless protected from physical damage.

(B) Pedestrians

Neon tubing, other than listed, dry-location, portable signs, readily accessible to pedestrians shall be protected from physical damage.

Informational Note: See 600.41(D) for additional requirements.

(C) Adjacent to Combustible Materials

Signs and outline lighting systems shall be installed so that adjacent combustible materials are not subjected to temperatures in excess of 90°C (194°F).

The spacing between wood or other combustible materials and an incandescent or HID lamp or lampholder shall not be less than 50 mm (2 in.).

(D) Wet Location

Signs and outline lighting system equipment for wet location use, other than listed watertight type, shall be weatherproof and have drain holes, as necessary, in accordance with the following:

Drain holes shall not be larger than 13 mm (1/2 in.) or smaller than 6 mm (1/4 in.).

Every low point or isolated section of the equipment shall have at least one drain hole.

Drain holes shall be positioned such that there will be no external obstructions.

600.10 Portable or Mobile Signs

(A) Support

Portable or mobile signs shall be adequately supported and readily movable without the use of tools.

(B) Attachment Plug

An attachment plug shall be provided for each portable or mobile sign.

(C) Wet or Damp Location

Portable or mobile signs in wet or damp locations shall comply with 600.10(C)(1) and (C)(2).

(1) Cords

All cords shall be junior hard-service or hard-service types as designated in Table 400.4 and have an equipment grounding conductor.

(2) Ground-Fault Circuit Interrupter

In addition to the requirements in 210.8, the manufacturer of portable or mobile signs shall provide listed ground-fault circuit-interrupter protection for personnel. The ground-fault circuit interrupter shall be an integral part of the attachment plug or shall be located in the power-supply cord within 300 mm (12 in.) of the attachment plug.

(D) Dry Location

Portable or mobile signs in dry locations shall meet the following:

Cords shall be SP-2, SPE-2, SPT-2, or heavier, as designated in Table 400.4.

The cord shall not exceed 4.5 m (15 ft) in length.

600.12 Field-Installed Secondary Wiring

Field-installed secondary circuit wiring for electric signs, retrofit kits, outline lighting systems, skeleton tubing, and photovoltaic (PV) powered sign systems shall be in accordance with their installation instructions and 600.12(A), (B), or (C).

(A) 1000 Volts or Less

Neon and secondary circuit wiring of 1000 volts or less shall comply with 600.31.

(B) Over 1000 Volts

Neon secondary circuit wiring of over 1000 volts shall comply with 600.32.

(C) Class 2

Where the installation complies with 600.33 and the power source provides a Class 2 output that complies with 600.24, either of the following wiring methods shall be permitted as determined by the installation instructions and conditions.

Wiring methods identified in Chapter 3

Class 2 cables complying with Table 600.33(A)(a) and Table 600.33(A)(b)

600.21 Ballasts, Transformers, Electronic Power Supplies, and Class 2 Power Sources

Ballasts, transformers, electronic power supplies, and Class 2 power sources shall be of the self-contained type or be enclosed by placement in a listed sign body or listed separate enclosure.

(A) Accessibility

Ballasts, transformers, electronic power supplies, and Class 2 power sources shall be located where accessible and shall be securely fastened in place.

(B) Location

Ballasts, transformers, electronic power supplies, and Class 2 power sources shall be installed as near to the lamps or neon tubing as practicable to keep the secondary conductors as short as possible.

(C) Wet Location

Ballasts, transformers, electronic power supplies, and Class 2 power sources used in wet locations shall be of the weatherproof type or be of the outdoor type and protected from the weather by placement in a sign body or separate enclosure.

(D) Working Space

A working space at least 900 mm (3 ft) high × 900 mm (3 ft) wide × 900 mm (3 ft) deep shall be provided at each ballast, transformer, electronic power supply, and Class 2 power source or at its enclosure where not installed in a sign.

(E) Attic and Soffit Locations

Ballasts, transformers, electronic power supplies, and Class 2 power sources shall be permitted to be located in attics and soffits, provided there is an access door at least 900 mm × 562.5 mm (36 in. × 221/2 in.) and a passageway of at least 900 mm (3 ft) high × 600 mm (2 ft) wide with a suitable permanent walkway at least 300 mm (12 in.) wide extending from the point of entry to each component. At least one lighting outlet containing a switch or controlled by a wall switch shall be installed in such spaces. At least one point of control shall be at the usual point of entry to these spaces. The lighting outlet shall be provided at or near the equipment requiring servicing.

(F) Suspended Ceilings

Ballasts, transformers, electronic power supplies, and Class 2 power sources shall be permitted to be located above suspended ceilings, provided that their enclosures are securely fastened in place and not dependent on the suspended-ceiling grid for support. Ballasts, transformers, and electronic power supplies installed in suspended ceilings shall not be connected to the branch circuit by flexible cord.

600.22 Ballasts

(A) Type

Ballasts shall be identified for the use and shall be listed.

(B) Thermal Protection

Ballasts shall be thermally protected.

600.23 Transformers and Electronic Power Supplies

(A) Type

Transformers and electronic power supplies shall be identified for the use and shall be listed.

(B) Secondary-Circuit Ground-Fault Protection

Transformers and electronic power supplies other than the following shall have secondary-circuit ground-fault protection:

Transformers with isolated ungrounded secondaries and with a maximum open circuit voltage of 7500 volts or less

Transformers with integral porcelain or glass secondary housing for the neon tubing and requiring no field wiring of the secondary circuit

(C) Voltage

Secondary-circuit voltage shall not exceed 15,000 volts, nominal, under any load condition. The voltage to ground of any output terminals of the secondary circuit shall not exceed 7500 volts, under any load condition.

(D) Rating

Transformers and electronic power supplies shall have a secondary-circuit current rating of not more than 300 mA.

(E) Secondary Connections

Secondary circuit outputs shall not be connected in parallel or in series.

(F) Marking

Transformers and electronic power supplies that are equipped with secondary-circuit ground-fault protection shall be so marked.

600.24 Class 2 Power Sources

Class 2 transformers, power supplies, and power sources shall comply with the requirements of Class 2 circuits and 600.24(A), (B), (C), and (D).

(A) Listing

Class 2 power supplies and power sources shall be listed for use with electric signs and outline lighting systems or shall be a component in a listed electric sign.

(B) Grounding

Metal parts of Class 2 power supplies and power sources shall be grounded by connecting to the equipment grounding conductor.

(C) Wiring Methods on the Supply Side of the Class 2 Power Supply

Conductors and equipment on the supply side of the power source shall be installed in accordance with the appropriate requirements of Chapter 3.

(D) Secondary Wiring

Secondary wiring on the load side of a Class 2 power source shall comply with 600.12(C) and 600.33.

Part II Field-Installed Skeleton Tubing, Outline Lighting, and Secondary Wiring

600.30 Applicability

Part II of this article shall apply to all of the following:

Field-installed skeleton tubing

Field-installed secondary circuits

Outline lighting

Field-installed retrofit kits

These requirements shall be in addition to the requirements of Part I.

600.31 Neon Secondary-Circuit Wiring, 1000 Volts or Less, Nominal

(A) Wiring Method

Conductors shall be installed using any wiring method included in Chapter 3 suitable for the conditions.

(B) Insulation and Size

Conductors shall be listed, insulated, and not smaller than 18 AWG.

(C) Number of Conductors in Raceway

The number of conductors in a raceway shall be in accordance with Table 1 of Chapter 9.

(D) Installation

Conductors shall be installed so they are not subject to physical damage.

(E) Protection of Leads

Bushings shall be used to protect wires passing through an opening in metal.

600.32 Neon Secondary-Circuit Wiring, Over 1000 Volts, Nominal

(A) Wiring Methods

(1) Installation

Conductors shall be installed in rigid metal conduit, intermediate metal conduit, liquidtight flexible nonmetallic conduit, flexible metal conduit, liquidtight flexible metal conduit, electrical metallic tubing, metal enclosures; on insulators in metal raceways; or in other equipment listed for use with neon secondary circuits over 1000 volts.

(2) Number of Conductors

Conduit or tubing shall contain only one conductor.

(3) Size

Conduit or tubing shall be a minimum of metric designator 16 (trade size 1/2).

(4) Spacing From Grounded Parts

Other than at the location of connection to a metal enclosure or sign body, nonmetallic conduit or flexible nonmetallic conduit shall be spaced no less than 38 mm (11/2 in.) from grounded or bonded parts when the conduit contains a conductor operating at 100 Hz or less, and shall be spaced no less than 45 mm (13/4 in.) from grounded or bonded parts when the conduit contains a conductor operating at more than 100 Hz.

(5) Metal Building Parts

Metal parts of a building shall not be permitted as a secondary return conductor or an equipment grounding conductor.

(B) Insulation and Size

Conductors shall be insulated, listed as gas tube sign and ignition cable type GTO, rated for 5, 10, or 15 kV, not smaller than 18 AWG, and have a minimum temperature rating of 105°C (221°F).

(C) Installation

Conductors shall be so installed that they are not subject to physical damage.

(D) Bends in Conductors

Sharp bends in insulated conductors shall be avoided.

(E) Spacing

Secondary conductors shall be separated from each other and from all objects other than insulators or neon tubing by a spacing of not less than 38 mm (11/2 in.). GTO cable installed in metal conduit or tubing shall not require spacing between the cable insulation and the conduit or tubing.

(F) Insulators and Bushings

Insulators and bushings for conductors shall be listed for use with neon secondary circuits over 1000 volts.

(G) Conductors in Raceways

The insulation on all conductors shall extend not less than 65 mm (21/2 in.) beyond the metal conduit or tubing.

(H) Between Neon Tubing and Midpoint Return

Conductors shall be permitted to run between the ends of neon tubing or to the secondary circuit midpoint return of listed transformers or listed electronic power supplies and provided with terminals or leads at the midpoint.

(I) Dwelling Occupancies

Equipment having an open circuit voltage exceeding 1000 volts shall not be installed in or on dwelling occupancies.

(J) Length of Secondary Circuit Conductors

(1) Secondary Conductor to the First Electrode

The length of secondary circuit conductors from a high-voltage terminal or lead of a transformer or electronic power supply to the first neon tube electrode shall not exceed the following:

6 m (20 ft) where installed in metal conduit or tubing

15 m (50 ft) where installed in nonmetallic conduit

(2) Other Secondary Circuit Conductors

All other sections of secondary circuit conductor in a neon tube circuit shall be as short as practicable.

(K) Splices

Splices in high-voltage secondary circuit conductors shall be made in listed enclosures rated over 1000 volts. Splice enclosures shall be accessible after installation and listed for the location where they are installed.

600.33 Class 2 Sign Illumination Systems, Secondary Wiring

The wiring methods and materials used shall be in accordance with the sign manufacturer's installation instructions using any applicable wiring methods from Chapter 3, Wiring Methods, or the requirements for Class 2 circuits contained in 600.12(C), 600.24, and 600.33(A), (B), (C), and (D).

(A) Insulation and Sizing of Class 2 Conductors

Class 2 cable listed for the application that complies with Table 600.33(A)(a) or Table 600.33(A)(b) for substitutions shall be installed on the load side of the Class 2 power source. The conductors shall have an ampacity not less than the load to be supplied and shall not be sized smaller than 18 AWG.

Table 600.33(A)(a) Applications of Power Limited Cable in Signs and Outline Lighting

Location CL2 CL3 CL2R CL3R CL2P CL3P PLTC

Nonconcealed spaces inside buildings Y Y Y Y Y Y Y

Concealed spaces inside buildings that are not used as plenums or risers Y Y Y Y Y Y Y

Environmental air spaces plenums N N N N Y Y N

Environmental air spaces risers N N Y Y Y Y N

Wet locations N N N N N N Y

Y = Permitted. N = Not Permitted.

Table 600.33(A)(b) Class 2 Cable Substitutions

Cable Type Permitted Substitutions

CL3P CMP

CL2P CMP, CL3P

CL3R CMP, CL3P, CMR

CL2R CMP, CL3P, CL2P, CMR, CL3R

CL3 CMP, CL3P, CMR, CL3R, CMG, CM, PLTC

CL2 CMP, CL3P, CL2P, CMR, CL3R, CL2R, CMG, CM, PLTC, CL3

CL3X CMP, CL3P, CMR, CL3R, CMG, CM, PLTC, CL3, CMX

CL2X CMP, CL3P, CL2P, CMR, CL3R, CL2R, CMG, CM, PLTC, CL3, CL2, CMX, CL3X

PLTC None

(1) General Use

CL2 or CL3, PLTC, or any listed applicable cable for general use shall be installed within and on buildings or structures.

(2) Other Building Locations

In other locations, any listed applicable cable permitted in 600.33(A)(1), (A)(2), (A)(3), and (A)(4) and Table 600.33(A)(a) and Table 600.33(A)(b) shall be permitted to be used as follows:

CL2P or CL3P — Ducts, plenums, or other spaces used for environmental air

CL2R or CL3R — Vertical shafts and risers

Substitutions from Table 600.33(A)(b)

(3) Wet Locations

Class 2 cable used in a wet location shall be listed and marked suitable for use in a wet location.

(4) Other Locations

Class 2 cable exposed to sunlight shall be listed and marked "sunlight resistant — suitable for outdoor use."

Exception: Listed PLTC not marked as sunlight resistant shall be permitted.

Informational Note: PLTC is tested for exposure to sunlight but might not be so marked.

(B) Installation

Secondary wiring shall be installed in accordance with 600.33(B)(1) and (B)(2).

Wiring shall be installed and supported in a neat and workmanlike manner. Cables and conductors installed exposed on the surface of ceilings and sidewalls shall be supported by the building structure in such a manner that the cable is not damaged by normal building use. The cable shall be supported and secured at intervals not exceeding 1.8 m (6 ft). Such cables shall be supported by straps, staples, hangers, cable ties, or similar fittings designed and installed so as not to damage the cable. The installation shall also comply with 300.4(D).

Connections in cable and conductors shall be made with listed insulating devices and be accessible after installation. Where made in a wall, connections shall be enclosed in a listed box.

(C) Protection Against Physical Damage

If subject to physical damage, the conductors shall be protected and installed in accordance with 300.4. All through-wall penetrations shall be protected by a listed bushing or raceway.

(D) Grounding and Bonding

Grounding and bonding shall be in accordance with 600.7.

600.34 Photovoltaic (PV) Powered Sign

All field wiring of components and subassemblies for an off-grid stand-alone, on-grid interactive, or non-grid interactive PV installation shall be installed in accordance with Article 690, as applicable, 600.34, and the PV powered sign installation instructions.

(A) Equipment

Inverters, motor generators, PV modules, PV panels, ac PV modules, dc combiners, dc-ac converters, and charge controllers intended for use in PV powered sign systems shall be listed for PV application.

(B) Wiring

Wiring from a photovoltaic panel or wiring external to the PV sign body shall be:

Listed, labeled, and suitable for photovoltaic applications

Routed to closely follow the sign body or enclosure

As short as possible and secured at intervals not exceeding 0.91 m (3 ft)

Protected where subject to physical damage

(C) Flexible Cords and Cables

Flexible cords and cables shall comply with Article 400 and be identified as extra hard usage, rated for outdoor use, and water and sunlight resistant.

(D) Grounding

Grounding a PV powered sign shall comply with Article 690, Part V and 600.7.

(E) Disconnecting Means

The disconnecting means for a PV powered sign shall comply with Article 690, Part III and 600.6.

(F) Battery Compartments

Battery compartments shall require a tool to open.

600.35 Retrofit Kits

(A) General

A general-use or sign-specific retrofit kit for a sign or outline lighting system shall include installation instructions and requirements for field conversion of a host sign. The retrofit kit shall be listed and labeled.

(B) Installation

The retrofit kit shall be installed in accordance with the installation instructions.

(1) Wiring Methods

Wiring methods shall be in accordance with Chapter 3.

Exception: If powered from a Class 2 source, wiring methods shall be in accordance with 600.12(C)(1)(2) and (C)(2), 600.24, and 600.33.

(2) Damaged Parts

All parts that are not replaced by a retrofit kit shall be inspected for damage. Any part found to be damaged or damaged during conversion of the sign shall be replaced or repaired to maintain the sign or outline lighting system's dry, damp, or wet location rating.

(3) Workmanship

Field conversion workmanship shall be in accordance with 110.12.

(4) Marking

The retrofitted sign shall be marked in accordance with 600.4(B).

600.41 Neon Tubing

(A) Design

The length and design of the tubing shall not cause a continuous overcurrent beyond the design loading of the transformer or electronic power supply.

(B) Support

Tubing shall be supported by listed tube supports. The neon tubing shall be supported within 150 mm (6 in.) from the electrode connection.

(C) Spacing

A spacing of not less than 6 mm (1/4 in.) shall be maintained between the tubing and the nearest surface, other than its support.

(D) Protection

Field-installed skeleton tubing shall not be subject to physical damage. Where the tubing is readily accessible to other than qualified persons, field-installed skeleton tubing shall be provided with suitable guards or protected by other approved means.

600.42 Electrode Connections

(A) Points of Transition

Where the high-voltage secondary circuit conductors emerge from the wiring methods specified in 600.32(A), they shall be enclosed in a listed assembly.

(B) Accessibility

Terminals of the electrode shall not be accessible to unqualified persons.

(C) Electrode Connections

Connections shall be made by use of a connection device, twisting of the wires together, or use of an electrode receptacle. Connections shall be electrically and mechanically secure and shall be in an enclosure listed for the purpose.

(D) Support

Neon secondary conductor(s) shall be supported not more than 150 mm (6 in.) from the electrode connection to the tubing.

(E) Receptacles

Electrode receptacles shall be listed.

(F) Bushings

Where electrodes penetrate an enclosure, bushings listed for the purpose shall be used unless receptacles are provided.

(G) Wet Locations

A listed cap shall be used to close the opening between neon tubing and a receptacle where the receptacle penetrates a building. Where a bushing or neon tubing penetrates a building, the opening between neon tubing and the bushing shall be sealed.

(H) Electrode Enclosures

Electrode enclosures shall be listed.

(1) Dry Locations

Electrode enclosures that are listed, labeled, and identified for use in dry, damp, or wet locations shall be permitted to be installed and used in such locations.

(2) Damp and Wet Locations

Electrode enclosures installed in damp and wet locations shall be specifically listed, labeled, and identified for use in such locations.

Informational Note: See 110.3(B) covering installation and use of electrical equipment.

Article 604 Manufactured Wiring Systems

604.1 Scope

This article applies to field-installed wiring using off-site manufactured subassemblies for branch circuits, remote-control circuits, signaling circuits, and communications circuits in accessible areas.

604.2 Definition

The definition in this section shall apply within this article and throughout the Code.

Manufactured Wiring System. A system containing component parts that are assembled in the process of manufacture and cannot be inspected at the building site without damage or destruction to the assembly and used for the connection of luminaires, utilization equipment, continuous plug-in type busways, and other devices.

604.6 Listing Requirements

Manufactured wiring systems and associated components shall be listed.

Informational Note: ANSI/UL 183, Standard for Manufacturing Wiring Systems, is a safety standard for manufactured wiring systems.

604.7 Installation

Manufactured wiring systems shall be secured and supported in accordance with the applicable cable or conduit article for the cable or conduit type employed.

604.10 Uses Permitted

Manufactured wiring systems shall be permitted in accessible and dry locations and in ducts, plenums, and other air-handling spaces where listed for this application and installed in accordance with 300.22.

Exception No. 1: In concealed spaces, one end of tapped cable shall be permitted to extend into hollow walls for direct termination at switch and outlet points.

Exception No. 2: Manufactured wiring system assemblies installed outdoors shall be listed for use in outdoor locations.

604.12 Uses Not Permitted

Manufactured wiring system types shall not be permitted where limited by the applicable article in Chapter 3 for the wiring method used in its construction.

604.100 Construction

(A) Cable or Conduit Types

(1) Cables

Cable shall be listed Type AC cable or listed Type MC cable containing nominal 600-volt, 8 to 12 AWG insulated copper conductors.

Other cables as listed in 725.154, 800.113, and 830.179 shall be permitted in manufactured wiring systems for wiring of equipment within the scope of their respective articles.

(2) Conduits

Conduit shall be listed flexible metal conduit or listed liquidtight flexible conduit containing nominal 600-volt, 8 to 12 AWG insulated copper conductors with a bare or insulated copper equipment grounding conductor equivalent in size to the ungrounded conductor.

Exception No. 1 to (1) and (2): A luminaire tap, no longer than 1.8 m (6 ft) and intended for connection to a single luminaire, shall be permitted to contain conductors smaller than 12 AWG but not smaller than 18 AWG.

Exception No. 2 to (1) and (2): Listed manufactured wiring assemblies containing conductors smaller than 12 AWG shall be permitted for remote-control, signaling, or communications circuits.

Exception No. 3 to (2): Listed manufactured wiring systems containing unlisted flexible metal conduit of noncircular cross section or trade sizes smaller than permitted by 348.20(A), or both, shall be permitted where the wiring systems are supplied with fittings and conductors at the time of manufacture.

(3) Flexible Cord

Flexible cord suitable for hard usage, with minimum 12 AWG conductors, shall be permitted as part of a listed factory-made assembly not exceeding 1.8 m (6 ft) in length when making a transition between components of a manufactured wiring system and utilization equipment not permanently secured to the building structure. The cord shall be visible for the entire length, shall not be subject to physical damage, and shall be provided with identified strain relief.

Exception: Listed electric-discharge luminaires that comply with 410.62(C) shall be permitted with conductors smaller than 12 A WG.

(4) Busways

Busways shall be listed continuous plug-in type containing factory-mounted, bare or insulated conductors, which shall be copper or aluminum bars, rods, or tubes. The busway shall be provided with an equipment ground. The busway shall be rated nominal 600 volts, 20, 30, or 40 amperes. Busways shall be installed in accordance with 368.12, 368.17(D), and 368.30.

(5) Raceway

Prewired, modular, surface-mounted raceways shall be listed for the use, rated nominal 600 volts, 20 amperes, and installed in accordance with 386.12, 386.30, 386.60, and 386.100.

(B) Marking

Each section shall be marked to identify the type of cable, flexible cord, or conduit.

(C) Receptacles and Connectors

Receptacles and connectors shall be of the locking type, uniquely polarized and identified for the purpose, and shall be part of a listed assembly for the appropriate system. All connector openings shall be designed to prevent inadvertent contact with live parts or capped to effectively close the connector openings.

(D) Other Component Parts

Other component parts shall be listed for the appropriate system.

Article 605 Office Furnishings

605.1 Scope

(A) Covered

This article covers electrical equipment, lighting accessories, and wiring systems used to connect, contained within, or installed on office furnishings.

(B) Not Covered

This article does not apply to individual office furnishings not connected to a system, such as chairs, freestanding desks, tables, storage units, and shelving units.

605.2 Definition

The definition in this section shall apply within this article and throughout the Code.

Office Furnishing. Cubicle panels, partitions, study carrels, workstations, desks, shelving systems, and storage units that may be mechanically and electrically interconnected to form an office furnishing system.

605.3 General

Wiring systems shall be identified as suitable for providing power for lighting accessories and utilization equipment used within office furnishings. A wired partition shall not extend from floor to ceiling.

Exception: Where permitted by the authority having jurisdiction, these relocatable wired partitions shall be permitted to extend to, but shall not penetrate, the ceiling.

(A) Use

These assemblies shall be installed and used only as provided for by this article.

(B) Hazardous (Classified) Locations

Where used in hazardous (classified) locations, these assemblies shall comply with Articles 500 through 517 in addition to this article.

605.4 Wireways

All conductors and connections shall be contained within wiring channels of metal or other material identified as suitable for the conditions of use. Wiring channels shall be free of projections or other conditions that might damage conductor insulation.

605.5 Office Furnishing Interconnections

The electrical connection between office furnishings shall be a flexible assembly identified for use with office furnishings or shall be permitted to be installed using flexible cord, provided that all the following conditions are met:

The cord is extra-hard usage type with 12 AWG or larger conductors, with an insulated equipment grounding conductor.

The office furnishings are mechanically contiguous.

The cord is not longer than necessary for maximum positioning of the office furnishing but is in no case to exceed 600 mm (2 ft).

The cord is terminated at an attachment plug-and-cord connector with strain relief.

605.6 Lighting Accessories

Lighting equipment shall be listed, labeled, and identified for use with office furnishings and shall comply with 605.6(A), (B), and (C).

(A) Support

A means for secure attachment or support shall be provided.

(B) Connection

Where cord and plug connection is provided, it shall comply with all of the following:

The cord length shall be suitable for the intended application but shall not exceed 2.7 m (9 ft) in length.

The cord shall not be smaller than 18 AWG.

The cord shall contain an equipment grounding conductor, except as specified in 605.6(B)(4).

Cords on the load side of a listed Class 2 power source shall not be required to contain an equipment grounding conductor.

The cord shall be of the hard usage type, except as specified in 605.6(B)(6).

A cord provided on a listed Class 2 power source shall be of the type provided with the listed luminaire assembly or of the type specified in 725.130 and 725.127.

Connection by other means shall be identified as suitable for the conditions of use.

(C) Receptacle Outlet

Receptacles shall not be permitted in lighting accessories.

605.7 Fixed-Type Office Furnishings

Office furnishings that are fixed (secured to building surfaces) shall be permanently connected to the building electrical system by one of the wiring methods of Chapter 3.

605.8 Freestanding-Type Office Furnishings

Office furnishings of the freestanding type (not fixed) shall be permitted to be connected to the building electrical system by one of the wiring methods of Chapter 3.

605.9 Freestanding-Type Office Furnishings, Cord- And Plug-Connected

Individual office furnishings of the freestanding type, or groups of individual office furnishings that are electrically connected, are mechanically contiguous, and do not exceed 9.0 m (30 ft) when assembled, shall be permitted to be connected to the building electrical system by a single flexible cord and plug, provided that all of the conditions of 605.9(A) through (D) are met.

(A) Flexible Power-Supply Cord

The flexible power supply cord shall be extra-hard usage type with 12 AWG or larger conductors, with an insulated equipment grounding conductor, and shall not exceed 600 mm (2 ft) in length.

(B) Receptacle Supplying Power

The receptacle(s) supplying power shall be on a separate circuit serving only the office furnishing and no other loads and shall be located not more than 300 mm (12 in.) from the office furnishing that is connected to it.

(C) Receptacle, Maximum

An individual office furnishing or groups of interconnected individual office furnishings shall not contain more than 13 15-ampere, 125-volt receptacles. For purposes of this requirement, a receptacle is considered (1) up to two (simplex) receptacles provided within a single enclosure and that are within 0.3 m (1 ft) of each other or (2) one duplex receptacle.

(D) Multiwire Circuits, Not Permitted

An individual office furnishing or groups of interconnected office furnishings shall not contain multiwire circuits.

Informational Note: See 210.4 for circuits supplying office furnishings in 605.7 and 605.8.

Article 610 Cranes and Hoists

Part I General

610.1 Scope

This article covers the installation of electrical equipment and wiring used in connection with cranes, monorail hoists, hoists, and all runways.

Informational Note: For further information, see ASME B30, Safety Standards for Cableways, Cranes, Derricks, Hoists, Hooks, Jacks, and Slings.

610.2 Definition

This definition shall apply only within this article.

Festoon Cable. Single-and multiple-conductor cable intended for use and installation in accordance with Article 610 where flexibility is required.

610.3 Special Requirements for Particular Locations

(A) Hazardous (Classified) Locations

All equipment that operates in a hazardous (classified) location shall conform to Article 500.

(1) Class I Locations

Equipment used in locations that are hazardous because of the presence of flammable gases or vapors shall conform to Article 501.

(2) Class II Locations

Equipment used in locations that are hazardous because of combustible dust shall conform to Article 502.

(3) Class III Locations

Equipment used in locations that are hazardous because of the presence of easily ignitible fibers or flyings shall conform to Article 503.

(B) Combustible Materials

Where a crane, hoist, or monorail hoist operates over readily combustible material, the resistors shall be located as permitted in the following:

A well ventilated cabinet composed of noncombustible material constructed so that it does not emit flames or molten metal

A cage or cab constructed of noncombustible material that encloses the sides of the cage or cab from the floor to a point at least 150 mm (6 in.) above the top of the resistors

(C) Electrolytic Cell Lines

See 668.32.

Part II Wiring

610.11 Wiring Method

Conductors shall be enclosed in raceways or be Type AC cable with insulated equipment grounding conductor, Type MC cable, or Type MI cable unless otherwise permitted or required in 610.11(A) through (E).

(A) Contact Conductor

Contact conductors shall not be required to be enclosed in raceways.

(B) Exposed Conductors

Short lengths of exposed conductors at resistors, collectors, and other equipment shall not be required to be enclosed in raceways.

(C) Flexible Connections to Motors and Similar Equipment

Where flexible connections are necessary, flexible stranded conductors shall be used. Conductors shall be in flexible metal conduit, liquidtight flexible metal conduit, liquidtight flexible nonmetallic conduit, multiconductor cable, or an approved nonmetallic flexible raceway.

(D) Pushbutton Station Multiconductor Cable

Where multiconductor cable is used with a suspended pushbutton station, the station shall be supported in some satisfactory manner that protects the electrical conductors against strain.

(E) Flexibility to Moving Parts

Where flexibility is required for power or control to moving parts, listed festoon cable or a cord suitable for the purpose shall be permitted, provided the following apply:

Suitable strain relief and protection from physical damage is provided.

In Class I, Division 2 locations, the cord is approved for extra-hard usage.

610.12 Raceway or Cable Terminal Fittings

Conductors leaving raceways or cables shall comply with either 610.12(A) or (B).

(A) Separately Bushed Hole

A box or terminal fitting that has a separately bushed hole for each conductor shall be used wherever a change is made from a raceway or cable to exposed wiring. A fitting used for this purpose shall not contain taps or splices and shall not be used at luminaire outlets.

(B) Bushing in Lieu of a Box

A bushing shall be permitted to be used in lieu of a box at the end of a rigid metal conduit, intermediate metal conduit, or electrical metallic tubing where the raceway terminates at unenclosed controls or similar equipment, including contact conductors, collectors, resistors, brakes, power-circuit limit switches, and dc split-frame motors.

610.13 Types of Conductors

Conductors shall comply with Table 310.4(A) unless otherwise permitted in 610.13(A) through (D).

(A) Exposed to External Heat or Connected to Resistors

A conductor(s) exposed to external heat or connected to resistors shall have a flame-resistant outer covering or be covered with flame-resistant tape individually or as a group.

(B) Contact Conductors

Contact conductors along runways, crane bridges, and monorails shall be permitted to be bare and shall be copper, aluminum, steel, or other alloys or combinations thereof in the form of hard-drawn wire, tees, angles, tee rails, or other stiff shapes.

(C) Flexibility

Where flexibility is required, listed flexible cord or cable, or listed festoon cable, shall be permitted to be used and, where necessary, cable reels or take-up devices shall be used.

(D) Class 1, Class 2, and Class 3 Circuits

Conductors for Class 1, Class 2, and Class 3 remote-control, signaling, and power-limited circuits, installed in accordance with Article 725, shall be permitted.

610.14 Rating and Size of Conductors

(A) Ampacity

The ampacities of conductors shall be as shown in Table 610.14(A).

Informational Note: For the ampacities of conductors between controllers and resistors, see 430.23.

Table 610.14(A) Ampacities of Insulated Copper Conductors Used with Short-Time Rated Crane and Hoist Motors. Based on Ambient Temperature of 30°C (86°F).

Maximum Operating Temperature Up to Four Simultaneously Energized Conductors in Raceway or Cable1 Up to Three ac2 or Four dc1 Simultaneously Energized Conductors in Raceway or Cable Maximum Operating Temperature

75°C (167°F) 90°C (194°F) 125°C (257°F)

Size (AWG or kcmil) Types MTW, RHW, THW, THWN, XHHW, USE, ZW Types TA, TBS, SA, SIS, PFA, FEP, FEPB, RHH, THHN, XHHW, Z, ZW Types FEP, FEPB, PFA, PFAH, SA, TFE, Z, ZW Size (AWG or kcmil)

60 Min 30 Min 60 Min 30 Min 60 Min 30 Min

16 10 12 - - - - 16

14 25 26 31 32 38 40 14

12 30 33 36 40 45 50 12

10 40 43 49 52 60 65 10

8 55 60 63 69 73 80 8

6 76 86 83 94 101 119 6

5 85 95 95 106 115 134 5

4 100 117 111 130 133 157 4

3 120 141 131 153 153 183 3

2 137 160 148 173 178 214 2

1 143 175 158 192 210 253 1

1/0 190 233 211 259 253 304 1/0

2/0 222 267 245 294 303 369 2/0

3/0 280 341 305 372 370 452 3/0

4/0 300 369 319 399 451 555 4/0

250 364 420 400 461 510 635 250

300 455 582 497 636 587 737 300

350 486 646 542 716 663 837 350

400 538 688 593 760 742 941 400

450 600 765 660 836 818 1042 450

500 660 847 726 914 896 1143 500

AMPACITY CORRECTION FACTORS

Ambient Temperature (°C) For ambient temperatures other than 30°C (86°F), multiply the ampacities shown above by the appropriate factor shown below. Ambient Temperature (°F)

21-25 1.05 1.05 1.04 1.04 1.02 1.02 70-77

26-30 1.00 1.00 1.00 1.00 1.00 1.00 79-86

31-35 0.94 0.94 0.96 0.96 0.97 0.97 88-95

36-40 0.88 0.88 0.91 0.91 0.95 0.95 97-104

41-45 0.82 0.82 0.87 0.87 0.92 0.92 106-113

46-50 0.75 0.75 0.82 0.82 0.89 0.89 115-122

51-55 0.67 0.67 0.76 0.76 0.86 0.86 124-131

56-60 0.58 0.58 0.71 0.71 0.83 0.83 133-140

61-70 0.33 0.33 0.58 0.58 0.76 0.76 142-158

71-80 - - 0.41 0.41 0.69 0.69 160-176

81-90 - - - - 0.61 0.61 177-194

91-100 - - - - 0.51 0.51 195-212

101-120 - - - - 0.40 0.40 213-248

Note: Other insulations shown in Table 310.4(A) and approved for the temperature and location shall be permitted to be substituted for those shown in Table 610.14(A). The allowable ampacities of conductors used with 15-minute motors shall be the 30-minute ratings increased by 12 percent.

1 For 5 to 8 simultaneously energized power conductors in raceway or cable, the ampacity of each power conductor shall be reduced to a value of 80 percent of that shown in this table.

2 For 4 to 6 simultaneously energized 125°C (257°F) ac power conductors in raceway or cable, the ampacity of each power conductor shall be reduced to a value of 80 percent of that shown in this table.

(B) Secondary Resistor Conductors

Where the secondary resistor is separate from the controller, the minimum size of the conductors between controller and resistor shall be calculated by multiplying the motor secondary current by the appropriate factor from Table 610.14(B) and selecting a wire from Table 610.14(A).

Table 610.14(B) Secondary Conductor Rating Factors

Time in Seconds Ampacity of Wire in Percent of Full-Load Secondary Current

On Off

5 75 35

10 70 45

15 75 55

15 45 65

15 30 75

15 15 85

Continuous Duty 110

(C) Minimum Size

Conductors external to motors and controls shall be not smaller than 16 AWG unless otherwise permitted in (1) or (2):

18 AWG wire in multiconductor cord shall be permitted for control circuits not exceeding 7 amperes.

Wires not smaller than 20 AWG shall be permitted for electronic circuits.

(D) Contact Conductors

Contact wires shall have an ampacity not less than that required by Table 610.14(A) for 75°C (167°F) wire, and in no case shall they be smaller than as shown in Table 610.14(D).

Table 610.14(D) Minimum Contact Conductor Size Based on Distance Between Supports

Minimum Size of Wire (AWG) Maximum Distance Between End Strain Insulators or Clamp-Type Intermediate Supports

6 9.0 m (30 ft) or less

4 18 m (60 ft) or less

2 Over 18 m (60 ft)

(E) Calculation of Motor Load

Table 610.14(E) Demand Factors

Number of Cranes or Hoists Demand Factor

2 0.95

3 0.91

4 0.87

5 0.84

6 0.81

7 0.78

(1) Single Motor

For one motor, 100 percent of motor nameplate full-load ampere rating shall be used.

(2) Multiple Motors on Single Crane or Hoist

For multiple motors on a single crane or hoist, the minimum ampacity of the power supply conductors shall be the nameplate full-load ampere rating of the largest motor or group of motors for any single crane motion, plus 50 percent of the nameplate full-load ampere rating of the next largest motor or group of motors, using that column of Table 610.14(A) that applies to the longest time-rated motor.

(3) Multiple Cranes or Hoists on a Common Conductor System

For multiple cranes, hoists, or both, supplied by a common conductor system, calculate the motor minimum ampacity shall be calculated for each crane as defined in 610.14(E), added them together, and the sum multiplied by the appropriate demand factor from Table 610.14(E).

(F) Other Loads

Additional loads, such as heating, lighting, and air conditioning, shall be provided for by application of the appropriate sections of this Code.

(G) Nameplate

Each crane, monorail, or hoist shall be provided with a visible nameplate marked with the manufacturer's name, rating in volts, frequency, number of phases, and circuit amperes as calculated in 610.14(E) and (F).

610.15 Common Return

Where a crane or hoist is operated by more than one motor, a common-return conductor of proper ampacity shall be permitted.

Part III Contact Conductors

610.21 Installation of Contact Conductors

Contact conductors shall comply with 610.21(A) through (H).

(A) Locating or Guarding Contact Conductors

Runway contact conductors shall be guarded, and bridge contact conductors shall be located or guarded in such a manner that persons cannot inadvertently touch energized current-carrying parts.

(B) Contact Wires

Wires that are used as contact conductors shall be secured at the ends by means of approved strain insulators and shall be mounted on approved insulators so that the extreme limit of displacement of the wire does not bring the latter within less than 38 mm (11/2 in.) from the surface wired over.

(C) Supports Along Runways

Main contact conductors carried along runways shall be supported on insulating supports placed at intervals not exceeding 6.0 m (20 ft) unless otherwise permitted in 610.21(F).

Such conductors shall be separated at not less than 150 mm (6 in.), other than for monorail hoists where a spacing of not less than 75 mm (3 in.) shall be permitted. Where necessary, intervals between insulating supports shall be permitted to be increased up to 12 m (40 ft), the separation between conductors being increased proportionately.

(D) Supports on Bridges

Bridge wire contact conductors shall be kept at least 65 mm (21/2 in.) apart, and, where the span exceeds 25 m (80 ft), insulating saddles shall be placed at intervals not exceeding 15 m (50 ft).

(E) Supports for Rigid Conductors

Conductors along runways and crane bridges, that are of the rigid type specified in 610.13(B) and not contained within an approved enclosed assembly, shall be carried on insulating supports spaced at intervals of not more than 80 times the vertical dimension of the conductor, but in no case greater than 4.5 m (15 ft), and spaced apart sufficiently to give a clear electrical separation of conductors or adjacent collectors of not less than 25 mm (1 in.).

(F) Track as Circuit Conductor

Monorail, tram rail, or crane runway tracks shall be permitted as a conductor of current for one phase of a 3-phase, ac system furnishing power to the carrier, crane, or trolley, provided all of the following conditions are met:

The conductors supplying the other two phases of the power supply are insulated.

The power for all phases is obtained from an insulating transformer.

The voltage does not exceed 300 volts.

The rail serving as a conductor shall be bonded to the equipment grounding conductor at the transformer and also shall be permitted to be grounded by the fittings used for the suspension or attachment of the rail to a building or structure.

(G) Electrical Continuity of Contact Conductors

All sections of contact conductors shall be mechanically joined to provide a continuous electrical connection.

(H) Not to Supply Other Equipment

Contact conductors shall not be used as feeders for any equipment other than the crane(s) or hoist(s) that they are primarily designed to serve.

610.22 Collectors

Collectors shall be designed so as to reduce to a minimum sparking between them and the contact conductor; and, where operated in rooms used for the storage of easily ignitible combustible fibers and materials, they shall comply with 503.155.

Part IV Disconnecting Means

610.31 Runway Conductor Disconnecting Means

A disconnecting means that has a continuous ampere rating not less than that calculated in 610.14(E) and (F) shall be provided between the runway contact conductors and the power supply. The disconnecting means shall comply with 430.109. This disconnecting means shall be as follows:

Readily accessible and operable from the ground or floor level

Lockable open in accordance with 110.25

Open all ungrounded conductors simultaneously

Placed within view of the runway contact conductors

Exception: The runway conductor disconnecting means for electrolytic cell lines shall be permitted to be placed out of view of the runway contact conductors where either of the following conditions are met:

Where a location in view of the contact conductors is impracticable or introduces additional or increased hazards to persons or property

In industrial installations, with written safety procedures, where conditions of maintenance and supervision ensure that only qualified persons service the equipment

610.32 Disconnecting Means for Cranes and Monorail Hoists

A disconnecting means in compliance with 430.109 shall be provided in the leads from the runway contact conductors or other power supply on all cranes and monorail hoists. The disconnecting means shall be lockable open in accordance with 110.25.

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

The unit is controlled from the ground or floor level.

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

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

Means shall be provided at the operating station to open the power circuit to all motors of the crane or monorail hoist.

610.33 Rating of Disconnecting Means

The continuous ampere rating of the switch or circuit breaker required by 610.32 shall not be less than 50 percent of the combined short-time ampere rating of the motors or less than 75 percent of the sum of the short-time ampere rating of the motors required for any single motion.

Part V Overcurrent Protection

610.41 Feeders, Runway Conductors

(A) Single Feeder

The runway supply conductors and main contact conductors of a crane or monorail shall be protected by an overcurrent device(s) that shall not be greater than the largest rating or setting of any branch-circuit protective device plus the sum of the nameplate ratings of all the other loads with application of the demand factors from Table 610.14(E).

(B) More Than One Feeder Circuit

Where more than one feeder circuit is installed to supply runway conductors, each feeder circuit shall be sized and protected in compliance with 610.41(A).

610.42 Branch-Circuit Short-Circuit and Ground-Fault Protection

Branch circuits shall be protected in accordance with 610.42(A). Branch-circuit taps, where made, shall comply with 610.42(B).

(A) Fuse or Circuit Breaker Rating

Crane, hoist, and monorail hoist motor branch circuits shall be protected by fuses or inverse-time circuit breakers that have a rating in accordance with Table 430.52. Where two or more motors operate a single motion, the sum of their nameplate current ratings shall be considered as that of a single motor.

(B) Taps

(1) Multiple Motors

Where two or more motors are connected to the same branch circuit, each tap conductor to an individual motor shall have an ampacity not less than one-third that of the branch circuit. Each motor shall be protected from overload according to 610.43.

(2) Control Circuits

Where taps to control circuits originate on the load side of a branch-circuit protective device, each tap and piece of equipment shall be protected in accordance with 430.72.

610.43 Overload Protection

(A) Motor and Branch-Circuit Overload Protection

Each motor, motor controller, and branch-circuit conductor shall be protected from overload by one of the following means:

A single motor shall be considered as protected where the branch-circuit overcurrent device meets the rating requirements of 610.42.

Overload relay elements in each ungrounded circuit conductor, with all relay elements protected from short circuit by the branch-circuit protection.

Thermal sensing devices, sensitive to motor temperature or to temperature and current, that are thermally in contact with the motor winding(s). Hoist functions shall be considered to be protected if the sensing device limits the hoist to lowering only during an overload condition. Traverse functions shall be considered to be protected if the sensing device limits the travel in both directions for the affected function during an overload condition of either motor.

(B) Manually Controlled Motor

If the motor is manually controlled, with spring return controls, the overload protective device shall not be required to protect the motor against stalled rotor conditions.

(C) Multimotor

Where two or more motors drive a single trolley, truck, or bridge and are controlled as a unit and protected by a single set of overload devices with a rating equal to the sum of their rated full-load currents, a hoist or trolley shall be considered to be protected if the sensing device is connected in the hoist's upper limit switch circuit so as to prevent further hoisting during an overtemperature condition of either motor.

(D) Hoists and Monorail Hoists

Hoists and monorail hoists and their trolleys that are not used as part of an overhead traveling crane shall not require individual motor overload protection, provided the largest motor does not exceed 71/2 hp and all motors are under manual control of the operator.

Part VI Control

610.51 Separate Controllers

Each motor shall be provided with an individual controller unless otherwise permitted in 610.51(A) or (B).

(A) Motions With More Than One Motor

Where two or more motors drive a single hoist, carriage, truck, or bridge, they shall be permitted to be controlled by a single controller.

(B) Multiple Motion Controller

One controller shall be permitted to be switched between motors, under the following conditions:

The controller has a horsepower rating that is not lower than the horsepower rating of the largest motor.

Only one motor is operated at one time.

610.53 Overcurrent Protection

Conductors of control circuits shall be protected against overcurrent. Control circuits shall be considered as protected by overcurrent devices that are rated or set at not more than 300 percent of the ampacity of the control conductors, unless otherwise permitted in 610.53(A) or (B).

(A) Taps to Control Transformers

Taps to control transformers shall be considered as protected where the secondary circuit is protected by a device rated or set at not more than 200 percent of the rated secondary current of the transformer and not more than 200 percent of the ampacity of the control circuit conductors.

(B) Continuity of Power

Where the opening of the control circuit would create a hazard, as for example, the control circuit of a hot metal crane, the control circuit conductors shall be considered as being properly protected by the branch-circuit overcurrent devices.

610.57 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 750 mm (21/2 ft). Where controls are enclosed in cabinets, the door(s) shall either open at least 90 degrees or be removable.

Part VII Grounding and Bonding

610.61 Grounding and Bonding

All exposed non—current-carrying metal parts of cranes, monorail hoists, hoists, and accessories, including pendant controls, shall be bonded either by mechanical connections or bonding jumpers, where applicable, so that the entire crane or hoist is an effective ground-fault current path by connection to the equipment grounding conductor of the branch circuit or feeder as required or permitted by Article 250, Parts I, V, VI, and VII.

Moving parts, other than removable accessories, or attachments that have metal-to-metal bearing surfaces, shall be considered to be electrically bonded to each other through bearing surfaces for the purpose of establishing an effective ground-fault current path. The trolley frame and bridge frame shall not be considered as electrically bonded through the bridge and trolley wheels and its respective tracks. A separate bonding conductor shall be provided.

Article 620 Elevators, Dumbwaiters, Escalators, Moving Walks, Platform Lifts, and Stairway Chairlifts

Part I General

620.1 Scope

This article covers the installation of electrical equipment and wiring used in connection with elevators, dumbwaiters, escalators, moving walks, platform lifts, and stairway chairlifts.

Informational Note No. 1: For further information, see ASME A17.1-2016/CSA B44-16, Safety Code for Elevators and Escalators.

Informational Note No. 2: For further information, see CSA B44.1-14/ASME A17.5-2014, Elevator and Escalator Electrical Equipment.

Informational Note No. 3: The term wheelchair lift has been changed to platform lift. For further information, see ASME A18.1-2014, Safety Standard for Platform Lifts and Stairway Chairlifts.

620.2 Definitions

The following definitions shall apply only within this article.

Informational Note No. 1: The motor controller, motion controller, and operation controller are located in a single enclosure or a combination of enclosures.

Informational Note No. 2: Informational Note Figure 620.2, No. 2 is for information only.

Informational Note Figure 620.2, No. 2 Control System.

Control Room (for Elevator, Dumbwaiter). An enclosed control space outside the hoistway, intended for full bodily entry, that contains the elevator motor controller. The room could also contain electrical and/or mechanical equipment used directly in connection with the elevator or dumbwaiter but not the electric driving machine or the hydraulic machine.

Control Space (for Elevator, Dumbwaiter). A space inside or outside the hoistway, intended to be accessed with or without full bodily entry, that contains the elevator motor controller. This space could also contain electrical and/or mechanical equipment used directly in connection with the elevator or dumbwaiter but not the electrical driving machine or the hydraulic machine.

Control System. The overall system governing the starting, stopping, direction of motion, acceleration, speed, and retardation of the moving member.

Controller, Motion. The electrical device(s) for that part of the control system that governs the acceleration, speed, retardation, and stopping of the moving member.

Controller, Motor. The operative units of the control system comprised of the starter device(s) and power conversion equipment used to drive an electric motor, or the pumping unit used to power hydraulic control equipment.

Controller, Operation. The electrical device(s) for that part of the control system that initiates the starting, stopping, and direction of motion in response to a signal from an operating device.

Machine Room (for Elevator, Dumbwaiter). An enclosed machinery space outside the hoistway, intended for full bodily entry, that contains the electrical driving machine or the hydraulic machine. The room could also contain electrical and/or mechanical equipment used directly in connection with the elevator or dumbwaiter.

Machinery Space (for Elevator, Dumbwaiter, Platform Lift, and Stairway Chairlift). A space inside or outside the hoistway, intended to be accessed with or without full bodily entry, that contains elevator, dumbwaiter, platform lift, or stairway chairlift equipment, and could also contain equipment used directly in connection with the elevator, dumbwaiter, platform lift, or stairway chairlift.

Operating Device. The car switch, pushbuttons, key or toggle switch(s), or other devices used to activate the operation controller.

Remote Machine Room and Control Room (for Elevator, Dumbwaiter). A machine room or control room that is not attached to the outside perimeter or surface of the walls, ceiling, or floor of the hoistway.

Remote Machinery Space and Control Space (for Elevator, Dumbwaiter). A machinery space or control space that is not within the hoistway, machine room, or control room and that is not attached to the outside perimeter or surface of the walls, ceiling, or floor of the hoistway.

Signal Equipment. Includes audible and visual equipment such as chimes, gongs, lights, and displays that convey information to the user.

620.3 Voltage Limitations

The supply voltage shall not exceed 300 volts between conductors unless otherwise permitted in 620.3(A) through (C).

(A) Power Circuits

Branch circuits to door operator controllers and door motors and branch circuits and feeders to motor controllers, driving machine motors, machine brakes, and motor-generator sets shall not have a circuit voltage in excess of 1000 volts. Internal voltages of power conversion equipment and functionally associated equipment, and the operating voltages of wiring interconnecting the equipment, shall be permitted to be higher, provided that all such equipment and wiring shall be listed for the higher voltages. Where the voltage exceeds 600 volts, warning labels or signs that read "DANGER — HIGH VOLTAGE" shall be attached to the equipment and shall be plainly visible. The danger sign(s) or label(s) shall comply with 110.21(B).

(B) Lighting Circuits

Lighting circuits shall comply with the requirements of Article 410.

(C) Heating and Air-Conditioning Circuits

Branch circuits for heating and air-conditioning equipment located on the elevator car shall not have a circuit voltage in excess of 1000 volts.

620.4 Live Parts Enclosed

All live parts of electrical apparatus in the hoistways, at the landings, in or on the cars of elevators and dumbwaiters, in the wellways or the landings of escalators or moving walks, or in the runways and machinery spaces of platform lifts and stairway chairlifts shall be enclosed to protect against accidental contact.

Informational Note: See 110.27 for guarding of live parts (1000 volts, nominal, or less).

620.5 Working Clearances

Working space shall be provided about controllers, disconnecting means, and other electrical equipment in accordance with 110.26(A).

Where conditions of maintenance and supervision ensure that only qualified persons examine, adjust, service, and maintain the equipment, the clearance requirements of 110.26(A) shall not be required where any of the conditions in 620.5(A) through (D) are met.

(A) Flexible Connections to Equipment

Electrical equipment in (A)(1) through (A)(4) is provided with flexible leads to all external connections so that it can be repositioned to meet the clear working space requirements of 110.26:

Controllers and disconnecting means for dumbwaiters, escalators, moving walks, platform lifts, and stairway chairlifts installed in the same space with the driving machine

Controllers and disconnecting means for elevators installed in the hoistway or on the car

Controllers for door operators

Other electrical equipment installed in the hoistway or on the car

(B) Guards

Live parts of the electrical equipment are suitably guarded, isolated, or insulated to reduce the likelihood of inadvertent contact with live parts operating at voltages greater than 30 volts ac rms, 42 volts ac peak, or 60 volts dc, and the equipment can be examined, adjusted, serviced, or maintained while energized without removal of this protection.

(C) Examination, Adjusting, and Servicing

Electrical equipment is not required to be examined, adjusted, serviced, or maintained while energized.

(D) Low Voltage

Uninsulated parts are at a voltage not greater than 30 volts rms, 42 volts peak, or 60 volts dc.

620.6 Ground-Fault Circuit-Interrupter Protection for Personnel

Each 125-volt, single-phase, 15- and 20-ampere receptacle installed in pits, in hoistways, on the cars of elevators and dumbwaiters associated with wind turbine tower elevators, on the platforms or in the runways and machinery spaces of platform lifts and stairway chairlifts, and in escalator and moving walk wellways shall be of the ground-fault circuit-interrupter type.

All 125-volt, single-phase, 15- and 20-ampere receptacles installed in machine rooms, control spaces, machinery spaces, and control rooms shall have ground-fault circuit-interrupter protection for personnel.

A permanently installed sump pump shall be permanently wired or shall be supplied by a single receptacle that is ground-fault circuit-interrupter protected.

Upcodes Diagrams

Part II Conductors

620.11 Insulation of Conductors

The insulation of conductors shall comply with 620.11(A) through (D).

Informational Note: One method of determining that the insulation of conductors is flame retardant is by testing the conductors or cables to the VW-1 (Vertical-Wire) Flame Test in ANSI/UL 1581-2011, Reference Standard for Electrical Wires, Cables, and Flexible Cords.

(A) Hoistway Door Interlock Wiring

The conductors to the hoistway door interlocks from the hoistway riser shall be one of the following:

Flame retardant and suitable for a temperature of not less than 200°C (392°F). Conductors shall be Type SF or equivalent.

Physically protected using an approved method, such that the conductor assembly is flame retardant and suitable for a temperature of not less than 200°C (392°F).

(B) Traveling Cables

Traveling cables used as flexible connections between the elevator or dumbwaiter car or counterweight and the raceway shall be of the types of elevator cable listed in Table 400.4 or other approved types.

(C) Other Wiring

All conductors in raceways shall have flame-retardant insulation.

Conductors shall be Type MTW, TF, TFF, TFN, TFFN, THHN, THW, THWN, TW, XHHW, hoistway cable, or any other conductor with insulation designated as flame retardant. Shielded conductors shall be permitted if such conductors are insulated for the maximum nominal circuit voltage applied to any conductor within the cable or raceway system.

(D) Insulation

All conductors shall have an insulation voltage rating equal to at least the maximum nominal circuit voltage applied to any conductor within the enclosure, cable, or raceway. Insulations and outer coverings that are marked for limited smoke and are so listed shall be permitted.

620.12 Minimum Size of Conductors

The minimum size of conductors, other than conductors that form an integral part of control equipment, shall be in accordance with 620.12(A) and (B).

(A) Traveling Cables

(1) Lighting Circuits

For lighting circuits, 14 AWG copper, 20 AWG copper or larger conductors shall be permitted in parallel, provided the ampacity is equivalent to at least that of 14 AWG copper.

(2) Other Circuits

For other circuits, 20 AWG copper.

(B) Other Wiring

24 AWG copper. Smaller size listed conductors shall be permitted.

620.13 Feeder and Branch-Circuit Conductors

Conductors shall have an ampacity in accordance with 620.13(A) through (D). With generator field control, the conductor ampacity shall be based on the nameplate current rating of the driving motor of the motor-generator set that supplies power to the elevator motor.

Informational Note No. 1: The heating of conductors depends on root-mean-square current values, which, with generator field control, are reflected by the nameplate current rating of the motor-generator driving motor rather than by the rating of the elevator motor, which represents actual but short-time and intermittent full-load current values.

Informational Note No. 2: See Informational Note, Informational Note Figure 620.13, No. 2.

Informational Note Figure 620.13 Single-Line Diagram.

(A) Conductors Supplying Single Motor

Conductors supplying a single motor shall have an ampacity not less than the percentage of motor nameplate current determined from 430.22(A) and (E).

Informational Note: Some elevator motor currents, or those motor currents of similar function, exceed the motor nameplate value. Heating of the motor and conductors is dependent on the root-mean square (rms) current value and the length of operation time. Because this motor application is inherently intermittent duty, conductors are sized for duty cycle service as shown in Table 430.22(E).

(B) Conductors Supplying a Single Motor Controller

Conductors supplying a single motor controller shall have an ampacity not less than the motor controller nameplate current rating, plus all other connected loads. Motor controller nameplate current ratings shall be permitted to be derived based on the rms value of the motor current using an intermittent duty cycle and other control system loads, if present.

(C) Conductors Supplying a Single Power Transformer

Conductors supplying a single power transformer shall have an ampacity not less than the nameplate current rating of the power transformer plus all other connected loads.

Informational Note No. 1: The nameplate current rating of a power transformer supplying a motor controller reflects the nameplate current rating of the motor controller at line voltage (transformer primary).

Informational Note No. 2: See Informative Annex D, Example No. D10.

(D) Conductors Supplying More Than One Motor, Motor Controller, or Power Transformer

Conductors supplying more than one motor, motor controller, or power transformer shall have an ampacity not less than the sum of the nameplate current ratings of the equipment plus all other connected loads. The ampere ratings of motors to be used in the summation shall be determined from Table 430.22(E), 430.24, and 430.24, Exception No. 1.

Informational Note: See Informative Annex D, Example Nos. D9 and D10.

620.14 Feeder Demand Factor

Feeder conductors of less ampacity than required by 620.13 shall be permitted, subject to the requirements of Table 620.14.

Table 620.14 Feeder Demand Factors for Elevators

Number of Elevators on a Single Feeder Demand Factor\*

1 1.00

2 0.95

3 0.90

4 0.85

5 0.82

6 0.79

7 0.77

8 0.75

9 0.73

10 or more 0.72

\* Demand factors are based on 50 percent duty cycle (i.e., half time on and half time off).

620.15 Motor Controller Rating

The motor controller rating shall comply with 430.83. The rating shall be permitted to be less than the nominal rating of the elevator motor, when the controller inherently limits the available power to the motor and is marked as power limited.

Informational Note: For controller markings, see 430.8.

620.16 Short-Circuit Current Rating

(A) Marking

Where an elevator control panel is installed, it shall be marked with its short-circuit current rating, based on one of the following:

Short-circuit current rating of a listed assembly

Short-circuit current rating established utilizing an approved method

Informational Note: UL 508A-2013, Standard for Industrial Control Panels, Supplement SB, is an example of an approved method.

(B) Installation

The elevator control panel shall not be installed where the available fault current exceeds its short-circuit current rating, as marked in accordance with 620.16(A).

Part III Wiring

620.21 Wiring Methods

Conductors, cables, and optical fiber cables located in hoistways, escalator and moving walk wellways, platform lifts, stairway chairlift runways, machinery spaces, control spaces, in or on cars, machine rooms, and control rooms, not including the traveling cables connecting the car or counterweight and hoistway wiring, shall be installed in rigid metal conduit, intermediate metal conduit, electrical metallic tubing, rigid nonmetallic conduit, or wireways, or shall be Type MC, MI, or AC cable unless otherwise permitted in 620.21(A) through (C). Unused conductors in an enclosure shall be insulated or protected from accidental contact with exposed live parts.

Exception: Cords and cables of listed cord-and-plug-connected equipment shall not be required to be installed in a raceway.

Informational Note: When an elevator is classified as a fire service access elevator or occupant evacuation operation elevator, some building codes require additional protection for conductors that are located outside of the elevator hoistway and machine room.

(A) Elevators

(1) Hoistways and Pits

Diagram

(a) Cables used in Class 2 power-limited circuits shall be permitted, provided the cables are supported and protected from physical damage and are of a jacketed and flame-retardant type.

(b) Flexible cords and cables that are components of listed equipment and used in circuits operating at 30 volts rms or less or 42 volts dc or less shall be permitted, provided the cords and cables are supported and protected from physical damage and are of a jacketed and flame-retardant type.

(c) The following wiring methods shall be permitted in the hoistway in lengths not to exceed 1.8 m (6 ft):

Flexible metal conduit.

Liquidtight flexible metal conduit.

Liquidtight flexible nonmetallic conduit.

Flexible cords and cables, or conductors grouped together and taped or corded, shall be permitted to be installed without a raceway. They shall be located to be protected from physical damage, shall be of a flame-retardant type, and shall be part of one of the following:

Listed equipment

Driving machine

Driving machine brake

Exception 620.21(A)(1)(c)(1), (A)(1)(c)(2), and (A)(1)(c)(3): The conduit length shall not be required to be limited between risers and limit switches, interlocks, operating buttons, and similar devices.

(d) A sump pump or oil recovery pump located in the pit shall be permitted to be cord connected. The cord shall be a hard usage oil-resistant type, of a length not to exceed 1.8 m (6 ft), and shall be located to be protected from physical damage.

(e) Hard-service cords and junior hard-service cords that conform to the requirements of Article 400 (Table 400.4) shall be permitted as flexible connections between the fixed wiring in the hoistway and hoistway access switches when located in the hoistway door sight guard.

Informational Note: See ASME A17.1-2016/CSA B44-16, Safety Code for Elevators and Escalators.

Upcodes Diagrams

(2) Cars

(a) Flexible metal conduit, liquidtight flexible metal conduit, or liquidtight flexible nonmetallic conduit of metric designator 12 (trade size 3/8), or larger, not exceeding 1.8 m (6 ft) in length, shall be permitted on cars where so located as to be free from oil and if securely fastened in place.

Exception: Liquidtight flexible nonmetallic conduit of metric designator 12 (trade size 3/8), or larger, as defined by 356.2(2), shall be permitted in lengths in excess of 1.8 m (6 ft).

(b) Hard-service cords and junior hard-service cords that conform to the requirements of Article 400 (Table 400.4) shall be permitted as flexible connections between the fixed wiring on the car and devices on the car doors or gates. Hard-service cords only shall be permitted as flexible connections for the top-of-car operating device or the car-top work light. Devices or luminaires shall be grounded by means of an equipment grounding conductor run with the circuit conductors. Cables with smaller conductors and other types and thicknesses of insulation and jackets shall be permitted as flexible connections between the fixed wiring on the car and devices on the car doors or gates, if listed for this use.

(c) Flexible cords and cables that are components of listed equipment and used in circuits operating at 30 volts rms or less or 42 volts dc or less shall be permitted, provided the cords and cables are supported and protected from physical damage and are of a jacketed and flame-retardant type.

(d) The following wiring methods shall be permitted on the car assembly in lengths not to exceed 1.8 m (6 ft):

Flexible metal conduit

Liquidtight flexible metal conduit

Liquidtight flexible nonmetallic conduit

Flexible cords and cables, or conductors grouped together and taped or corded, shall be permitted to be installed without a raceway. They shall be located to be protected from physical damage and shall be of a flame-retardant type and shall be part of one of the following:

Listed equipment

A driving machine

A driving machine brake

(3) Within Machine Rooms, Control Rooms, and Machinery Spaces and Control Spaces

(a) Flexible metal conduit, liquidtight flexible metal conduit, or liquidtight flexible nonmetallic conduit of metric designator 12 (trade size 3/8), or larger, not exceeding 1.8 m (6 ft) in length, shall be permitted between control panels and machine motors, machine brakes, motor-generator sets, disconnecting means, and pumping unit motors and valves.

Exception: Liquidtight flexible nonmetallic conduit metric designator 12 (trade size 3/8) or larger, as defined in 356.2(2), shall be permitted to be installed in lengths in excess of 1.8 m (6 ft).

(b) Where motor-generators, machine motors, or pumping unit motors and valves are located adjacent to or underneath control equipment and are provided with extra-length terminal leads not exceeding 1.8 m (6 ft) in length, such leads shall be permitted to be extended to connect directly to controller terminal studs without regard to the carrying-capacity requirements of Articles 430 and 445. Auxiliary gutters shall be permitted in machine and control rooms between controllers, starters, and similar apparatus.

(c) Flexible cords and cables that are components of listed equipment and used in circuits operating at 30 volts rms or less or 42 volts dc or less shall be permitted, provided the cords and cables are supported and protected from physical damage and are of a jacketed and flame-retardant type.

(d) On existing or listed equipment, conductors shall also be permitted to be grouped together and taped or corded without being installed in a raceway. Such cable groups shall be supported at intervals not over 900 mm (3 ft) and located so as to be protected from physical damage.

(e) Flexible cords and cables in lengths not to exceed 1.8 m (6 ft) that are of a flame-retardant type and located to be protected from physical damage shall be permitted in these rooms and spaces without being installed in a raceway. They shall be part of one of the following:

Listed equipment

A driving machine

A driving machine brake

(4) Counterweight

The following wiring methods shall be permitted on the counterweight assembly in lengths not to exceed 1.8 m (6 ft):

Flexible metal conduit

Liquidtight flexible metal conduit

Liquidtight flexible nonmetallic conduit

Flexible cords and cables, or conductors grouped together and taped or corded, shall be permitted to be installed without a raceway. They shall be located to be protected from physical damage, shall be of a flame-retardant type, and shall be part of one of the following:

Listed equipment

A driving machine

A driving machine brake

(B) Escalators

(1) Wiring Methods

Flexible metal conduit, liquidtight flexible metal conduit, or liquidtight flexible nonmetallic conduit shall be permitted in escalator and moving walk wellways. Flexible metal conduit or liquidtight flexible conduit of metric designator 12 (trade size 3/8) shall be permitted in lengths not in excess of 1.8 m (6 ft).

Exception: Metric designator 12 (trade size 3/8), nominal, or larger liquidtight flexible nonmetallic conduit, as defined in 356.2(2), shall be permitted to be installed in lengths in excess of 1.8 m (6 ft).

(2) Class 2 Circuit Cables

Cables used in Class 2 power-limited circuits shall be permitted to be installed within escalators and moving walkways, provided the cables are supported and protected from physical damage and are of a jacketed and flame-retardant type.

(3) Flexible Cords

Hard-service cords that conform to the requirements of Article 400 (Table 400.4) shall be permitted as flexible connections on escalators and moving walk control panels and disconnecting means where the entire control panel and disconnecting means are arranged for removal from machine spaces as permitted in 620.5.

(C) Platform Lifts and Stairway Chairlift Raceways

(1) Wiring Methods

Flexible metal conduit or liquidtight flexible metal conduit shall be permitted in platform lifts and stairway chairlift runways and machinery spaces. Flexible metal conduit or liquidtight flexible conduit of metric designator 12 (trade size 3/8) shall be permitted in lengths not in excess of 1.8 m (6ft).

Exception: Metric designator 12 (trade size 3/8) or larger liquidtight flexible nonmetallic conduit, as defined in 356.2(2), shall be permitted to be installed in lengths in excess of 1.8 m (6 ft).

(2) Class 2 Circuit Cables

Cables used in Class 2 power-limited circuits shall be permitted to be installed within platform lifts and stairway chairlift runways and machinery spaces, provided the cables are supported and protected from physical damage and are of a jacketed and flame-retardant type.

(3) Flexible Cords and Cables

Flexible cords and cables that are components of listed equipment and used in circuits operating at 30 volts rms or less or 42 volts dc or less shall be permitted in lengths not to exceed 1.8 m (6 ft), provided the cords and cables are supported and protected from physical damage and are of a jacketed and flame-retardant type.

620.22 Branch Circuits for Car Lighting, Receptacle(s), Ventilation, Heating, and Air-Conditioning

(A) Car Light Receptacles, Auxiliary Lighting, and Ventilation

A separate branch circuit shall supply the car lights. The car lights branch circuit shall be permitted to supply receptacles, accessory equipment (alarm devices, alarm bells, monitoring devices not part of the control system), auxiliary lighting power source, and ventilation on each elevator car or inside the operation controller. The overcurrent device protecting the branch circuit shall be located in the elevator machine room, control room, machinery space, or control space. Where there is no machine room, control room, machinery space, or control space outside the hoistway, the overcurrent device shall be located outside the hoistway and accessible to qualified persons only.

Required lighting shall not be connected to the load side of a ground-fault circuit interrupter.

(B) Air-Conditioning and Heating Source

A separate branch circuit shall supply the air-conditioning and heating units on each elevator car. The overcurrent device protecting the branch circuit shall be located in the elevator machine room or control room/machinery space or control space.

620.23 Branch Circuits for Machine Room or Control Room/Machinery Space or Control Space Lighting and Receptacle(s)

(A) Separate Branch Circuits

The branch circuit(s) supplying the lighting for machine rooms, control rooms, machinery spaces, or control spaces shall be separate from the branch circuit(s) supplying the receptacle(s) in those places. These circuits shall supply no other loads.

Required lighting shall not be connected to the load side of a ground-fault circuit interrupter.

(B) Lighting Switch

The machine room or control room/machinery space or control space lighting switch shall be located at the point of entry.

(C) Duplex Receptacle

At least one 125-volt, single-phase, 15- or 20-ampere duplex receptacle shall be provided in each machine room or control room and machinery space or control space.

Informational Note: See ASME A17.1-2016/CSA B44-16, Safety Code for Elevators and Escalators, for illumination levels.

620.24 Branch Circuit for Hoistway Pit Lighting and Receptacles

(A) Separate Branch Circuits

Separate branch circuits shall supply the hoistway pit lighting and receptacles.

Required lighting shall not be connected to the load side of a ground-fault circuit interrupter.

(B) Lighting Switch

The lighting switch shall be so located as to be readily accessible from the pit access door.

(C) Duplex Receptacle

At least one 125-volt, single-phase, 15- or 20-ampere duplex receptacle shall be provided in the hoistway pit.

Informational Note No. 1: See ASME A17.1-2016/CSA B44-16, Safety Code for Elevators and Escalators, for illumination levels.

Informational Note No. 2: See 620.6 for ground-fault circuit-interrupter requirements.

620.25 Branch Circuits for Other Utilization Equipment

(A) Additional Branch Circuits

Additional branch circuit(s) shall supply utilization equipment not identified in 620.22, 620.23, and 620.24. Other utilization equipment shall be restricted to that equipment identified in 620.1.

(B) Overcurrent Devices

The overcurrent devices protecting the branch circuit(s) shall be located in the elevator machine room, control room, machinery space, or control space.

Part IV Installation of Conductors

620.32 Metal Wireways and Nonmetallic Wireways

The sum of the cross-sectional area of the individual conductors in a wireway shall not be more than 50 percent of the interior cross-sectional area of the wireway.

Vertical runs of wireways shall be securely supported at intervals not exceeding 4.5 m (15 ft) and shall have not more than one joint between supports. Adjoining wireway sections shall be securely fastened together to provide a rigid joint.

620.33 Number of Conductors in Raceways

The sum of the cross-sectional area of the individual conductors in raceways shall not exceed 40 percent of the interior cross-sectional area of the raceway, except as permitted in 620.32 for wireways.

620.34 Supports

Supports for cables or raceways in a hoistway or in an escalator or moving walk wellway or platform lift and stairway chairlift runway shall be securely fastened to the guide rail; escalator or moving walk truss; or to the hoistway, wellway, or runway construction.

620.35 Auxiliary Gutters

Auxiliary gutters shall not be subject to the restrictions of 366.12(2) covering length or of 366.22 covering number of conductors.

620.36 Different Systems in One Raceway or Traveling Cable

Optical fiber cables and conductors for operating devices, operation and motion control, power, signaling, fire alarm, lighting, heating, and air-conditioning circuits of 1000 volts or less shall be permitted to be run in the same traveling cable or raceway system if all conductors are insulated for the maximum voltage applied to any conductor within the cables or raceway system and if all live parts of the equipment are insulated from ground for this maximum voltage. Such a traveling cable or raceway shall also be permitted to include shielded conductors and/or one or more coaxial cables if such conductors are insulated for the maximum voltage applied to any conductor within the cable or raceway system. Conductors shall be permitted to be covered with suitable shielding for telephone, audio, video, or higher frequency communications circuits.

620.37 Wiring in Hoistways, Machine Rooms, Control Rooms, Machinery Spaces, and Control Spaces

(A) Uses Permitted

Only such electrical wiring, raceways, and cables used directly in connection with the elevator or dumbwaiter, including wiring for signals, for communication with the car, for lighting, heating, air conditioning, and ventilating the elevator car, for fire detecting systems, for pit sump pumps, and for heating, lighting, and ventilating the hoistway, shall be permitted inside the hoistway, machine rooms, control rooms, machinery spaces, and control spaces.

(B) Lightning Protection

Bonding of elevator rails (car and/or counterweight) to a lightning protection system down conductor(s) shall be permitted. The lightning protection system down conductor(s) shall not be located within the hoistway. Elevator rails or other hoistway equipment shall not be used as the down conductor for lightning protection systems.

Informational Note: See 250.106 for bonding requirements. For further information, see NFPA 780-2017, Standard for the Installation of Lightning Protection Systems.

(C) Main Feeders

Main feeders for supplying power to elevators and dumbwaiters shall be installed outside the hoistway unless as follows:

By special permission, feeders for elevators shall be permitted within an existing hoistway if no conductors are spliced within the hoistway.

Feeders shall be permitted inside the hoistway for elevators with driving machine motors located in the hoistway or on the car or counterweight.

620.38 Electrical Equipment in Garages and Similar Occupancies

Electrical equipment and wiring used for elevators, dumbwaiters, escalators, moving walks, and platform lifts and stairway chairlifts in garages shall comply with the requirements of Article 511.

Informational Note: Garages used for parking or storage and where no repair work is done in accordance with 511.3(A) are not classified.

Part V Traveling Cables

620.41 Suspension of Traveling Cables

Traveling cables shall be suspended at the car and hoistways' ends, or counterweight end where applicable, so as to reduce the strain on the individual copper conductors to a minimum.

Traveling cables shall be supported, utilizing listed components, by one of the following methods:

By their steel supporting member(s)

By looping the cables around supports for unsupported lengths less than 30 m (100 ft)

By suspending from the supports by a means that automatically tightens around the cable when tension is increased for unsupported lengths up to 60 m (200 ft)

Unsupported length for the hoistway suspension means shall be that length of cable measured from the point of suspension in the hoistway to the bottom of the loop, with the elevator car located at the bottom landing. Unsupported length for the car suspension means shall be that length of cable measured from the point of suspension on the car to the bottom of the loop, with the elevator car located at the top landing.

620.42 Hazardous (Classified) Locations

In hazardous (classified) locations, traveling cables shall be of a type approved for hazardous (classified) locations as permitted in 501.10(B)(2)(7), 502.10(B)(2)(6), 503.10(A)(3)(6), 505.15(C)(2), and 506.15(A)(6).

620.43 Location of and Protection for Cables

Traveling cable supports shall be located so as to reduce to a minimum the possibility of damage due to the cables coming in contact with the hoistway construction or equipment in the hoistway. Where necessary, suitable guards shall be provided to protect the cables against damage.

620.44 Installation of Traveling Cables

Traveling cables that are suitably supported and protected from physical damage shall be permitted to be run without the use of a raceway in either or both of the following:

When used inside the hoistway, on the elevator car, hoistway wall, counterweight, or controllers and machinery that are located inside the hoistway, provided the cables are in the original sheath.

From inside the hoistway, to elevator controller enclosures and to elevator car and machine room, control room, machinery space, and control space connections that are located outside the hoistway for a distance not exceeding 1.8 m (6 ft) in length as measured from the first point of support on the elevator car or hoistway wall, or counterweight where applicable, provided the conductors are grouped together and taped or corded, or in the original sheath. These traveling cables shall be permitted to be continued to this equipment.

Part VI Disconnecting Means and Control

620.51 Disconnecting Means

A single means for disconnecting all ungrounded main power supply conductors for each elevator, dumbwaiter, escalator, moving walk, platform lift, or stairway chairlift 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 circuits required in 620.22, 620.23, and 620.24.

(A) Type

The disconnecting means shall be an enclosed externally operable fused motor circuit switch or circuit breaker that is lockable only in the open position in accordance with 110.25.

The disconnecting means shall be a listed device.

Informational Note: For additional information, see ASME A17.1-2016/CSA B44-16, Safety Code for Elevators and Escalators.

Exception No. 1: Where an individual branch circuit supplies a platform lift, the disconnecting means required by 620.51(C)(4) shall be permitted to comply with 430.109(C). This disconnecting means shall be listed and shall be lockable open in accordance with 110.25.

Exception No. 2: Where an individual branch circuit supplies a stairway chairlift, the stairway chairlift shall be permitted to be cord-and-plug-connected, provided it complies with 422.16(A) and the cord does not exceed 1.8 m (6 ft) in length.

(B) 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, control rooms, machinery spaces, or control 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.

Informational Note: To reduce hazards associated with water on live elevator electrical equipment.

(C) Location

The disconnecting means shall be located where it is readily accessible to qualified persons.

(1) On Elevators Without Generator Field Control

On elevators without generator field control, the disconnecting means shall be located within sight of the motor controller. Where the motor controller is located in the elevator hoistway, the disconnecting means required by 620.51(A) shall be located outside the hoistway and accessible to qualified persons only. An additional fused or non-fused, enclosed, externally operable motor-circuit switch that is lockable open in accordance with 110.25 to disconnect all ungrounded main power-supply conductors shall be located within sight of the motor controller. The additional switch shall be a listed device and shall comply with 620.91(C).

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(es) shall be installed adjacent to this equipment.

Where the driving machine of an electric elevator or the hydraulic machine of a hydraulic elevator is located in a remote machine room or remote machinery space, a single means for disconnecting all ungrounded main power-supply conductors shall be provided and be lockable open in accordance with 110.25.

(2) 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(es) shall be installed adjacent to this equipment.

Where the driving machine or the motor-generator set is located in a remote machine room or remote machinery space, a single means for disconnecting all ungrounded main power-supply conductors shall be provided and be lockable open in accordance with 110.25.

(3) On Escalators and Moving Walks

On escalators and moving walks, the disconnecting means shall be installed in the space where the controller is located.

(4) On Platform Lifts and Stairway Chairlifts

On platform lifts and stairway chairlifts, the disconnecting means shall be located within sight of the motor controller.

(D) Identification and Signs

(1) More Than One Driving Machine

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.

(2) Available Fault Current Field Marking

Where an elevator control panel is used, it shall be legibly marked in the field with the available fault current at its line terminals. The field marking(s) shall include the date the available fault current calculation was performed and be of sufficient durability to withstand the environment involved.

When modifications to the electrical installation occur that affect the available fault current at the elevator control panel, the available fault current shall be verified or recalculated as necessary to ensure the elevator control panel's short-circuit current rating is sufficient for the available fault current at the line terminals of the equipment. The required field marking(s) shall be adjusted to reflect the new level of available fault current.

(E) Surge Protection

Where any of the disconnecting means in 620.51 has been designated as supplying an emergency system load, a legally required system load, or a critical operation power system load, listed surge protection shall be provided.

620.52 Power From More Than One Source

(A) 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.

(B) 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 as follows:

WARNING

PARTS OF THE CONTROLLER ARE NOT DE-ENERGIZED BY THIS SWITCH.

The warning sign(s) or label(s) shall comply with 110.21(B).

(C) 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 620.52(B) shall be mounted on or next to the disconnecting means.

620.53 Car Light, Receptacle(s), and Ventilation Disconnecting Means

Elevators shall have a single means for disconnecting all ungrounded car light, receptacle(s), and ventilation power-supply conductors for that elevator car.

The disconnecting means shall be an enclosed, externally operable, fused motor-circuit switch or circuit breaker that is lockable open in accordance with 110.25 and shall be located in the machine room or control room for that elevator car. Where there is no machine room or control room outside the hoistway, the disconnecting means shall be located outside the hoistway and accessible to qualified persons only.

Disconnecting means shall be numbered to correspond to the identifying number of the elevator car whose light source they control.

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

Exception: Where a separate branch circuit supplies car lighting, a receptacle(s), and a ventilation motor not exceeding 2 hp, the disconnecting means required by 620.53 shall be permitted to comply with 430.109(C). This disconnecting means shall be listed and shall be lockable open in accordance with 110.25.

620.54 Heating and Air-Conditioning Disconnecting Means

Elevators shall have a single means for disconnecting all ungrounded car heating and air-conditioning power-supply conductors for that elevator car.

The disconnecting means shall be an enclosed, externally operable, fused motor-circuit switch or circuit breaker that is lockable open in accordance with 110.25 and shall be located in the machine room or control room for that elevator car. Where there is no machine room or control room outside the hoistway, the disconnecting means shall be located outside the hoistway and accessible to qualified persons only.

Where there is equipment for more than one elevator car in the machine room, the disconnecting means shall be numbered to correspond to the identifying number of the elevator car whose heating and air-conditioning source they control.

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

620.55 Utilization Equipment Disconnecting Means

Each branch circuit for other utilization equipment shall have a single means for disconnecting all ungrounded conductors. The disconnecting means shall be lockable open in accordance with 110.25.

Where there is more than one branch circuit for other utilization equipment, the disconnecting means shall be numbered to correspond to the identifying number of the equipment served. The disconnecting means shall be provided with a sign to identify the location of the supply side overcurrent protective device.

Part VII Overcurrent Protection

620.61 Overcurrent Protection

Overcurrent protection shall be provided in accordance with 620.61(A) through (D).

(A) Operating Devices and Control and Signaling Circuits

Operating devices and control and signaling circuits shall be protected against overcurrent in accordance with the requirements of 725.43 and 725.45.

Class 2 power-limited circuits shall be protected against overcurrent in accordance with the requirements of Chapter 9, Notes to Tables 11 (A) and 11(B).

(B) Overload Protection for Motors

Motor and branch-circuit overload protection shall conform to Article 430, Part III, and (B)(1) through (B)(4).

(1) Duty Rating on Elevator, Dumbwaiter, and Motor-Generator Sets Driving Motors

Duty on elevator and dumbwaiter driving machine motors and driving motors of motorgenerators used with generator field control shall be rated as intermittent. Such motors shall be permitted to be protected against overload in accordance with 430.33.

(2) Duty Rating on Escalator Motors

Duty on escalator and moving walk driving machine motors shall be rated as continuous. Such motors shall be protected against overload in accordance with 430.32.

(3) Overload Protection

Escalator and moving walk driving machine motors and driving motors of motor-generator sets shall be protected against running overload as provided in Table 430.37.

(4) Duty Rating and Overload Protection on Platform Lift and Stairway Chairlift Motors

Duty on platform lift and stairway chairlift driving machine motors shall be rated as intermittent. Such motors shall be permitted to be protected against overload in accordance with 430.33.

Informational Note: For further information, see 430.44 for orderly shutdown.

(C) Motor Feeder Short-Circuit and Ground-Fault Protection

Motor feeder short-circuit and ground-fault protection shall be as required in Article 430, Part V.

(D) Motor Branch-Circuit Short-Circuit and Ground-Fault Protection

Motor branch-circuit short-circuit and ground-fault protection shall be as required in Article 430, Part IV.

620.62 Selective Coordination

Where more than one driving machine disconnecting means is supplied by the same source, the overcurrent protective devices in each disconnecting means shall be selectively coordinated with any other supply side overcurrent protective devices.

Selective coordination shall be selected by a licensed professional engineer or other qualified person engaged primarily in the design, installation, or maintenance of electrical systems. The selection and device settings shall be documented and made available to those authorized to design, install, inspect, maintain, and operate the system.

Exception No. 1: Selective coordination shall not be required between transformer primary and secondary overcurrent protective devices where only one overcurrent device or set of overcurrent devices exists on the transformer secondary.

Exception No. 2: Selective coordination shall not be required between overcurrent protective devices of the same rating located in series where no loads are connected in parallel with the downstream device.

620.65 Signage

Equipment enclosures containing selectively coordinated overcurrent devices shall be legibly marked in the field to indicate that the overcurrent devices are selectively coordinated. The marking shall meet the requirements of 110.21(B), shall be readily visible, and shall state the following:

CAUTION: OVERCURRENT DEVICES IN THIS ENCLOSURE ARE SELECTIVELY COORDINATED. EQUIVALENT REPLACEMENTS AND TRIP SETTINGS ARE REQUIRED.

Part VIII Machine Rooms, Control Rooms, Machinery Spaces, and Control Spaces

620.71 Guarding Equipment

Elevator, dumbwaiter, escalator, and moving walk driving machines; motor-generator sets; motor controllers; and disconnecting means shall be installed in a room or space set aside for that purpose unless otherwise permitted in 620.71(A) or (B). The room or space shall be secured against unauthorized access.

(A) Motor Controllers

Motor controllers shall be permitted outside the spaces herein specified, provided they are in enclosures with doors or removable panels that are 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.

(B) Driving Machines

Elevators with driving machines located on the car, on the counterweight, or in the hoistway, and driving machines for dumbwaiters, platform lifts, and stairway lifts, shall be permitted outside the spaces herein specified.

Part IX Grounding and Bonding

620.81 Metal Raceways Attached to Cars

Metal raceways, Type MC cable, Type MI cable, or Type AC cable attached to elevator cars shall be bonded to metal parts of the car that are bonded to the equipment grounding conductor.

620.82 Electric Elevators

For electric elevators, the frames of all motors, elevator machines, controllers, and the metal enclosures for all electrical equipment in or on the car or in the hoistway shall be bonded in accordance with Article 250, Parts V and VII.

620.83 Nonelectric Elevators

For elevators other than electric having any electrical conductors attached to the car, the metal frame of the car, where normally accessible to persons, shall be bonded in accordance with Article 250, Parts V and VII.

620.84 Escalators, Moving Walks, Platform Lifts, and Stairway Chairlifts

Escalators, moving walks, platform lifts, and stairway chairlifts shall comply with Article 250.

Part X Emergency and Standby Power Systems

620.91 Emergency and Standby Power Systems

Elevators shall be permitted to be powered by an emergency or standby power system.

Informational Note No. 1: See ASME A17.1-2016/CSA B44-16, Safety Code for Elevators and Escalators, 2.27.2, for additional information.

Informational Note No. 2: When an elevator is classified as a fire service access elevator or occupant evacuation operation elevator, some building codes require the elevator equipment, elevator hoistway lighting, ventilation and cooling equipment for elevator machine rooms, control rooms, machine spaces, and control spaces as well as elevator car lighting to be supplied by standby power systems in compliance with Article 701.

(A) Regenerative Power

For elevator systems that regenerate power back into the power source that is unable to absorb the regenerative power under overhauling elevator load conditions, a means shall be provided to absorb this power.

(B) Other Building Loads

Other building loads, such as power and lighting, shall be permitted as the energy absorption means required in 620.91(A), provided that such loads are automatically connected to the emergency or standby power system operating the elevators and are large enough to absorb the elevator regenerative power.

(C) Disconnecting Means

The disconnecting means required by 620.51 shall disconnect the elevator from both the emergency or standby power system and the normal power system.

Where an additional power source is connected to the load side of the disconnecting means, which allows automatic movement of the car to permit evacuation of passengers, the disconnecting means required in 620.51 shall be provided with an auxiliary contact that is positively opened mechanically, and the opening shall not be solely dependent on springs. This contact shall cause the additional power source to be disconnected from its load when the disconnecting means is in the open position.

Article 625 Electric Vehicle Power Transfer System

Diagram

UpCodes Diagrams

P

EV Charging Station Location within a Site

EV Charging Station Clearances

EV Accessible Charging Stations

Part I General

625.1 Scope

This article covers the electrical conductors and equipment connecting an electric vehicle to premises wiring for the purposes of charging, power export, or bidirectional current flow.

Informational Note No. 1: For industrial trucks, see NFPA 505-2018, Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operations.

Informational Note No. 2: UL 2594-2013, Standard for Electric Vehicle Supply Equipment, is a safety standard for conductive electric vehicle supply equipment. UL 2202-2009, Standard for Electric Vehicle Charging System Equipment, is a safety standard for conductive electric vehicle charging equipment.

625.2 Definitions

The following definitions shall apply only within this article.

Cable Management System. An apparatus designed to control and organize the output cable to the electric vehicle or to the primary pad.

Charger Power Converter. The device used to convert energy from the power grid to a high-frequency output for wireless power transfer.

Electric Vehicle Connector. A device that, when electrically coupled (conductive or inductive) to an electric vehicle inlet, establishes an electrical connection to the electric vehicle for the purpose of power transfer and information exchange.

Informational Note: For further information, see 625.48 for interactive systems.

Electric Vehicle Power Export Equipment (EVPE). The equipment, including the outlet on the vehicle, that is used to provide electrical power at voltages greater than or equal to 30 Vac or 60 Vdc to loads external to the vehicle, using the vehicle as the source of supply.

Informational Note: Electric vehicle power export equipment and electric vehicle supply equipment are sometimes contained in one piece of equipment, sometimes referred to as a bidirectional EVSE.

Electric Vehicle Supply Equipment (EVSE). The conductors, including the ungrounded, grounded, and equipment grounding conductors, and the electric vehicle connectors, attachment plugs, personnel protection system, and all other fittings, devices, power outlets, or apparatus installed specifically for the purpose of transferring energy between the premises wiring and the electric vehicle.

Informational Note: Electric vehicle power export equipment and electric vehicle supply equipment are sometimes contained in one piece of equipment, sometimes referred to as a bidirectional EVSE.

Fastened in Place. Mounting means of equipment in which the fastening means are specifically designed to permit periodic removal, without the use of a tool, for relocation, interchangeability, maintenance, or repair.

Fixed in Place. Mounting means of an EVSE attached to a wall or surface with fasteners that require a tool to be removed.

Output Cable to the Electric Vehicle. An assembly consisting of a length of flexible EV cable and an electric vehicle connector (supplying power to the electric vehicle).

Output Cable to the Primary Pad. A multi-conductor, shielded cable assembly consisting of conductors to carry the high-frequency energy and any status signals between the charger power converter and the primary pad.

Personnel Protection System. A system of personnel protection devices and constructional features that when used together provide protection against electric shock of personnel.

Portable (as applied to EVSE). A device intended for indoor or outdoor use that can be carried from charging location to charging location and is designed to be transported in the vehicle when not in use.

Power-Supply Cord. An assembly consisting of an attachment plug and length of flexible cord that connects equipment to a receptacle.

Primary Pad. A device external to the EV that transfers power via the contactless coupling as part of a wireless power transfer system.

Wireless Power Transfer (WPT). The transfer of electrical energy from a power source to an electrical load via electric and magnetic fields or waves by a contactless inductive means between a primary and a secondary device.

Wireless Power Transfer Equipment (WPTE). Equipment consisting of a charger power converter and a primary pad. The two devices are either separate units or contained within one enclosure.

625.4 Voltages

Unless other voltages are specified, the nominal ac system voltages of 120, 120/240, 208Y/120, 240, 480Y/277, 480, 600Y/347, 600, and 1000 volts and dc system voltages of up to 1000 volts shall be used to supply equipment covered by this article.

625.5 Listed

All equipment covered by the scope of this article shall be listed.

Part II Equipment Construction

625.17 Cords and Cables

(A) Power-Supply Cord

The cable for cord-connected equipment shall comply with all of the following:

Be any of the types specified in 625.17(B)(1) or hard service cord, junior hard service cord, or portable power cable types in accordance with Table 400.4. Hard service cord, junior hard service cord, or portable power cable types shall be listed, as applicable, for exposure to oil and damp and wet locations.

Have an ampacity as specified in Table 400.5(A)(1) or, for 8 AWG and larger, in the 60°C columns of Table 400.5(A)(2).

Have an overall length as specified in either of the following:

When the interrupting device of the personnel protection system specified in 625.22 is located within the enclosure of the supply equipment or charging system, the power-supply cord shall be not more than the length indicated in (i) or (ii):

For portable equipment in accordance with 625.44(A), the power supply cord shall be not more than 300 mm (12 in.) long.

For stationary equipment in accordance with 625.44(B), the power supply cord shall be not more than 1.8 m (6 ft) long and the equipment shall be installed at a height that prevents the power supply cord from contacting the floor when it is connected to the proper receptacle.

When the interrupting device of the personnel protection system specified in 625.22 is located at the attachment plug, or within the first 300 mm (12 in.) of the power-supply cord, the overall cord length shall be not greater than 4.6 m (15 ft).

(B) Output Cable to Electric Vehicle

The output cable to the electric vehicle shall be one of the following:

Listed Type EV, EVJ, EVE, EVJE, EVT, or EVJT flexible cable as specified in Table 400.4

An integral part of listed electric vehicle supply equipment

Informational Note: For information and listing requirements for electric vehicle supply equipment, see UL 2594-2016, Standard for Electric Vehicle Supply Equipment, and UL 2202-2009, Standard for Electric Vehicle (EV) Charging System Equipment.

(C) Overall Cord and Cable Length

The overall usable length shall not exceed 7.5 m (25 ft) unless equipped with a cable management system that is part of the listed electric vehicle supply equipment.

(1) Portable Equipment

For portable EVSE, the cord-exposed usable length shall be measured from the face of the attachment plug to the face of the electric vehicle connector.

(2) Fastened in Place

Where the electric vehicle supply equipment is fastened in place, the usable length of the output cable shall be measured from the cable exit of the electric vehicle supply equipment to the face of the electric vehicle connector.

(D) Interconnecting Cabling Systems

Other cabling systems that are integral parts of listed EVSE and are intended to interconnect pieces of equipment within an EVSE system using approved installation methods shall be permitted.

625.22 Personnel Protection System

The equipment shall have a listed system of protection against electric shock of personnel. Where cord-and-plug-connected equipment is used, the interrupting device of a listed personnel protection system shall be provided according to 625.17(A). A personnel protection system shall not be required for supplies less than 60 volts dc.

Part III Installation

625.40 Electric Vehicle Branch Circuit

Each outlet installed for the purpose of charging electric vehicles shall be supplied by an individual branch circuit. Each circuit shall have no other outlets.

625.41 Overcurrent Protection

Overcurrent protection for feeders and branch circuits supplying EVSE, including bidirectional EVSE, and WPTE shall be sized for continuous duty and shall have a rating of not less than 125 percent of the maximum load of the equipment. Where noncontinuous loads are supplied from the same feeder, the overcurrent device shall have a rating of not less than the sum of the noncontinuous loads plus 125 percent of the continuous loads.

625.42 Rating

The power transfer equipment shall have sufficient rating to supply the load served. Electric vehicle charging loads shall be considered to be continuous loads for the purposes of this article. Service and feeder shall be sized in accordance with the product ratings. Where an automatic load management system is used, the maximum equipment load on a service and feeder shall be the maximum load permitted by the automatic load management system.

Adjustable settings shall be permitted on fixed-in-place equipment only. If adjustments have an impact on the rating label, those changes shall be in accordance with manufacturer's instructions, and the adjusted rating shall appear with sufficient durability to withstand the environment involved on the rating label. Electric vehicle supply equipment with restricted access to an ampere adjusting means shall be permitted to have ampere ratings that are equal to the adjusted current setting. Sizing the service and feeder to match the adjusting means shall be permitted. Restricted access shall prevent the user from gaining access to the adjusting means. Restricted access shall be accomplished by at least one of the following:

A cover or door that requires the use of a tool to open

Locked doors accessible only to qualified personnel

Password protected commissioning software accessible only to qualified personnel

625.43 Disconnecting Means

For equipment rated more than 60 amperes or more than 150 volts to ground, the disconnecting means shall be provided and installed in a readily accessible location. The disconnecting means shall be lockable open in accordance with 110.25.

625.44 Equipment Connection

EVSE and WPTE shall be connected to the premises wiring system in accordance with one of the methods in 625.44(A) through (C).

(A) Portable Equipment

Portable equipment shall be connected to the premises wiring system by one or more of the following methods:

A nonlocking, 2-pole, 3-wire grounding-type receptacle outlet rated at 125 volts, single phase, 15 or 20 amperes

A nonlocking, 2-pole, 3-wire grounding-type receptacle outlet rated at 250 volts, single phase, 15 or 20 amperes

A nonlocking, 2-pole, 3-wire or 3-pole, 4-wire grounding-type receptacle outlet rated at 250 volts, single phase, 30 or 50 amperes

A nonlocking, 2-pole, 3-wire grounding-type receptacle outlet rated at 60 volts dc maximum, 15 or 20 amperes

(B) Fastened-in-Place Equipment

Equipment that is fastened in place shall be connected to the premises wiring system by one of the following methods:

A nonlocking, 2-pole, 3-wire grounding-type receptacle outlet rated 125 volts or 250 volts, single phase, up to 50 amperes

A nonlocking, 3-pole, 4-wire grounding-type receptacle outlet rated 250 volts, three phase, up to 50 amperes

A nonlocking, 3-pole, 4-wire grounding-type receptacle outlet rated 250 volts, single phase, 30 or 50 amperes

A nonlocking, 2-pole, 3-wire grounding-type receptacle outlet rated 60 volts dc maximum, 15 or 20 amperes

(C) Fixed Equipment

All other EVSE and WPTE shall be permanently wired and fixed in place to the supporting surface.

625.46 Loss of Primary Source

Means shall be provided such that, upon loss of voltage from the utility or other electrical system(s), energy cannot be back fed through the electric vehicle and the supply equipment to the premises wiring system unless permitted by 625.48.

625.47 Multiple Feeder or Branch Circuits

Where equipment is identified for the application, more than one feeder or branch circuit shall be permitted to supply equipment.

625.48 Interactive Systems

EVSE that incorporates a power export function and that is part of an interactive system that serves as an optional standby system, an electric power production source, or a bidirectional power feed shall be listed and marked as suitable for that purpose. When used as an optional standby system, the requirements of Article 702 shall apply; when used as an electric power production source, the requirements of Article 705 shall apply. EVPE that consists of a receptacle outlet only shall be in accordance with 625.60.

Informational Note: For further information on supply equipment, see ANSI/UL 1741, Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources, and ANSI/UL 9741, Bidirectional Electric Vehicle (EV) Charging System Equipment; for vehicle interactive systems, see SAE J3072, Standard for Interconnection Requirements for Onboard, Utility-Interactive Inverter Systems.

625.50 Location

The EVSE shall be located for direct electrical coupling of the EV connector (conductive or inductive) to the electric vehicle. Unless specifically listed and marked for the location, the coupling means of the EVSE shall be stored or located at a height of not less than 450 mm (18 in.) above the floor level for indoor locations or 600 mm (24 in.) above the grade level for outdoor locations. This requirement does not apply to portable EVSE constructed in accordance with 625.44(A).

625.52 Ventilation

The ventilation requirement for charging an electric vehicle in an indoor enclosed space shall be determined by 625.52(A) or (B).

(A) Ventilation Not Required

Where electric vehicle storage batteries are used or where the equipment is listed for charging electric vehicles indoors without ventilation, mechanical ventilation shall not be required.

(B) Ventilation Required

Where the equipment is listed for charging electric vehicles that require ventilation for indoor charging, mechanical ventilation, such as a fan, shall be provided. The ventilation shall include both supply and exhaust equipment and shall be permanently installed and located to intake from, and vent directly to, the outdoors. Positive-pressure ventilation systems shall be permitted only in vehicle charging buildings or areas that have been specifically designed and approved for that application. Mechanical ventilation requirements shall be determined by one of the methods specified in 625.52(B)(1) through (B)(4).

(1) Table Values

For supply voltages and currents specified in Table 625.52(B)(1)(a) or Table 625.52(B)(1)(b), the minimum ventilation requirements shall be as specified in Table 625.52(B)(1)(a) or Table 625.52(B)(1)(b) for each of the total number of electric vehicles that can be charged at one time.

Table 625.52(B)(1)(a) Minimum Ventilation Required in Cubic Meters per Minute (m3/min) for Each of the Total Number of Electric Vehicles That Can Be Charged at One Time

Branch-Circuit Ampere Rating Branch-Circuit Voltage

DC

≥ 50 V Single Phase 3 Phase

120 V 208 V 240 V or

120/240 V 208 V or

208Y/120 V 240 V 480 V or

480Y/277V 600 V or

600Y/347V

15 0.5 1.1 1.8 2.1 — — — —

20 0.6 1.4 2.4 2.8 4.2 4.8 9.7 12

30 0.9 2.1 3.6 4.2 6.3 7.2 15 18

40 1.2 2.8 4.8 5.6 8.4 9.7 19 24

50 1.5 3.5 6.1 7.0 10 12 24 30

60 1.8 4.2 7.3 8.4 13 15 29 36

100 2.9 7.0 12 14 21 24 48 60

150 — — — — 31 36 73 91

200 — — — — 42 48 97 120

250 — — — — 52 60 120 150

300 — — — — 63 73 145 180

350 — — — — 73 85 170 210

400 — — — — 84 97 195 240

Table 625.52(B)(1)(b) Minimum Ventilation Required in Cubic Feet per Minute (cfm) for Each of the Total Number of Electric Vehicles That Can Be Charged at One Time

Branch-Circuit Ampere Rating Branch-Circuit Voltage

DC

≥ 50 V Single Phase 3 Phase

120 V 208 V 240 V or

120/240 V 208 V or

208Y/120 V 240 V 480 V or

480Y/277V 600 V or

600Y/347V

15 15.4 37 64 74 — — — —

20 20.4 49 85 99 148 171 342 427

30 30.8 74 128 148 222 256 512 641

40 41.3 99 171 197 296 342 683 854

50 51.3 123 214 246 370 427 854 1066

60 61.7 148 256 296 444 512 1025 1281

100 102.5 246 427 493 740 854 1708 2135

150 — — — — 1110 1281 2562 3203

200 — — — — 1480 1708 3416 4270

250 — — — — 1850 2135 4270 5338

300 — — — — 2221 2562 5125 6406

350 — — — — 2591 2989 5979 7473

400 — — — — 2961 3416 6832 8541

(2) Other Values

For supply voltages and currents other than specified in Table 625.52(B)(1)(a) or Table 625.52(B)(1)(b), the minimum ventilation requirements shall be calculated by means of the following general formulas, as applicable:

(1) Single-phase ac or dc:

Ventilationsingle-phase ac or dc in cubic meters per minute (m3/min) =

Ventilationsingle-phase ac or dc in cubic feet per minute (cfm) =

(2) Three-phase ac:

Ventilation3-phase in cubic meters per minute (m3/min) =

Ventilation3-phase in cubic feet per minute (cfm) =

(3) Engineered Systems

For an equipment ventilation system designed by a person qualified to perform such calculations as an integral part of a building's total ventilation system, the minimum ventilation requirements shall be permitted to be determined in accordance with calculations specified in the engineering study.

(4) Supply Circuits

The supply circuit to the mechanical ventilation equipment shall be electrically interlocked with the equipment and shall remain energized during the entire electric vehicle charging cycle. Equipment receptacles rated at 125 volts, single phase, 15 and 20 amperes shall be switched and the mechanical ventilation system shall be electrically interlocked through the switch supply power to the receptacle. Equipment supplied from less than 50 volts dc shall be switched and the mechanical ventilation system shall be electrically interlocked through the switch supply power to the equipment.

625.54 Ground-Fault Circuit-Interrupter Protection for Personnel

In addition to the requirements in 210.8, all receptacles installed for the connection of electric vehicle charging shall have ground-fault circuit-interrupter protection for personnel.

625.56 Receptacle Enclosures

All receptacles installed in a wet location for electric vehicle charging shall have an enclosure that is weatherproof with the attachment plug cap inserted or removed. An outlet box hood installed for this purpose shall be listed and shall be identified as extra duty. Other listed products, enclosures, or assemblies providing weatherproof protection that do not utilize an outlet box hood shall not be required to be marked extra duty.

625.60 AC Receptacle Outlets Used for EVPE

AC receptacles installed in electric vehicles and intended to allow for connection of off-board utilization equipment shall comply with 625.60(A) through (D).

(A) Type

The receptacle outlet shall be listed.

(B) Rating

The receptacle outlet shall be rated 250 volts maximum, single phase 50 amperes maximum.

(C) Overcurrent Protection

Electric vehicles provided with receptacle outlets for power export shall be provided with overcurrent protection integral to the power export system. The overcurrent protection shall have a nominal rating sufficient for the receptacle it protects. The overcurrent protection shall also be sufficiently rated for the maximum available fault current at the receptacle and shall be included in the interactive equipment evaluation. See 625.48.

(D) GFCI Protection for Personnel

Ground-fault circuit-interrupter protection for personnel shall be provided for all receptacles. The ground-fault circuit-interrupter indication and reset shall be installed in a readily accessible location.

Informational Note: There are various methods available to achieve ground-fault circuit-interrupter protection.

Part IV Wireless Power Transfer Equipment

625.101 Grounding

The primary pad base plate shall be of a non-ferrous metal and shall be grounded unless the listed WPTE employs a double-insulation system. The base plate shall be sized to match the size of the primary pad enclosure.

625.102 Installation

(A) Type

The charger power converter, where integral to the primary pad, shall comply with 625.102(C). The charger power converter, if not integral to the primary pad, shall be provided with a minimum Type 3R enclosure rating.

(B) General

If the charger power converter is not integral to the primary pad, it shall be mounted at a height of not less than 450 mm (18 in.) above the floor level for indoor locations or 600 mm (24 in.) above grade level for outdoor locations. The charger power converter shall be mounted in one of the following forms:

Pedestal

Wall or pole

Building or structure

Raised concrete pad

(C) Primary Pad

The primary pad shall be installed on the surface, embedded in the surface of the floor with its top flush with the surface, or embedded in the surface of the floor with its top below the surface. This includes primary pad constructions with the charger power converter located in the primary pad enclosure.

If the primary pad is located in an area requiring snow removal, it shall not be located on or above the surface.

Exception: Where installed on private property where snow removal is done manually, the primary pad shall be permitted to be located on or above the surface.

The enclosure shall be provided with a suitable enclosure rating minimum Type 3. If the primary pad is located in an area subject to severe climatic conditions (e.g., flooding), it shall be suitably rated for those conditions or be provided with a suitably rated enclosure.

(D) Protection of Output Cable

The output cable to the primary pad shall be secured in place over its entire length for the purpose of restricting its movement and to prevent strain at the connection points. If installed in conditions where drive-over could occur, the cable shall be provided with supplemental protection. Where the charger power converter is a part of the primary pad assembly, the power supply cord to the primary pad shall also be protected.

(E) Other Wiring Systems

Other wiring systems and fittings specifically listed for use on the WPTE shall be permitted.

Article 626 Electrified Truck Parking Spaces

Part I General

626.1 Scope

This article covers the electrical conductors and equipment external to the truck or transport refrigerated unit that connect trucks or transport refrigerated units to a supply of electricity, and the installation of equipment and devices related to electrical installations within an electrified truck parking space.

626.2 Definitions

The following definitions shall apply only within this article.

Cable Management System (Electrified Truck Parking Spaces). An apparatus designed to control and organize unused lengths of cable or cord at electrified truck parking spaces.

Cord Connector. A device that, by inserting it into a truck flanged surface inlet, establishes an electrical connection to the truck for the purpose of providing power for the on-board electric loads and may provide a means for information exchange. This device is part of the truck coupler.

Disconnecting Means, Parking Space. The necessary equipment usually consisting of a circuit breaker or switch and fuses, and their accessories, located near the point of entrance of supply conductors in an electrified truck parking space and intended to constitute the means of cutoff for the supply to that truck.

Electrified Truck Parking Space. A truck parking space that has been provided with an electrical system that allows truck operators to connect their vehicles while stopped and to use off-board power sources in order to operate on-board systems such as air conditioning, heating, and appliances, without any engine idling.

Informational Note: An electrified truck parking space also includes dedicated parking areas for heavy-duty trucks at travel plazas, warehouses, shipper and consignee yards, depot facilities, and border crossings. It does not include areas such as the shoulders of highway ramps and access roads, camping and recreational vehicle sites, residential and commercial parking areas used for automotive parking or other areas where ac power is provided solely for the purpose of connecting automotive and other light electrical loads, such as engine block heaters, and at private residences.

Electrified Truck Parking Space Wiring Systems. All of the electrical wiring, equipment, and appurtenances related to electrical installations within an electrified truck parking space, including the electrified parking space supply equipment.

Overhead Gantry. A structure consisting of horizontal framework, supported by vertical columns spanning above electrified truck parking spaces, that supports equipment, appliances, raceway, and other necessary components for the purpose of supplying electrical, HVAC, internet, communications, and other services to the spaces.

Separable Power Supply Cable Assembly. A flexible cord or cable, including ungrounded, grounded, and equipment grounding conductors, provided with a cord connector, an attachment plug, and all other fittings, grommets, or devices installed for the purpose of delivering energy from the source of electrical supply to the truck or TRU flanged surface inlet.

Transport Refrigerated Unit (TRU). A trailer or container, with integrated cooling or heating, or both, used for the purpose of maintaining the desired environment of temperature-sensitive goods or products.

Truck. A motor vehicle designed for the transportation of goods, services, and equipment.

Truck Coupler. A truck flanged surface inlet and mating cord connector.

Truck Flanged Surface Inlet. The device(s) on the truck into which the connector(s) is inserted to provide electric energy and other services. This device is part of the truck coupler. For the purposes of this article, the truck flanged surface inlet is considered to be part of the truck and not part of the electrified truck parking space supply equipment.

626.3 Other Articles

Wherever the requirements of other articles of this Code and Article 626 differ, the requirements of Article 626 shall apply. Unless electrified truck parking space wiring systems are supported or arranged in such a manner that they cannot be used in or above locations classified in 511.3 or 514.3, or both, they shall comply with 626.3(A) and (B) in addition to the requirements of this article.

(A) Vehicle Repair and Storage Facilities

Electrified truck parking space electrical wiring systems located at facilities for the repair or storage of self-propelled vehicles that use volatile flammable liquids or flammable gases for fuel or power shall comply with Article 511.

(B) Motor Fuel Dispensing Stations

Electrified truck parking space electrical wiring systems located at or serving motor fuel dispensing stations shall comply with Article 514.

Informational Note: For additional information, see NFPA 88A-2019. Standard for Parking Structures, and NFPA 30A-2018, Code for Motor Fuel Dispensing Facilities and Repair Garages.

626.4 General Requirements

(A) Not Covered

This article shall not apply to that portion of other equipment in residential, commercial, or industrial facilities that requires electric power used to load and unload cargo, operate conveyors, and for other equipment used on the site or truck.

(B) Distribution System Voltages

Unless other voltages are specified, the nominal ac system voltages of 120, 120/240, 208Y/120, 240, or 480Y/277 shall be used to supply equipment covered by this article.

(C) Connection to Wiring System

This article shall apply to the electrified truck parking space supply equipment intended for connection to a wiring system as defined in 626.4(B).

Part II Electrified Truck Parking Space Electrical Wiring Systems

626.10 Branch Circuits

Electrified truck parking space single-phase branch circuits shall be derived from a 208Y/120-volt, 3-phase, 4-wire system or a 120/240-volt, single-phase, 3-wire system.

Exception: A 120-volt distribution system shall be permitted to supply existing electrified truck parking spaces.

626.11 Feeder and Service Load Calculations

(A) Parking Space Load

The calculated load of a feeder or service shall be not less than the sum of the loads on the branch circuits. Electrical service and feeders shall be calculated on the basis of not less than 11 kVA per electrified truck parking space.

(B) Demand Factors

Electrified truck parking space electrical wiring system demand factors shall be based upon the climatic temperature zone in which the equipment is installed. The demand factors set forth in Table 626.11(B) shall be the minimum allowable demand factors that shall be permitted for calculating load for service and feeders. No demand factor shall be allowed for any other load, except as provided in this article.

Informational Note: The U.S. Department of Agriculture (USDA) has developed a commonly used "Plant Hardiness Zone" map that is publicly available. The map provides guidance for determining the Climatic Temperature Zone. Data indicate that the HVAC has the highest power requirement in cold climates, with the heating demand representing the greatest load, which in turn is dependent on outside temperature. In very warm climates, where no heating load is necessary, the cooling load increases as the outdoor temperature rises. These demand factors do not apply to the portion of electrical wiring systems that supply the transport refrigerated units (TRUs).

Table 626.11(B) Demand Factors for Services and Feeders

Climatic Temperature Zone

(USDA Hardiness Zone)

(See Note) Demand Factor

%

1 70

2a 67

2b 62

3a 59

3b 57

4a 55

4b 51

5a 47

5b 43

6a 39

6b 34

7a 29

7b 24

8a 21

8b 20

9a 20

9b 20

10a 21

10b 23

11 24

Note: The climatic temperature zones shown in Table 626.11(B) correlate with those found on the "USDA Plant Hardiness Zone Map," and the climatic temperature zone selected for use with the table shall be determined through the use of this map based on the installation location.

(C) Two or More Electrified Truck Parking Spaces

Where the electrified truck parking space wiring system is in a location that serves two or more electrified truck parking spaces, the equipment for each space shall comply with 626.11(A), and the calculated load shall be calculated on the basis of each parking space.

(D) Conductor Rating

Truck space branch-circuit supplied loads shall be considered to be continuous.

Part III Electrified Truck Parking Space Supply Equipment

626.22 Wiring Methods and Materials

(A) Electrified Truck Parking Space Supply Equipment Type

The electrified truck parking space supply equipment shall be provided in one of the following forms:

Pedestal

Overhead gantry

Raised concrete pad

(B) Mounting Height

Post, pedestal, and raised concrete pad types of electrified truck parking space supply equipment shall be not less than 600 mm (2 ft) aboveground or above the point identified as the prevailing highest water level mark or an equivalent benchmark based on seasonal or storm-driven flooding from the authority having jurisdiction.

(C) Access to Working Space

All electrified truck parking space supply equipment shall be accessible by an unobstructed entrance or passageway not less than 600 mm (2 ft) wide and not less than 2.0 m (6 ft 6 in.) high.

(D) Disconnecting Means

A disconnecting switch or circuit breaker shall be provided to disconnect one or more electrified truck parking space supply equipment sites from a remote location. The disconnecting means shall be provided and installed in a readily accessible location and shall be lockable open in accordance with 110.25.

626.23 Overhead Gantry or Cable Management System

(A) Cable Management

Electrified truck parking space equipment provided from either overhead gantry or cable management systems shall utilize a permanently attached power supply cable in electrified truck parking space supply equipment. Other cable types and assemblies listed as being suitable for the purpose, including optional hybrid communications, signal, and composite optical fiber cables, shall be permitted.

(B) Strain Relief

Means to prevent strain from being transmitted to the wiring terminals shall be provided. Permanently attached power supply cable(s) shall be provided with a means to de-energize the cable conductors and power service delivery device upon exposure to strain that could result in either cable damage or separation from the power service delivery device and exposure of live parts.

626.24 Electrified Truck Parking Space Supply Equipment Connection Means

(A) General

Each truck shall be supplied from electrified truck parking space supply equipment through suitable extrahard service cables or cords. Each connection to the equipment shall be by a single separable power supply cable assembly.

(B) Receptacle

All receptacles shall be listed and of the grounding type. Every truck parking space with electrical supply shall be equipped with 626.24(B)(1) and (B)(2).

A maximum of three receptacles, each 2-pole, 3-wire grounding type and rated 20 amperes, 125 volts, and two of the three connected to two separate branch circuits.

Informational Note: For the non-locking-type and grounding-type 20-ampere receptacle configuration, see ANSI/NEMA WD 6-2016, Wiring Devices — Dimensional Specifications, Figure 5-20.

One single receptacle, 3-pole, 4-wire grounding type, single phase rated either 30 amperes 208Y/120 volts or 125/250 volts. The 125/250-volt receptacle shall be permitted to be used on a 208Y/120-volt, single-phase circuit.

Informational Note: For various configurations of 30-ampere pin and sleeve receptacles, see ANSI/UL 1686-2012, Standard for Pin and Sleeve Configurations, Figure C2.9 or Part C3.

Exception: Where electrified truck parking space supply equipment provides the heating, air-conditioning, and comfort-cooling function without requiring a direct electrical connection at the truck, only two receptacles identified in 626.24(B)(1) shall be required.

(C) Disconnecting Means, Parking Space

The electrified truck parking space supply equipment shall be provided with a switch or circuit breaker for disconnecting the power supply to the electrified truck parking space. A disconnecting means shall be provided and installed in a readily accessible location and shall be lockable open in accordance with 110.25.

(D) Ground-Fault Circuit-Interrupter Protection for Personnel

In addition to the requirements in 210.8, the electrified truck parking space equipment shall be designed and constructed such that all receptacle outlets in 626.24 are provided with ground-fault circuit-interrupter protection for personnel.

626.25 Separable Power-Supply Cable Assembly

A separable power-supply cable assembly, consisting of a power-supply cord, a cord connector, and an attachment plug intended for connection with a truck flanged surface inlet, shall be of a listed type. The power-supply cable assembly or assemblies shall be identified and be one of the types and ratings specified in 626.25(A) and (B). Cords with adapters and pigtail ends, extension cords, and similar items shall not be used.

(A) Rating(s)

(1) Twenty-Ampere Power-Supply Cable Assembly

Equipment with a 20-ampere, 125-volt receptacle, in accordance with 626.24(B)(1), shall use a listed 20-ampere power-supply cable assembly.

Exception: It shall be permitted to use a listed separable power-supply cable assembly, either hard service or extra-hard service and rated 15 amperes, 125 volts, for connection to an engine block heater for legacy vehicles.

(2) Thirty-Ampere Power-Supply Cable Assembly

Equipment with a 30-ampere, 208Y/120-volt or 125/250-volt receptacle, in accordance with 626.24(B)(2), shall use a listed 30-ampere main power-supply cable assembly.

(B) Power-Supply Cord

(1) Conductors

The cord shall be a listed type with three or four conductors, for single-phase connection, one conductor of which shall be identified in accordance with 400.23.

Exception: It shall be permitted to use a separate listed three-conductor separable power-supply cable assembly, one conductor of which shall be identified in accordance with 400.23 and rated 15 amperes, 125 volts for connection to an engine block heater for existing vehicles.

(2) Cord

Extra-hard usage flexible cords and cables rated not less than 90°C (194°F), 600 volts; listed for both wet locations and sunlight resistance; and having an outer jacket rated to be resistant to temperature extremes, oil, gasoline, ozone, abrasion, acids, and chemicals shall be permitted where flexibility is necessary between the electrified truck parking space supply equipment, the panel board, and flanged surface inlet(s) on the truck.

Exception: Cords for the separable power supply cable assembly for 15- and 20-ampere connections shall be permitted to be a hard service type.

(3) Cord Overall Length

The exposed cord length shall be measured from the face of the attachment plug to the point of entrance to the truck or the face of the flanged surface inlet or to the point where the cord enters the truck. The overall length of the cable shall not exceed 7.5 m (25 ft) unless equipped with a cable management system that is listed as suitable for the purpose.

(4) Attachment Plug

The attachment plug(s) shall be listed, by itself or as part of a cord set, for the purpose and shall be molded to or installed on the flexible cord so that it is secured tightly to the cord at the point where the cord enters the attachment plug. If a right-angle cap is used, the configuration shall be oriented so that the grounding member is farthest from the cord. Where a flexible cord is provided, the attachment plug shall comply with 250.138(A).

(a) Connection to 20-Ampere Receptacle. A separable power-supply cable assembly for connection to a truck flanged surface inlet, rated at 20 amperes, shall have a non-locking-type attachment plug that shall be 2-pole, 3-wire grounding type rated 20 amperes, 125 volts and intended for use with the 20-ampere, 125-volt receptacle.

Exception: A separable power-supply cable assembly, provided for the connection of only an engine block heater, shall have an attachment plug of the 2-pole, 3-wire grounding type, rated 15 amperes, 125 volts.

Informational Note: For non-locking-and grounding-type 15- or 20-ampere plug and receptacle configurations, see ANSI/NEMA WD 6-2016, Wiring Devices — Dimensional Specifications, Figure 5-15 or Figure 5-20.

(b) Connection to 30-Ampere Receptacle. A separable power-supply cable assembly for connection to a truck flanged surface inlet, rated at 30 amperes, shall have an attachment plug that shall be 3-pole, 4-wire grounding type rated 30 amperes, 208Y/120 volts or 125/250 volts, and intended for use with the receptacle in accordance with 626.24(B)(2). The 125/250-volt attachment plug shall be permitted to be used on a 208Y/120-volt, single-phase circuit.

Informational Note: For various configurations of 30-ampere pin and sleeve plugs, see ANSI/UL 1686-2012, Standard for Pin and Sleeve Configurations, Figure C2.10 or Part C3.

(5) Cord Connector

The cord connector for a separable power-supply cable assembly, as specified in 626.25(A)(1), shall be a 2-pole, 3-wire grounding type rated 20 amperes, 125 volts. The cord connector for a separable power-supply cable assembly, as specified in 626.25(A)(2), shall be a 3-pole, 4-wire grounding type rated 30 amperes, 208Y/120 volts or 125/250 volts. The 125/250-volt cord connector shall be permitted to be used on a 208Y/120-volt, single-phase circuit.

Exception: The cord connector for a separable power supply cable assembly, rated 15 amperes, provided for the connection of an engine block heater for existing vehicles, shall have an attachment plug that shall be 2-pole, 3-wire grounding type rated 15 amperes, 125 volts.

Informational Note: For various configurations of 30-ampere cord connectors, see ANSI/UL 1686-2012, Standard for Pin and Sleeve Configurations, Figure C2.9 or Part C3.

626.26 Loss of Primary Power

Means shall be provided such that, upon loss of voltage from the utility or other electric supply system(s), energy cannot be back-fed through the truck and the truck supply equipment to the electrified truck parking space wiring system unless permitted by 626.27.

626.27 Interactive Systems

Electrified truck parking space supply equipment and other parts of a system, either on-board or off-board the vehicle, that are identified for and intended to be interconnected to a vehicle and also serve as an optional standby system or an electric power production source or provide for bi-directional power feed shall be listed as suitable for that purpose. When used as an optional standby system, the requirements of Article 702 shall apply, and when used as an electric power production source, the requirements of Article 705 shall apply.

Part IV Transport Refrigerated Units (TRUs)

626.30 Transport Refrigerated Units

Electrified truck parking spaces intended to supply transport refrigerated units (TRUs) shall include an individual branch circuit and receptacle for operation of the refrigeration/heating units. The receptacle associated with the TRUs shall be provided in addition to the receptacles required in 626.24(B).

(A) Branch Circuits

TRU spaces shall be supplied from 208-volt, 3-phase, 240-volt, 3-phase, or 480-volt, 3-phase branch circuits and with an equipment grounding conductor.

(B) Electrified Truck Parking Space Supply Equipment

The electrified truck parking space supply equipment, or portion thereof, providing electric power for the operation of TRUs shall be independent of the loads in Part III of Article 626.

626.31 Disconnecting Means and Receptacles

(A) Disconnecting Means

Disconnecting means shall be provided to isolate each refrigerated unit from its supply connection. A disconnecting means shall be provided and installed in a readily accessible location and shall be lockable open in accordance with 110.25.

(B) Location

The disconnecting means shall be readily accessible, located not more than 750 mm (30 in.) from the receptacle it controls, and located in the supply circuit ahead of the receptacle. Circuit breakers or switches located in power outlets complying with this section shall be permitted as the disconnecting means.

(C) Receptacles

All receptacles shall be listed and of the grounding type. Every electrified truck parking space intended to provide an electrical supply for TRUs shall be equipped with one or more of the following:

A 30-ampere, 480-volt, 3-phase, 3-pole, 4-wire receptacle

A 60-ampere, 208-volt, 3-phase, 3-pole, 4-wire receptacle

A 20-ampere, 1000-volt, 3-phase, 3-pole, 4-wire receptacle, pin and sleeve type

A 60-ampere, 250-volt, 3-phase, 3-pole, 4-wire receptacle

A 60-ampere, 480-volt, 3-phase, 3-pole, 4-wire receptacle

Informational Note: Complete details of the 30-ampere pin and sleeve receptacle configuration for refrigerated containers (TRUs) can be found in ANSI/UL 1686-2012, Standard for Pin and Sleeve Configurations, Figure C2.11. For various configurations of 60-ampere pin and sleeve receptacles, see ANSI/UL 1686.

626.32 Separable Power Supply Cable Assembly

A separable power supply cable assembly, consisting of a cord with an attachment plug and cord connector, shall be one of the types and ratings specified in 626.32(A), (B), and (C). Cords with adapters and pigtail ends, extension cords, and similar items shall not be used.

(A) Rating(s)

The power supply cable assembly shall be listed and rated in accordance with one of the following:

A 30-ampere, 480-volt, 3-phase assembly

A 60-ampere, 208-volt, 3-phase assembly

A 20-ampere, 1000-volt, 3-phase assembly

A 60-ampere, 480-volt, 3-phase assembly

A 60-ampere, 250-volt, 3-phase assembly

(B) Cord Assemblies

The cord shall be a listed type with four conductors, for 3-phase connection, one of which shall be identified in accordance with 400.23 for use as the equipment grounding conductor. Extra-hard usage cables rated not less than 90°C (194°F), 600 volts, listed for both wet locations and sunlight resistance, and having an outer jacket rated to be resistant to temperature extremes, oil, gasoline, ozone, abrasion, acids, and chemicals, shall be permitted where flexibility is necessary between the electrified truck parking space supply equipment and the inlet(s) on the TRU.

(C) Attachment Plug(s) and Cord Connector(s)

Where a flexible cord is provided with an attachment plug and cord connector, they shall comply with 250.138(A). The attachment plug(s) and cord connector(s) shall be listed, by itself or as part of the power-supply cable assembly, for the purpose and shall be molded to or installed on the flexible cord so that it is secured tightly to the cord at the point where the cord enters the attachment plug or cord connector. If a right-angle cap is used, the configuration shall be oriented so that the grounding member is farthest from the cord. An attachment plug and cord connector for the connection of a truck or trailer shall be rated in accordance with one of the following:

30-ampere, 480-volt, 3-phase, 3-pole, 4-wire and intended for use with 30-ampere, 480-volt, 3-phase, 3-pole, 4-wire receptacles and inlets, respectively

60-ampere, 208-volt, 3-phase, 3-pole, 4-wire and intended for use with 60-ampere, 208-volt, 3-phase, 3-pole, 4-wire receptacles and inlets, respectively

20-ampere, 1000-volt, 3-phase, 3-pole, 4-wire and intended for use with 20-ampere, 1000-volt, 3-phase, 3-pole, 4-wire receptacles and inlets, respectively

60-ampere, 480-volt, 3-phase, 3-pole, 4-wire and intended for use with 60-ampere, 480-volt, 3-phase, 3-pole, 4-wire receptacles and inlets, respectively

60-ampere, 250-volt, 3-phase, 3-pole, 4-wire and intended for use with 60-ampere, 250-volt, 3-phase, 3-pole, 4-wire receptacles and inlets, respectively

Informational Note: Complete details of the 30-ampere pin and sleeve attachment plug and cord connector configurations for refrigerated containers (TRUs) can be found in ANSI/UL 1686-2012, Standard for Pin and Sleeve Configurations, Figures C2.12 and C2.11. For various configurations of 60-ampere pin and sleeve attachment plugs and cord connectors, see ANSI/UL 1686.

Article 630 Electric Welders

Part I General

630.1 Scope

This article covers apparatus for electric arc welding, resistance welding, plasma cutting, and other similar welding and cutting process equipment that is connected to an electrical supply system.

630.6 Listing

All welding and cutting power equipment under the scope of this article shall be listed.

Part II Arc Welders

630.11 Ampacity of Supply Conductors

The ampacity of conductors for arc welders shall be in accordance with 630.11(A) and (B).

(A) Individual Welders

The ampacity of the supply conductors shall be not less than the I1eff value on the rating plate. Alternatively, if the I1eff is not given, the ampacity of the supply conductors shall not be less than the current value determined by multiplying the rated primary current in amperes given on the welder rating plate by the factor shown in Table 630.11(A) based on the duty cycle of the welder.

Table 630.11(A) Duty Cycle Multiplication Factors for Arc Welders

Duty Cycle Multiplier for Arc Welders

Nonmotor

Generator Motor

Generator

100 1.00 1.00

90 0.95 0.96

80 0.89 0.91

70 0.84 0.86

60 0.78 0.81

50 0.71 0.75

40 0.63 0.69

30 0.55 0.62

20 or less 0.45 0.55

(B) Group of Welders

Minimum conductor ampacity shall be based on the individual currents determined in 630.11(A) as the sum of 100 percent of the two largest welders, plus 85 percent of the third largest welder, plus 70 percent of the fourth largest welder, plus 60 percent of all remaining welders.

Exception: Percentage values lower than those given in 630.11(B) shall be permitted in cases where the work is such that a high-operating duty cycle for individual welders is impossible.

Informational Note: Duty cycle considers welder loading based on the use to be made of each welder and the number of welders supplied by the conductors that will be in use at the same time. The load value used for each welder considers both the magnitude and the duration of the load while the welder is in use.

630.12 Overcurrent Protection

Overcurrent protection for arc welders shall be as provided in 630.12(A) and (B). Where the values as determined by this section do not correspond to the standard ampere ratings provided in 240.6 or where the rating or setting specified results in unnecessary opening of the overcurrent device, the next higher standard rating or setting shall be permitted.

(A) For Welders

Each welder shall have overcurrent protection rated or set at not more than 200 percent of I1max. Alternatively, if the I1max is not given, the overcurrent protection shall be rated or set at not more than 200 percent of the rated primary current of the welder.

An overcurrent device shall not be required for a welder that has supply conductors protected by an overcurrent device rated or set at not more than 200 percent of I1max or at the rated primary current of the welder.

If the supply conductors for a welder are protected by an overcurrent device rated or set at not more than 200 percent of I1max or at the rated primary current of the welder, a separate overcurrent device shall not be required.

(B) For Conductors

Conductors that supply one or more welders shall be protected by an overcurrent device rated or set at not more than 200 percent of the conductor ampacity.

Informational Note: I1max is the maximum value of the rated supply current at maximum rated output. I1eff is the maximum value of the effective supply current, calculated from the rated supply current (I1), the corresponding duty cycle (duty factor) (X), and the supply current at no-load (I0) by the following equation:

630.13 Disconnecting Means

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 identity shall be marked in accordance with 110.22(A).

The disconnecting means shall be a switch or circuit breaker, and its rating shall be not less than that necessary to accommodate overcurrent protection as specified under 630.12.

630.14 Marking

A rating plate shall be provided for arc welders giving the following information:

Name of manufacturer

Frequency

Number of phases

Primary voltage

I1max and I1eff, or rated primary current

Maximum open-circuit voltage

Rated secondary current

Basis of rating, such as the duty cycle

630.15 Grounding of Welder Secondary Circuit

The secondary circuit conductors of an arc welder, consisting of the electrode conductor and the work conductor, shall not be considered as premises wiring for the purpose of applying Article 250.

Informational Note: Connecting welder secondary circuits to grounded objects can create parallel paths and can cause objectionable current over equipment grounding conductors.

Part III Resistance Welders

630.31 Ampacity of Supply Conductors

The ampacity of the supply conductors for resistance welders shall be in accordance with 630.31(A) and (B).

Informational Note: The ampacity of the supply conductors for resistance welders necessary to limit the voltage drop to a value permissible for the satisfactory performance of the welder is usually greater than that required to prevent overheating.

(A) Individual Welders

The ampacity of conductors for individual welders shall comply with the following:

The ampacity of the supply conductors for a welder that can be operated at different times at different values of primary current or duty cycle shall not be less than 70 percent of the rated primary current for seam and automatically fed welders, and 50 percent of the rated primary current for manually operated nonautomatic welders.

The ampacity of the supply conductors for a welder wired for a specific operation for which the actual primary current and duty cycle are known and remain unchanged shall not be less than the product of the actual primary current and the multiplier specified in Table 630.31(A) for the duty cycle at which the welder will be operated.

Table 630.31(A) Duty Cycle Multiplication Factors for Resistance Welders

Duty Cycle

(%) Multiplier

50 0.71

40 0.63

30 0.55

25 0.50

20 0.45

15 0.39

10 0.32

7.5 0.27

5 or less 0.22

(B) Groups of Welders

The ampacity of conductors that supply two or more welders shall not be less than the sum of the value obtained in accordance with 630.31(A) for the largest welder supplied and 60 percent of the values obtained for all the other welders supplied.

Informational Note: Explanation of Terms

The rated primary current is the rated kilovolt-amperes (kVA) multiplied by 1000 and divided by the rated primary voltage, using values given on the nameplate.

The actual primary current is the current drawn from the supply circuit during each welder operation at the particular heat tap and control setting used.

The duty cycle is the percentage of the time during which the welder is loaded. For instance, a spot welder supplied by a 60-Hz system (216,000 cycles per hour) and making 400 15-cycle welds per hour would have a duty cycle of 2.8 percent (400 multiplied by 15, divided by 216,000, multiplied by 100). A seam welder operating 2 cycles "on" and 2 cycles "off" would have a duty cycle of 50 percent.

630.32 Overcurrent Protection

Overcurrent protection for resistance welders shall be as provided in 630.32(A) and (B). Where the values as determined by this section do not correspond with the standard ampere ratings provided in 240.6 or where the rating or setting specified results in unnecessary opening of the overcurrent device, a higher rating or setting that does not exceed the next higher standard ampere rating shall be permitted.

(A) For Welders

Each welder shall have an overcurrent device rated or set at not more than 300 percent of the rated primary current of the welder.If the supply conductors for a welder are protected by an overcurrent device rated or set at not more than 200 percent of the rated primary current of the welder, a separate overcurrent device shall not be required.

(B) For Conductors

Conductors that supply one or more welders shall be protected by an overcurrent device rated or set at not more than 300 percent of the conductor ampacity.

630.33 Disconnecting Means

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 determined in accordance with 630.31. The supply circuit switch shall be permitted as the welder disconnecting means where the circuit supplies only one welder.

630.34 Marking

A nameplate shall be provided for each resistance welder, giving the following information:

Name of manufacturer

Frequency

Primary voltage

Rated kilovolt-amperes (kVA) at 50 percent duty cycle

Maximum and minimum open-circuit secondary voltage

Short-circuit secondary current at maximum secondary voltage

Specified throat and gap setting

Part IV Welding Cable

630.41 Conductors

Insulation of conductors intended for use in the secondary circuit of electric welders shall be flame retardant.

630.42 Installation

Cables shall be permitted to be installed in a dedicated cable tray as provided in 630.42(A), (B), and (C).

(A) Cable Support

The cable tray shall provide support at not greater than 150-mm (6-in.) intervals.

(B) Spread of Fire and Products of Combustion

The installation shall comply with 300.21.

(C) Signs

A permanent sign shall be attached to the cable tray at intervals not greater than 6.0 m (20 ft). The sign shall read as follows:

CABLE TRAY FOR WELDING CABLES ONLY

Article 640 Audio Signal Processing, Amplification, and Reproduction Equipment

Part I General

640.1 Scope

(A) Covered

This article covers equipment and wiring for audio signal generation, recording, processing, amplification, and reproduction; distribution of sound; public address; speech input systems; temporary audio system installations; and electronic organs or other electronic musical instruments. This also includes audio systems subject to Article 517, Part VI, and Articles 518, 520, 525, and 530.

Informational Note: Examples of permanently installed distributed audio system locations include, but are not limited to, restaurant, hotel, business office, commercial and retail sales environments, churches, and schools. Both portable and permanently installed equipment locations include, but are not limited to, residences, auditoriums, theaters, stadiums, and movie and television studios. Temporary installations include, but are not limited to, auditoriums, theaters, stadiums (which use both temporary and permanently installed systems), and outdoor events such as fairs, festivals, circuses, public events, and concerts.

(B) Not Covered

This article does not cover the installation and wiring of fire and burglary alarm signaling devices.

640.2 Definitions

The following definitions shall apply only within this article.

Abandoned Audio Distribution Cable. Installed audio distribution cable that is not terminated at equipment and not identified for future use with a tag.

Audio Amplifier or Pre-Amplifier. Electronic equipment that increases the current or voltage, or both, of an audio signal intended for use by another piece of audio equipment. Amplifier is the term used within this article to denote an audio amplifier.

Audio Autotransformer. A transformer with a single winding and multiple taps intended for use with an amplifier loudspeaker signal output.

Audio Signal Processing Equipment. Electrically operated equipment that produces, processes, or both, electronic signals that, when appropriately amplified and reproduced by a loudspeaker, produce an acoustic signal within the range of normal human hearing (typically 20—20 kHz). Within this article, the terms equipment and audio equipment are assumed to be equivalent to audio signal processing equipment.

Informational Note: This equipment includes, but is not limited to, loudspeakers; headphones; pre-amplifiers; microphones and their power supplies; mixers; MIDI (musical instrument digital interface) equipment or other digital control systems; equalizers, compressors, and other audio signal processing equipment; and audio media recording and playback equipment, including turntables, tape decks and disk players (audio and multimedia), synthesizers, tone generators, and electronic organs. Electronic organs and synthesizers may have integral or separate amplification and loudspeakers. With the exception of amplifier outputs, virtually all such equipment is used to process signals (utilizing analog or digital techniques) that have nonhazardous levels of voltage or current.

Audio System. Within this article, the totality of all equipment and interconnecting wiring used to fabricate a fully functional audio signal processing, amplification, and reproduction system.

Audio Transformer. A transformer with two or more electrically isolated windings and multiple taps intended for use with an amplifier loudspeaker signal output.

Equipment Rack. A framework for the support, enclosure, or both, of equipment; can be portable or stationary.

Informational Note: See EIA/ECA 310-E-2005, Cabinets, Racks, Panels and Associated Equipment.

Loudspeaker. Equipment that converts an ac electric signal into an acoustic signal. The term speaker is commonly used to mean loudspeaker.

Maximum Output Power. The maximum power delivered by an amplifier into its rated load as determined under specified test conditions.

Informational Note: The maximum output power can exceed the manufacturer's rated output power for the same amplifier.

Mixer. Equipment used to combine and level match a multiplicity of electronic signals, such as from microphones, electronic instruments, and recorded audio.

Portable Equipment. Equipment fed with portable cords or cables intended to be moved from one place to another.

Rated Output Power. The amplifier manufacturer's stated or marked output power capability into its rated load.

Technical Power System. An electrical distribution system where the equipment grounding conductor is isolated from the premises grounded conductor and the premises equipment grounding conductor except at a single grounded termination point within a branch-circuit panelboard, at the originating (main breaker) branch-circuit panelboard, or at the premises grounding electrode.

Temporary Equipment. Portable wiring and equipment intended for use with events of a transient or temporary nature where all equipment is presumed to be removed at the conclusion of the event.

640.3 Locations and Other Articles

Circuits and equipment shall comply with 640.3(A) through (M), as applicable.

(A) Spread of Fire or Products of Combustion

Section 300.21 shall apply.

(B) Ducts, Plenums, and Other Air-Handling Spaces

Section 300.22(B) shall apply to circuits and equipment installed in ducts specifically fabricated for environmental air. Section 300.22(C) shall apply to circuits and equipment installed in other spaces used for environmental air (plenums).

Exception No. 1: Class 2 and Class 3 cables installed in accordance with 725.135(B) and Table 725.154 shall be permitted to be installed in ducts specifically fabricated for environmental air.

Exception No. 2: Class 2 and Class 3 cables installed in accordance with 725.135(C) and Table 725.154 shall be permitted to be installed in other spaces used for environmental air (plenums).

Informational Note: NFPA 90A-2018, Standard for the Installation of Air-Conditioning and Ventilating Systems, 4.3.11.2.6.5, permits loudspeakers, loudspeaker assemblies, and their accessories listed in accordance with UL 2043-2013, Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces, to be installed in other spaces used for environmental air (ceiling cavity plenums).

(C) Cable Trays

Cable trays and cable tray systems shall be installed in accordance with Article 392.

Informational Note: See 725.135(H), 725.136(G), and Table 725.154 for the use of Class 2, Class 3, and Type PLTC cable in cable trays.

(D) Hazardous (Classified) Locations

Equipment used in hazardous (classified) locations shall comply with the applicable requirements of Chapter 5.

(E) Assembly Occupancies

Equipment used in assembly occupancies shall comply with Article 518.

(F) Theaters, Audience Areas of Motion Picture and Television Studios, and Similar Locations

Equipment used in theaters, audience areas of motion picture and television studios, and similar locations shall comply with Article 520.

(G) Carnivals, Circuses, Fairs, and Similar Events

Equipment used in carnivals, circuses, fairs, and similar events shall comply with Article 525.

(H) Motion Picture and Television Studios

Equipment used in motion picture and television studios shall comply with Article 530.

(I) Swimming Pools, Fountains, and Similar Locations

Audio equipment used in or near swimming pools, fountains, and similar locations shall comply with Article 680.

(J) Combination Systems

Where the authority having jurisdiction permits audio systems for paging or music, or both, to be combined with fire alarm systems, the wiring shall comply with Article 760.

Informational Note: For installation requirements for such combination systems, refer to NFPA 72-2016, National Fire Alarm and Signaling Code, and NFPA 101-2018, Life Safety Code.

(K) Antennas

Equipment used in audio systems that contain an audio or video tuner and an antenna input shall comply with Article 810. Wiring other than antenna wiring that connects such equipment to other audio equipment shall comply with this article.

(L) Generators

Generators shall be installed in accordance with 445.10 through 445.12, 445.14 through 445.16, and 445.18. Grounding of portable and vehicle-mounted generators shall be in accordance with 250.34.

(M) Organ Pipes

Additions of pipe organ pipes to an electronic organ shall be in accordance with 650.4 through 650.9.

640.4 Protection of Electrical Equipment

Amplifiers, loudspeakers, and other equipment shall be so located or protected as to guard against environmental exposure or physical damage, such as might result in fire, shock, or personal hazard.

640.5 Access to Electrical Equipment Behind Panels Designed to Allow Access

Access to equipment shall not be denied by an accumulation of wires and cables that prevents removal of panels, including suspended ceiling panels.

640.6 Mechanical Execution of Work

(A) Installation of Audio Distribution Cables

Cables installed exposed on the surface of ceilings and sidewalls shall be supported in such a manner that the audio distribution cables will not be damaged by normal building use. Such cables shall be secured by straps, staples, cable ties, hangers, or similar fittings designed and installed so as not to damage the cable. The installation shall conform to 300.4 and 300.11(A).

(B) Abandoned Audio Distribution Cables

The accessible portion of abandoned audio distribution cables shall be removed.

(C) Installed Audio Distribution Cable Identified for Future Use

(1)

Cables identified for future use shall be marked with a tag of sufficient durability to withstand the environment involved.

(2)

Cable tags shall have the following information:

Date cable was identified for future use

Date of intended use

Information related to the intended future use of cable

640.7 Grounding

(A) General

Wireways and auxiliary gutters shall be connected to an equipment grounding conductor(s), to an equipment bonding jumper, or to the grounded conductor where permitted or required by 250.92(B)(1) or 250.142. Where the wireway or auxiliary gutter does not contain power-supply wires, the equipment grounding conductor shall not be required to be larger than 14 AWG copper or its equivalent. Where the wireway or auxiliary gutter contains power-supply wires, the equipment grounding conductor shall not be smaller than specified in 250.122.

(B) Separately Derived Systems With 60 Volts to Ground

Grounding of separately derived systems with 60 volts to ground shall be in accordance with 647.6.

(C) Isolated Ground Receptacles

Isolated grounding-type receptacles shall be permitted as described in 250.146(D), and for the implementation of other technical power systems in compliance with Article 250. For separately derived systems with 60 volts to ground, the branch-circuit equipment grounding conductor shall be terminated as required in 647.6(B).

Informational Note: See 406.3(D) for grounding-type receptacles and required identification.

640.8 Grouping of Conductors

Insulated conductors of different systems grouped or bundled so as to be in close physical contact with each other in the same raceway or other enclosure, or in portable cords or cables, shall comply with 300.3(C)(1).

640.9 Wiring Methods

(A) Wiring to and Between Audio Equipment

(1) Power Wiring

Wiring and equipment from source of power to and between devices connected to the premises wiring systems shall comply with the requirements of Chapters 1 through 4, except as modified by this article.

(2) Separately Derived Power Systems

Separately derived systems shall comply with the applicable articles of this Code, except as modified by this article. Separately derived systems with 60 volts to ground shall be permitted for use in audio system installations as specified in Article 647.

(3) Other Wiring

All wiring not connected to the premises wiring system or to a wiring system separately derived from the premises wiring system shall comply with Article 725.

(B) Auxiliary Power Supply Wiring

Equipment that has a separate input for an auxiliary power supply shall be wired in compliance with Article 725. Battery installation shall be in accordance with Article 480. This section shall not apply to the use of uninterruptible power supply (UPS) equipment, or other sources of supply, that are intended to act as a direct replacement for the primary circuit power source and are connected to the primary circuit input.

Informational Note: Refer to NFPA 72-2019, National Fire Alarm and Signaling Code, where equipment is used for a fire alarm system.

(C) Output Wiring and Listing of Amplifiers

Amplifiers with output circuits carrying audio program signals shall be permitted to employ Class 1, Class 2, or Class 3 wiring where the amplifier is listed and marked for use with the specific class of wiring method. Such listing shall ensure the energy output is equivalent to the shock and fire risk of the same class as stated in Article 725. Overcurrent protection shall be provided and shall be permitted to be inherent in the amplifier.

Audio amplifier output circuits wired using Class 1 wiring methods shall be considered equivalent to Class 1 circuits and shall be installed in accordance with 725.46, where applicable.

Audio amplifier output circuits wired using Class 2 or Class 3 wiring methods shall be considered equivalent to Class 2 or Class 3 circuits, respectively. They shall use conductors insulated at not less than the requirements of 725.179 and shall be installed in accordance with 725.133 and 725.154.

Informational Note No. 1: ANSI/UL 1711-2016, Amplifiers for Fire Protective Signaling Systems, contains requirements for the listing of amplifiers used for fire alarm systems in compliance with NFPA 72-2019, National Fire Alarm and Signaling Code.

Informational Note No. 2: Examples of requirements for listing amplifiers used in residential, commercial, and professional use are found in ANSI/UL 813-1996, Commercial Audio Equipment; ANSI/UL 1419-2016, Professional Video and Audio Equipment; ANSI/UL 1492-1996 revised 2013, Audio-Video Products and Accessories; ANSI/UL 6500-1999 revised 2013, Audio/Video and Musical Instrument Apparatus for Household, Commercial, and Similar Use; and UL 62368-1-2014, Audio/Video, Information and Communication Technology Equipment — Part 1: Safety Requirements.

(D) Use of Audio Transformers and Autotransformers

Audio transformers and autotransformers shall be used only for audio signals in a manner so as not to exceed the manufacturer's stated input or output voltage, impedance, or power limitations. The input or output wires of an audio transformer or autotransformer shall be allowed to connect directly to the amplifier or loudspeaker terminals. No electrical terminal or lead shall be required to be grounded or bonded.

640.10 Audio Systems Near Bodies of Water

Audio systems near bodies of water, either natural or artificial, shall be subject to the restrictions specified in 640.10(A) and (B).

Exception: This section does not include audio systems intended for use on boats, yachts, or other forms of land or water transportation used near bodies of water, whether or not supplied by branch-circuit power.

Informational Note: See 680.27(A) for installation of underwater audio equipment.

(A) Equipment Supplied by Branch-Circuit Power

Audio system equipment supplied by branch-circuit power shall not be placed horizontally within 1.5 m (5 ft) of the inside wall of a pool, spa, hot tub, or fountain, or within 1.5 m (5 ft) of the prevailing or tidal high water mark. In addition to the requirements in 210.8(B), the equipment shall be provided with branch-circuit power protected by a ground-fault circuit interrupter where required by other articles.

(B) Equipment Not Supplied by Branch-Circuit Power

Audio system equipment powered by a listed Class 2 power supply or by the output of an amplifier listed as permitting the use of Class 2 wiring shall be restricted in placement only by the manufacturer's recommendations.

Informational Note: See 640.10(A) for placement of the power supply or amplifier if supplied by branch-circuit power.

Part II Permanent Audio System Installations

640.21 Use of Flexible Cords and Cables

(A) Between Equipment and Branch-Circuit Power

Power supply cords for audio equipment shall be suitable for the use and shall be permitted to be used where the interchange, maintenance, or repair of such equipment is facilitated through the use of a power-supply cord.

(B) Between Loudspeakers and Amplifiers or Between Loudspeakers

Cables used to connect loudspeakers to each other or to an amplifier shall comply with Article 725. Other listed cable types and assemblies, including optional hybrid communications, signal, and composite optical fiber cables, shall be permitted.

(C) Between Equipment

Cables used for the distribution of audio signals between equipment shall comply with Article 725. Other listed cable types and assemblies, including optional hybrid communications, signal, and composite optical fiber cables, shall be permitted. Other cable types and assemblies specified by the equipment manufacturer as acceptable for the use shall be permitted in accordance with 110.3(B).

Informational Note: See 770.3 for the classification of composite optical fiber cables.

(D) Between Equipment and Power Supplies Other Than Branch-Circuit Power

The following power supplies, other than branch-circuit power supplies, shall be installed and wired between equipment in accordance with the requirements of this Code for the voltage and power delivered:

Storage batteries

Transformers

Transformer rectifiers

Other ac or dc power supplies

Informational Note: For some equipment, these sources such as in items (1) and (2) serve as the only source of power. These could, in turn, be supplied with intermittent or continuous branch-circuit power.

(E) Between Equipment Racks and Premises Wiring System

Flexible cords and cables shall be permitted for the electrical connection of permanently installed equipment racks to the premises wiring system to facilitate access to equipment or for the purpose of isolating the technical power system of the rack from the premises ground. Connection shall be made either by using approved plugs and receptacles or by direct connection within an approved enclosure. Flexible cords and cables shall not be subjected to physical manipulation or abuse while the rack is in use.

640.22 Wiring of Equipment Racks and Enclosures

Metal equipment racks and enclosures shall be bonded and grounded. Bonding shall not be required if the rack is connected to a technical power ground.

Wires, cables, structural components, or other equipment shall not be placed in such a manner as to prevent reasonable access to equipment power switches and resettable or replaceable circuit overcurrent protection devices.

Supply cords or cables, if used, shall terminate within the equipment rack enclosure in an identified connector assembly. The supply cords or cable (and connector assembly if used) shall have sufficient ampacity to carry the total load connected to the equipment rack and shall be protected by overcurrent devices.

640.23 Conduit or Tubing

(A) Number of Conductors

The number of conductors permitted in a single conduit or tubing shall not exceed the percentage fill specified in Table 1, Chapter 9.

(B) Nonmetallic Conduit or Tubing and Insulating Bushings

The use of nonmetallic conduit or tubing and insulating bushings shall be permitted where a technical power system is employed and shall comply with applicable articles.

640.24 Wireways, Gutters, and Auxiliary Gutters

The use of metallic and nonmetallic wireways, gutters, and auxiliary gutters shall be permitted for use with audio signal conductors and shall comply with applicable articles with respect to permitted locations, construction, and fill.

640.25 Loudspeaker Installation in Fire Resistance-Rated Partitions, Walls, and Ceilings

Loudspeakers installed in a fire resistance-rated partition, wall, or ceiling shall be listed and labeled, or identified as speaker assemblies for fire resistance, or installed in an enclosure or recess that maintains the fire resistance rating.

Informational Note: Fire-rated construction is the fire-resistive classification used in building codes.

Part III Portable and Temporary Audio System Installations

640.41 Multipole Branch-Circuit Cable Connectors

Multipole branch-circuit cable connectors, male and female, for power-supply cords and cables shall be so constructed that tension on the cord or cable is not transmitted to the connections. The female half shall be attached to the load end of the power supply cord or cable. The connector shall be rated in amperes and designed so that differently rated devices cannot be connected together. Alternating-current multipole connectors shall be polarized and comply with 406.7(A) and (B) and 406.10. Alternating-current or direct-current multipole connectors utilized for connection between loudspeakers and amplifiers, or between loudspeakers, shall not be compatible with nonlocking 15- or 20-ampere rated connectors intended for branch-circuit power or with connectors rated 250 volts or greater and of either the locking or nonlocking type. Signal cabling not intended for such loudspeaker and amplifier interconnection shall not be permitted to be compatible with multipole branch-circuit cable connectors of any accepted configuration.

Informational Note: See 400.14 for pull at terminals.

640.42 Use of Flexible Cords and Cables

(A) Between Equipment and Branch-Circuit Power

Power supply cords for audio equipment shall be listed and shall be permitted to be used where the interchange, maintenance, or repair of such equipment is facilitated through the use of a power-supply cord.

(B) Between Loudspeakers and Amplifiers, or Between Loudspeakers

Installation of flexible cords and cables used to connect loudspeakers to each other or to an amplifier shall comply with Part I of Article 400 and Parts I, II, III, and IV of Article 725, respectively. Cords and cables listed for portable use, either hard or extra-hard usage as defined by Article 400, shall also be permitted. Other listed cable types and assemblies, including optional hybrid communications, signal, and composite optical fiber cables, shall be permitted.

(C) Between Equipment and/or Between Equipment Racks

Installation of flexible cords and cables used for the distribution of audio signals between equipment shall comply with Parts I and II of Article 400 and Parts I, II, and III of Article 725, respectively. Cords and cables listed for portable use, either hard or extra-hard service as defined by Article 400, shall also be permitted. Other listed cable types and assemblies, including optional hybrid communications, signal, and composite optical fiber cables, shall be permitted.

(D) Between Equipment, Equipment Racks, and Power Supplies Other Than Branch-Circuit Power

Wiring between the following power supplies, other than branch-circuit power supplies, shall be installed, connected, or wired in accordance with the requirements of this Code for the voltage and power required:

Storage batteries

Transformers

Transformer rectifiers

Other ac or dc power supplies

(E) Between Equipment Racks and Branch-Circuit Power

The supply to a portable equipment rack shall be by means of listed extra-hard usage cords or cables, as defined in Table 400.4. For outdoor portable or temporary use, the cords or cables shall be further listed as being suitable for wet locations and sunlight resistant. Sections 520.5, 520.10, and 525.3 shall apply as appropriate when the following conditions exist:

Where equipment racks include audio and lighting and/or power equipment

When using or constructing cable extensions, adapters, and breakout assemblies

640.43 Wiring of Equipment Racks

Equipment racks fabricated of metal shall be bonded and grounded. Nonmetallic racks with covers (if provided) removed shall not allow access to Class 1, Class 3, or primary circuit power without the removal of covers over terminals or the use of tools.

Wires, cables, structural components, or other equipment shall not be placed in such a manner as to prevent reasonable access to equipment power switches and resettable or replaceable circuit overcurrent protection devices.

Wiring that exits the equipment rack for connection to other equipment or to a power supply shall be relieved of strain or otherwise suitably terminated such that a pull on the flexible cord or cable will not increase the risk of damage to the cable or connected equipment such as to cause an unreasonable risk of fire or electric shock.

640.44 Environmental Protection of Equipment

Portable equipment not listed for outdoor use shall be permitted only where appropriate protection of such equipment from adverse weather conditions is provided to prevent risk of fire or electric shock. Where the system is intended to remain operable during adverse weather, arrangements shall be made for maintaining operation and ventilation of heat-dissipating equipment.

640.45 Protection of Wiring

Where accessible to the public, flexible cords and cables laid or run on the ground or on the floor shall be covered with approved nonconductive mats. Cables and mats shall be arranged so as not to present a tripping hazard. The cover requirements of 300.5 shall not apply to wiring protected by burial.

640.46 Equipment Access

Equipment likely to present a risk of fire, electric shock, or physical injury to the public shall be protected by barriers or supervised by qualified personnel so as to prevent public access.

Article 645 Information Technology Equipment

645.1 Scope

This article covers equipment, power-supply wiring, equipment interconnecting wiring, and grounding of information technology equipment and systems in an information technology equipment room.

Informational Note No. 1: For further information, see NFPA 75-2017, Standard for the Fire Protection of Information Technology Equipment, which covers the requirements for the protection of information technology equipment and information technology equipment areas.

Informational Note No. 2: Text that is followed by a reference in brackets has been extracted from NFPA 75-2017, Standard for the Fire Protection of Information Technology Equipment. Only editorial changes were made to the extracted text to make it consistent with this Code.

645.2 Definitions

The following definitions shall apply only within this article.

Abandoned Supply Circuits and Interconnecting Cables. Installed supply circuits and interconnecting cables that are not terminated at equipment and not identified for future use with a tag.

Critical Operations Data System. An information technology equipment system that requires continuous operation for reasons of public safety, emergency management, national security, or business continuity.

Remote Disconnect Control. An electric device and circuit that controls a disconnecting means through a relay or equivalent device.

Zone. A physically identifiable area (such as barriers or separation by distance) within an information technology equipment room, with dedicated power and cooling systems for the information technology equipment or systems.

645.3 Other Articles

Circuits and equipment shall comply with 645.3(A) through (I), as applicable.

(A) Spread of Fire or Products of Combustion

Sections 300.21, 770.26, and 800.26 shall apply to penetrations of the fire-resistant room boundary.

(B) Wiring and Cabling in Other Spaces Used for Environmental Air (Plenums)

The following sections and tables shall apply to wiring and cabling in other spaces used for environmental air (plenums) above an information technology equipment room:

Wiring methods: 300.22(C)(1)

Class 2, Class 3, and PLTC cables: 725.135(C) and Table 725.154

Fire alarm systems: 760.53(B)(2), 760.135(C), and Table 760.154

Optical fiber cables: 770.113(C) and Table 770.154(a)

Communications circuits: 800.113 and Table 800.154(a)

CATV and radio distribution systems: 800.113 and Table 800.154(a)

(C) Bonding and Grounding

The non-current-carrying conductive members of optical fiber cables in an information technology equipment room shall be bonded and grounded in accordance with 770.114.

(D) Electrical Classification of Data Circuits

Section 725.121(A)(4) shall apply to the electrical classification of listed information technology equipment signaling circuits. Sections 725.139(D)(1) and 805.133(A)(1)(c) shall apply to the electrical classification of Class 2 and Class 3 circuits in the same cable with communications circuits.

(E) Fire Alarm Cables and Equipment

Parts I, II, and III of Article 760 shall apply to fire alarm systems cables and equipment installed in an information technology equipment room. Only fire alarm cables listed in accordance with Part IV of Article 760 and listed fire alarm equipment shall be permitted to be installed in an information technology equipment room.

(F) Cable Routing Assemblies, Communications Wires, Cables, Raceways, and Equipment

Sections 800.110, 800.113, and 800.154 shall apply to cable routing assemblies and communications raceways. Parts I, II, III, IV, and V of Article 805 shall apply to communications wires, cables, and equipment installed in an information technology equipment room. Only communications wires and cables listed in accordance with 805.179, cable routing assemblies, and communications raceways listed in accordance with 800.182, and communications equipment listed in accordance with 805.170 shall be permitted to be installed in an information technology equipment room. Article 645 shall apply to the powering of communications equipment in an information technology equipment room.

Informational Note: See Part I of Article 100, Definitions, for a definition of communications equipment.

(G) Community Antenna Television and Radio Distribution Systems Cables and Equipment

Parts I, II, III, IV, and V of Article 820 shall apply to community antenna television and radio distribution systems cables and equipment installed in an information technology equipment room. Only community antenna television and radio distribution cables listed in accordance with 820.179 and listed CATV equipment shall be permitted to be installed in an information technology equipment room. Article 645 shall apply to the powering of community antenna television and radio distribution systems equipment installed in an information technology equipment room.

(H) Optical Fiber Cables

Only optical fiber cables listed in accordance with 770.179 shall be permitted to be installed in an information technology equipment room.

(I) Cables Not in Information Technology Equipment Room

Cables extending beyond the information technology equipment room shall be subject to the applicable requirements of this Code.

645.4 Special Requirements for Information Technology Equipment Room

The alternative wiring methods to Chapter 3 and Parts I and III of Article 725 for signaling wiring and Parts I and V of Article 770 for optical fiber cabling shall be permitted where all of the following conditions are met:

Disconnecting means complying with 645.10 are provided.

A heating/ventilating/air-conditioning (HVAC) system is provided in one of the methods identified in 645.4(2) a or b.

A separate HVAC system that is dedicated for information technology equipment use and is separated from other areas of occupancy; or

An HVAC system that serves other occupancies and meets all of the following:

Also serves the information technology equipment room

Provides fire/smoke dampers at the point of penetration of the room boundary

Activates the damper operation upon initiation by smoke detector alarms, by operation of the disconnecting means required by 645.10, or by both

Informational Note: For further information, see NFPA 75-2017, Standard for the Fire Protection of Information Technology Equipment, Chapter 10, 10.1, 10.1.1, 10.1.2, and 10.1.3.

All information technology and communications equipment installed in the room is listed.

The room is occupied by, and accessible to, only those personnel needed for the maintenance and functional operation of the installed information technology equipment.

The room is separated from other occupancies by fire-resistant-rated walls, floors, and ceilings with protected openings.

Informational Note: For further information on room construction requirements, see NFPA 75-2017, Standard for the Fire Protection of Information Technology Equipment, Chapter 5.

Only electrical equipment and wiring associated with the operation of the information technology room is installed in the room.

Informational Note: HVAC systems, communications systems, and monitoring systems such as telephone, fire alarm systems, security systems, water detection systems, and other related protective equipment are examples of equipment associated with the operation of the information technology room.

645.5 Supply Circuits and Interconnecting Cables

(A) Branch-Circuit Conductors

The branch-circuit conductors supplying one or more units of information technology equipment shall have an ampacity not less than 125 percent of the total connected load.

(B) Power-Supply Cords

Information technology equipment shall be permitted to be connected to a branch circuit by a power-supply cord.

Power-supply cords shall not exceed 4.5 m (15 ft).

Power cords shall be listed and a type permitted for use on listed information technology equipment or shall be constructed of listed flexible cord and listed attachment plugs and cord connectors of a type permitted for information technology equipment.

Informational Note: One method of determining if cords are of a type permitted for the purpose is found in UL 60950-1-2007, Safety of Information Technology Equipment — Safety — Part 1: General Requirements; or UL 62368-1-2012, Audio/Video, Information and Communication Technology Equipment — Part 1: Safety Requirements.

(C) Interconnecting Cables

Separate information technology equipment units shall be permitted to be interconnected by means of listed cables and cable assemblies. The 4.5 m (15 ft) limitation in 645.5(B)(1) shall not apply to interconnecting cables.

(D) Physical Protection

Where exposed to physical damage, supply circuits and interconnecting cables shall be protected.

(E) Under Raised Floors

Where the area under the floor is accessible and openings minimize the entrance of debris beneath the floor, power cables, communications cables, connecting cables, interconnecting cables, cord-and-plug connections, and receptacles associated with the information technology equipment shall be permitted under a raised floor of approved construction. The installation requirement shall comply with 645.5(E)(1) through (E)(3).

(1) Installation Requirements for Branch Circuit Supply Conductors Under a Raised Floor

(a) The supply conductors shall be installed in accordance with the requirements of 300.11.

(b) In addition to the wiring methods of 300.22(C), the following wiring methods shall also be permitted:

Rigid metal conduit

Rigid nonmetallic conduit

Intermediate metal conduit

Electrical metallic tubing

Electrical nonmetallic tubing

Metal wireway

Nonmetallic wireway

Surface metal raceway with metal cover

Surface nonmetallic raceway

Flexible metal conduit

Liquidtight flexible metal conduit

Liquidtight flexible nonmetallic conduit

Type MI cable

Type MC cable

Type AC cable

Associated metallic and nonmetallic boxes or enclosures

Type TC power and control tray cable

(2) Installation Requirements for Electrical Supply Cords, Data Cables, Interconnecting Cables, and Grounding Conductors Under a Raised Floor

The following cords, cables, and conductors shall be permitted to be installed under a raised floor:

Supply cords of listed information technology equipment in accordance with 645.5(B).

Interconnecting cables enclosed in a raceway.

Equipment grounding conductors.

Where the air space under a raised floor is protected by an automatic lire suppression system, in addition to wiring installed in compliance with 725.135(C), Types CL2R, CL3R, CL2, and CL3 and substitute cables including CMP, CMR, CM, and CMG installed in accordance with 725.154(A) shall be permitted under raised floors.

Informational Note: Figure 725.154(A) illustrates the cable substitution hierarchy for Class 2 and Class 3 cables.

Where the air space under a raised floor is not protected by an automatic fire suppression system, in addition to wiring installed in compliance with 725.135(C), substitute cable Type CMP installed in accordance with 725.154(A) shall be permitted under raised floors.

Listed Type DP cable having adequate fire-resistant characteristics suitable for use under raised floors of an information technology equipment room.

Informational Note: One method of defining fire resistance is by establishing that the cables do not spread fire to the top of the tray in the "UL Flame Exposure, Vertical Tray Flame Test" in UL 1685-2015, Standard for Safety for Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables. The smoke measurements in the test method are not applicable.

Another method of defining fire resistance is for the damage (char length) not to exceed 1.5 m (4 ft 11 in.) when performing the CSA "Vertical Flame Test — Cables in Cable Trays," as described in CSA C22.2 No. 0.3-2014, Test Methods for Electrical Wires and Cables.

(3) Installation Requirements for Optical Fiber Cables Under a Raised Floor

The installation of optical fiber cables shall comply with either of the following:

Where the air space under a raised floor is protected by an automatic fire suppression system, optical fiber cables installed in accordance with 770.113(C), Types OFNR, OFCR, OFN, and OFC shall be permitted under raised floors.

Where the air space under a raised floor is not protected by an automatic fire suppression system, only optical fiber cables installed in accordance with 770.113(C) shall be permitted under raised floors.

(F) Securing in Place

Power cables; communications cables, connecting cables, interconnecting cables, and associated boxes, connectors, plugs, and receptacles that are listed as part of, or for, information technology equipment shall not be required to be secured in place where installed under raised floors.

Informational Note: Securement requirements for raceways and cables not listed as part of, or for, information technology equipment are found in 300.11.

(G) Abandoned Supply Circuits and Interconnecting Cables

The accessible portion of abandoned supply circuits and interconnecting cables shall be removed unless contained in a raceway.

(H) Installed Supply Circuits and Interconnecting Cables Identified for Future Use

(1)

Supply circuits and interconnecting cables identified for future use shall be marked with a tag of sufficient durability to withstand the environment involved.

(2)

Supply circuit tags and interconnecting cable tags shall have the following information:

Date identified for future use

Date of intended use

Information relating to the intended future use

645.10 Disconnecting Means

An approved means shall be provided to disconnect power to all electronic equipment in the information technology equipment room or in designated zones within the room. There shall also be a similar approved means to disconnect the power to all dedicated HVAC systems serving the room or designated zones and to cause all required fire/smoke dampers to close. The disconnecting means shall comply with either 645.10(A) or (B).

Exception: Installations complying with Article 685.

(A) Remote Disconnect Controls

(1)

Remote disconnect controls shall be located at approved locations readily accessible in case of fire to authorized personnel and emergency responders.

(2)

The remote disconnect means for the control of electronic equipment power and HVAC systems shall be grouped and identified. A single means to control both systems shall be permitted.

(3)

Where multiple zones are created, each zone shall have an approved means to confine fire or products of combustion to within the zone.

(4)

Additional means to prevent unintentional operation of remote disconnect controls shall be permitted.

Informational Note: For further information, see NFPA 75-2017, Standard for the Fire Protection of Information Technology Equipment.

(B) Critical Operations Data Systems

Remote disconnecting controls shall not be required for critical operations data systems when all of the following conditions are met:

An approved procedure has been established and maintained for removing power and air movement within the room or zone.

Qualified personnel are continuously available to advise emergency responders and to instruct them of disconnecting methods.

A smoke-sensing fire detection system is in place.

Informational Note: For further information, see NFPA 72-2019, National Fire Alarm and Signaling Code.

An approved fire suppression system suitable for the application is in place.

Cables installed under a raised floor, other than branch-circuit wiring, and power cords are installed in compliance with 645.5(E)(2) or (E)(3), or in compliance with Table 645.10(B)(5).

Table 645.10(B)(5) Cables Installed Under Raised Floors

Cable Type Applicable Sections

Branch circuits under raised floors 645.5(E)(1)

Supply cords of listed information technology equipment 645.5(E)(2)(a), 300.22(C)

Class 2 and Class 3 remote control and PLTC cables in other spaces used for environmental air (plenums) 725.135(C) and Table 725.154

Optical fiber cable in other spaces used for environmental air (plenums) 770.113(C) and Table 770.154(a)

Communications wires and cables, cable routing assemblies, and communications raceways in other spaces used for environmental air (plenums) 800.113, 800.113(C), and Tables 800.154(a), (b), and (c)

Coaxial CATV and radio distribution cables in other spaces used for environmental air (plenums) 800.113(C) and Table 800.154(a)

645.11 Uninterruptible Power Supply (UPS)

UPS systems installed within the information technology equipment room, and their supply and output circuits, shall comply with 645.10, except for the following installations and constructions:

Installations complying with Article 685

Power sources limited to 750 volt-amperes or less derived either from UPS equipment or from battery circuits integral to electronic equipment

The disconnecting means shall also disconnect the battery from its load.

Informational Note: For information on product listings for electronic equipment disconnecting means and backup battery power sources, see UL 1778-2014 (R2017), Uninterruptible Power Systems, and UL 62368-1-2014, Audio/Video, Information and Communication Technology Equipment — Part 1: Safety Requirements.

645.14 System Grounding

Separately derived power systems shall be installed in accordance with Parts I and II of Article 250. Power systems derived within listed information technology equipment that supply information technology systems through receptacles or cable assemblies supplied as part of this equipment shall not be considered separately derived for the purpose of applying 250.30.

645.15 Equipment Grounding and Bonding

All exposed non—current-carrying metal parts of an information technology system shall be bonded to the equipment grounding conductor in accordance with Parts I, V, VI, VII, and VIII of Article 250 or shall be double insulated. Where signal reference structures are installed, they shall be bonded to the equipment grounding conductor provided for the information technology equipment. Any auxiliary grounding electrode(s) installed for information technology equipment shall be installed in accordance with 250.54.

Informational Note No. 1: The bonding requirements in the product standards governing this listed equipment ensure that it complies with Article 250.

Informational Note No. 2: Where isolated grounding-type receptacles are used, see 250.146(D) and 406.3(D).

645.16 Marking

Each unit of an information technology system supplied by a branch circuit shall be provided with a manufacturer's nameplate, which shall also include the input power requirements for voltage, frequency, and maximum rated load in amperes.

645.17 Power Distribution Units

Power distribution units that are used for information technology equipment shall be permitted to have multiple panelboards within a single cabinet if the power distribution unit is utilization equipment listed for information technology application.

645.18 Surge Protection for Critical Operations Data Systems

Listed surge protection shall be provided for critical operations data systems.

645.25 Engineering Supervision

As an alternative to the feeder and service load calculations required by Parts III and IV of Article 220, feeder and service load calculations for new or existing loads shall be permitted to be used if provided by qualified persons under engineering supervision.

645.27 Selective Coordination

Critical operations data system(s) overcurrent protective devices shall be selectively coordinated with all supply-side overcurrent protective devices.

Selective coordination shall be selected by a licensed professional engineer or other qualified persons engaged primarily in the design, installation, or maintenance of electrical systems. The selection shall be documented and made available to those authorized to design, install, inspect, maintain, and operate the system.

Article 646 Modular Data Centers

Part I General

646.1 Scope

This article covers modular data centers.

Informational Note No. 1: Modular data centers include the installed information technology equipment (ITE) and support equipment, electrical supply and distribution, wiring and protection, working space, grounding, HVAC, and the like, that are located in an equipment enclosure.

Informational Note No. 2: For further information, see NFPA 75-2017, Standard for the Protection of Information Technology Equipment, which covers the requirements for the protection of information technology equipment and systems in an information technology equipment room.

646.2 Definitions

The following definition shall apply only within this article.

Modular Data Center (MDC). Prefabricated units, rated 1000 volts or less, consisting of an outer enclosure housing multiple racks or cabinets of information technology equipment (ITE) (e.g., servers) and various support equipment, such as electrical service and distribution equipment, HVAC systems, and the like.

Informational Note No. 1: A typical construction may use a standard ISO shipping container or other structure as the outer enclosure, racks or cabinets of ITE, service-entrance equipment and power distribution components, power storage such as a UPS, and an air or liquid cooling system. Modular data centers are intended for fixed installation, either indoors or outdoors, based on their construction and resistance to environmental conditions. MDCs can be configured as an all-in-one system housed in a single equipment enclosure or as a system with the support equipment housed in separate equipment enclosures.

Informational Note No. 2: For information on listing requirements for both information technology equipment and communications equipment contained within a modular data center, see UL 60950-1-2014, Information Technology Equipment — Safety — Part 1: General Requirements, and UL 62368-1-2012, Audio/Video, Information and Communication Technology Equipment — Part 1: Safety Requirements.

Informational Note No. 3: Modular data centers as defined in this article are sometimes referred to as containerized data centers.

Informational Note No. 4: Equipment enclosures housing only support equipment (e.g., HVAC or power distribution equipment) that are not part of a specific modular data center are not considered a modular data center as defined in this article.

646.3 Other Articles

Circuits and equipment shall comply with 646.3(A) through (N) as applicable. Wherever the requirements of other articles of this Code and Article 646 differ, the requirements of Article 646 shall apply.

(A) Spread of Fire or Products of Combustion

Sections 300.21, 770.26, and 800.26 shall apply to penetrations of a fire-resistant room boundary, if provided.

(B) Wiring and Cabling in Other Spaces Used for Environmental Air (Plenums)

The following sections and tables shall apply to wiring and cabling in other spaces used for environmental air (plenums) within a modular data center space:

Wiring methods: 300.22(C)(1)

Class 2, Class 3, and PLTC cables: 725.135(C), and Table 725.154

Fire alarm systems: 760.53(B)(2), 760.135(C), and Table 760.154

Optical fiber cables: 770.113(C) and Table 770.154(a)

Communications circuits: 800.113 and Table 800.154(a)

CATV and radio distribution systems: 800.113 and Table 800.154(a)

Informational Note: Environmentally controlled working spaces, aisles, and equipment areas in an MDC are not considered a plenum.

(C) Grounding

Grounding and bonding of an MDC shall comply with Article 250. The non-current-carrying conductive members of optical fiber cables in an MDC shall be grounded in accordance with 770.114. Grounding and bonding of communications protectors, cable shields, and non-current-carrying metallic members of cable shall comply with Part IV of Article 805.

(D) Electrical Classification of Data Circuits

Section 725.121(A)(4) shall apply to the electrical classification of listed information technology equipment signaling circuits. Sections 725.139(D)(1) and 805.133(A)(1)(c) shall apply to the electrical classification of Class 2 and Class 3 circuits in the same cable with communications circuits.

(E) Fire Alarm Equipment

Parts I, II, and III of Article 760 shall apply to fire alarm systems, cables, and equipment installed in an MDC, where provided. Only fire alarm cables listed in accordance with Part IV of Article 760 and listed fire alarm equipment shall be permitted to be installed in an MDC.

(F) Cable Routing Assemblies and Communications Wires, Cables, Raceways, and Equipment

Sections 800.110, 800.113, and 800.154 shall apply to cable routing assemblies and communications raceways. Parts I, II, III, IV, and V of Article 805 shall apply to communications wires, cables, and equipment installed in an MDC. Only communications wires and cables listed in accordance with 805.179, cable routing assemblies and communications raceways listed in accordance with 800.182, and communications equipment listed in accordance with 805.170 shall be permitted to be installed in an MDC.

Informational Note: See Part I of Article 100 for a definition of communications equipment.

(G) Community Antenna Television and Radio Distribution Systems Cables and Equipment

Parts I, II, III, IV, and V of Article 820 shall apply to community antenna television and radio distribution systems equipment installed in an MDC. Only community antenna television and radio distribution cables listed in accordance with 820.179 and listed CATV equipment shall be permitted to be installed in an MDC.

(H) Storage Batteries

Installation of storage batteries shall comply with Article 480.

Exception: Batteries that are part of listed and labeled equipment and installed in accordance with the listing requirements.

(I) Surge-Protective Devices (SPDs)

Where provided, surge-protective devices shall be listed and labeled and installed in accordance with Article 242.

(J) Lighting

Lighting shall be installed in accordance with Article 410.

(K) Power Distribution Wiring and Wiring Protection

Power distribution wiring and wiring protection within an MDC shall comply with Article 210 for branch circuits.

(L) Wiring Methods and Materials

Unless modified elsewhere in this article, wiring methods and materials for power distribution shall comply with Chapter 3. Wiring shall be suitable for its use and installation and shall be listed and labeled.

Exception: This requirement shall not apply to wiring that is part of listed and labeled equipment.

The following wiring methods shall not be permitted:

Integrated gas spacer cable: Type IGS (Article 326)

Concealed knob-and-tube wiring (Article 394)

Messenger-supported wiring (Article 396)

Open wiring on insulators (Article 398)

Outdoor overhead conductors over 600 volts (Article 399)

Wiring in areas under a raised floor that are constructed and used for ventilation as described in 645.5(E) shall be permitted to use the wiring methods described in 645.5(E) if the conditions of 645.4 are met.

Installation of wiring for remote-control, signaling, and power-limited circuits shall comply with Part III of Article 725.

Installation of optical fiber cables shall comply with Part V of Article 770.

Alternate wiring methods as permitted by Article 645 shall be permitted for MDCs, provided that all of the conditions of 645.4 are met.

(M) Service Equipment

For an MDC that is designed such that it can be powered from a separate electrical service, the service equipment for control and protection of services and their installation shall comply with Article 230. The service equipment and their arrangement and installation shall permit the installation of the service-entrance conductors in accordance with Article 230. Service equipment shall be listed and labeled and marked as being suitable for use as service equipment.

(N) Disconnecting Means

An approved means shall be provided to disconnect power to all electronic equipment in the MDC in accordance with 645.10. There shall also be a similar approved means to disconnect the power to all dedicated HVAC systems serving the MDC that shall cause all required fire/smoke dampers to close.

646.4 Applicable Requirements

All MDCs shall be listed and labeled and comply with 646.3(N) and 646.5 through 646.9, or comply with this article.

Informational Note: For information on listing requirements for MDCs, see UL Subject 2755, Outline of Investigation for Modulai Data Centers.

646.5 Nameplate Data

A permanent nameplate shall be attached to each equipment enclosure of an MDC and shall be plainly visible after installation. The nameplate shall include the information in 646.5(1) through (6), as applicable:

Supply voltage, number of phases, frequency, and full-load current. The full-load current shown on the nameplate shall not be less than the sum of the full-load currents required for all motors and other equipment that may be in operation at the same time under normal conditions of use. Where unusual type loads, duty cycles, and so forth, require oversized conductors or permit reduced-size conductors, the required capacity shall be included in the marked full-load current. Where more than one incoming supply circuit is to be provided, the nameplate shall state the preceding information for each circuit.

Informational Note No. 1: See 430.22(E) and 430.26 for duty cycle requirements.

Informational Note No. 2: For listed equipment, the full-load current shown on the nameplate may be the maximum, measured, 15-minute, average full-load current.

For MDCs powered by a separate service, the short-circuit current rating of the service equipment provided as part of the MDC.

Informational Note: This rating may be part of the service equipment marking.

For MDCs powered by a separate service, if the required service as determined by Parts III and IV of Article 220 is less than the rating of the service panel used, the required service shall be included on the nameplate.

Informational Note: Branch circuits supplying ITE loads are assumed to be loaded not less than 80 percent of the branch-circuit rating with a 100 percent duty cycle. As an alternative to the feeder and service load calculations required by Parts III and IV of Article 220, feeder and service load calculations for new, future, or existing loads may be permitted to be used if performed by qualified persons under engineering supervision.

Electrical diagram number(s) or the number of the index to the electrical drawings.

For MDC equipment enclosures that are not powered by a separate service, feeder, or branch circuit, a reference to the powering equipment.

Manufacturer's name or trademark.

646.6 Supply Conductors and Overcurrent Protection

(A) Size

The size of the supply conductor shall be such as to have an ampacity not less than 125 percent of the full-load current rating.

Informational Note No. 1: See the 0-2000-volt ampacity tables of Article 310 for ampacity of conductors rated 600 V and below.

Informational Note No. 2: See 430.22(E) and 430.26 for duty cycle requirements.

(B) Overcurrent Protection

Where overcurrent protection for supply conductors is furnished as part of the MDC, overcurrent protection for each supply circuit shall comply with 646.6(B)(1) through (B)(2).

(1) Service Equipment — Overcurrent Protection

Service conductors shall be provided with overcurrent protection in accordance with 230.90 through 230.95.

(2) Taps and Feeders

Where overcurrent protection for supply conductors is furnished as part of the MDC as permitted by 240.21, the overcurrent protection shall comply with the following:

The overcurrent protection shall consist of a single circuit breaker or set of fuses.

The MDC shall be marked "OVERCURRENT PROTECTION PROVIDED AT MDC SUPPLY TERMINALS."

The supply conductors shall be considered either as feeders or as taps and be provided with overcurrent protection complying with 240.21.

646.7 Short-Circuit Current Rating

(A) Service Equipment

The service equipment of an MDC that connects directly to a service shall have a short-circuit current rating not less than the available fault current of the service.

(B) MDCs Connected to Branch Circuits and Feeders

Modular data centers that connect to a branch circuit or a feeder circuit shall have a short-circuit current rating not less than the available fault current of the branch circuit or feeder. The short-circuit current rating of the MDC shall be based on the short-circuit current rating of a listed and labeled MDC or the short-circuit current rating established utilizing an approved method.

Exception: This requirement shall not apply to listed and labeled equipment connected to branch circuits located inside of the MDC equipment enclosure.

Informational Note: UL 508A-2013, Standard for Industrial Control Panels, Supplement SB, is an example of an approved method.

(C) MDCs Powered From Separate MDC System Enclosures

Modular data center equipment enclosures, powered from a separate MDC system enclosure that is part of the specific MDC system, shall have a short-circuit current rating coordinated with the powering module in accordance with 110.10.

Informational Note: UL 508A-2013, Standard for Industrial Control Panels, Supplement SB, is an example of an approved method for determining short-circuit current ratings.

646.8 Field-Wiring Compartments

A field-wiring compartment in which service or feeder connections are to be made shall be readily accessible and comply with 646.8(1) through (3) as follows:

Permit the connection of the supply wires after the MDC is installed

Permit the connection to be introduced and readily connected

Be located so that the connections may be readily inspected after the MDC is installed

646.9 Flexible Power Cords and Cables for Connecting Equipment Enclosures of an MDC System

(A) Uses Permitted

Flexible power cords and cables shall be permitted to be used for connections between equipment enclosures of an MDC system where not subject to physical damage.

Informational Note: One example of flexible power cord usage for connections between equipment enclosures of an MDC system is between an MDC enclosure containing only servers and one containing power distribution equipment.

(B) Uses Not Permitted

Flexible power cords and cables shall not be used for connection to external sources of power.

Informational Note: Examples of external sources of power are electrical services, feeders, and premises branch circuits.

(C) Listing

Where flexible power cords or cables are used, they shall be listed as suitable for extra-hard usage. Where used outdoors, flexible power cords and cables shall also be listed as suitable for wet locations and shall be sunlight resistant.

(D) Single-Conductor Cable

Single-conductor power cable shall be permitted to be used only in sizes 2 AWG or larger.

Part II Equipment

646.10 Electrical Supply and Distribution

Equipment used for electrical supply and distribution in an MDC, including fittings, devices, luminaires, apparatus, machinery, and the like, shall comply with Parts I and II of Article 110.

646.11 Distribution Transformers

(A) Utility-Owned Transformers

Utility-owned distribution transformers shall not be permitted in an MDC.

(B) Non-Utility-Owned Premises Transformers

Non-utility-owned premises distribution transformers installed in the vicinity of an MDC shall be of the dry type or the type filled with a noncombustible dielectric medium. Such transformers shall be installed in accordance with the requirements of Article 450. Non-utility-owned premises distribution transformers shall not be permitted in an MDC.

(C) Power Transformers

Power transformers that supply power only to the MDC shall be permitted to be installed in the MDC equipment enclosure. Only dry-type transformers shall be permitted to be installed in the MDC equipment enclosure. Such transformers shall be installed in accordance with the requirements of Article 450.

646.12 Receptacles

At least one 125-volt ac, 15- or 20-ampererated duplex convenience outlet shall be provided in each work area of the MDC to facilitate the powering of test and measurement equipment that may be required during routine maintenance and servicing, without having to route flexible power cords through or across doorways or around line-ups of equipment, or the like.

646.13 Other Electrical Equipment

Electrical equipment that is an integral part of the MDC, including information technology equipment, lighting, control, power, HVAC (heating, ventilation, and air-conditioning), emergency lighting, alarm circuits, and so forth, shall comply with the requirements for its use and installation and shall be listed and labeled.

646.14 Installation and Use

Listed and labeled equipment shall be installed and used in accordance with any instructions or limitations included in the listing.

Part III Lighting

646.15 General Illumination

Illumination shall be provided for all workspaces and areas that are used for exit access and exit discharge. The illumination shall be arranged so that the failure of any single lighting unit does not result in a complete loss of illumination.

Informational Note: See NFPA 101-2018, Life Safety Code, Section 7.8, for information on illumination of means of egress.

646.16 Emergency Lighting

Diagram

Areas that are used for exit access and exit discharge shall be provided with emergency lighting. Emergency lighting systems shall be listed and labeled equipment installed in accordance with the manufacturer's instructions.

Informational Note: See NFPA 101-2018, Life Safety Code, Section 7.9, for information on emergency lighting.

UpCodes Diagrams

P

Means of Egress Illumination: Exit Discharge

Means of Egress Illumination (NFPA)

646.17 Emergency Lighting Circuits

No appliances or lamps, other than those specified as required for emergency use, shall be supplied by emergency lighting circuits. Branch circuits supplying emergency lighting shall be installed to provide service from storage batteries, generator sets, UPS, separate service, fuel cells, or unit equipment. No other equipment shall be connected to these circuits unless the emergency lighting system includes a backup system where only the lighting is supplied by battery circuits under power failure conditions. All boxes and enclosures (including transfer switches, generators, and power panels) for emergency circuits shall be marked to identify them as components of an emergency circuit or system.

Part IV Workspace

646.18 General

Space about electrical equipment shall comply with 110.26.

646.19 Entrance to and Egress From Working Space

For equipment over 1.8 m (6 ft) wide or deep, there shall be one entrance to and egress from the required working space not less than 610 mm (24 in.) wide and 2.0 m (6 1/2 ft) high at each end of the working space. Doors shall open in the direction of egress and be equipped with listed panic hardware or listed fire exit hardware. A single entrance to and egress from the required working space shall be permitted where either of the conditions in 646.19(A) or (B) is met.

(A) Unobstructed Egress

Where the location permits a continuous and unobstructed way of egress travel, a single entrance to the working space shall be permitted.

(B) Extra Working Space

Where the depth of the working space is twice that required by 110.26(A)(1), a single entrance shall be permitted. It shall be located such that the distance from the equipment to the nearest edge of the entrance is not less than the minimum clear distance specified in Table 110.26(A)(1) for equipment operating at that voltage and in that condition.

646.20 Working Space for ITE

(A) Low-Voltage Circuits

The working space about ITE where any live parts that may be exposed during routine servicing operate at not greater than 30 volts rms, 42 volts peak, or 60 volts dc shall not be required to comply with the workspace requirements of 646.19.

(B) Other Circuits

Any areas of ITE that require servicing of parts that are greater than 30 volts rms, 42 volts peak, or 60 volts dc shall comply with the workspace requirements of 646.19.

Informational Note No. 1: For example, field-wiring compartments for ac mains connections, power distribution units, and so forth.

Informational Note No. 2: It is assumed that ITE operates at voltages not exceeding 1000 volts.

646.21 Work Areas and Working Space About Batteries

Working space about a battery system shall comply with 110.26. Working space shall be measured from the edges of the battery racks, cabinets, or trays.

646.22 Workspace for Routine Service and Maintenance

Workspace shall be provided to facilitate routine servicing and maintenance (those tasks involving operations that can be accomplished by employees and where extensive disassembly of equipment is not required). Routine servicing and maintenance shall be able to be performed without exposing the worker to a risk of electric shock or personal injury.

Informational Note: An example of such routine maintenance is cleaning or replacing an air filter.

Article 647 Sensitive Electronic Equipment

647.1 Scope

This article covers the installation and wiring of separately derived systems operating at 120 volts line-to-line and 60 volts to ground for sensitive electronic equipment.

647.3 General

Use of a separately derived 120-volt single-phase 3-wire system with 60 volts on each of two ungrounded conductors to an equipment grounding conductor shall be permitted for the purpose of reducing objectionable noise in sensitive electronic equipment locations, provided the following conditions apply:

The system is installed only in commercial or industrial occupancies.

The system's use is restricted to areas under close supervision by qualified personnel.

All of the requirements in 647.4 through 647.8 are met.

647.4 Wiring Methods

(A) Panelboards and Overcurrent Protection

Use of standard single-phase panelboards and distribution equipment with a higher voltage rating shall be permitted. The system shall be clearly marked on the face of the panel or on the inside of the panel doors. Common trip two-pole circuit breakers or a combination two-pole fused disconnecting means that are identified for use at the system voltage shall be provided for both ungrounded conductors in all feeders and branch circuits. Branch circuits and feeders shall be provided with a means to simultaneously disconnect all ungrounded conductors.

(B) Junction Boxes

All junction box covers shall be clearly marked to indicate the distribution panel and the system voltage.

(C) Conductor Identification

All feeders and branch-circuit conductors installed under this section shall be identified as to system at all splices and terminations by color, marking, tagging, or equally effective means. The means of identification shall be posted at each branch-circuit panelboard and at the disconnecting means for the building.

(D) Voltage Drop

The voltage drop on any branch circuit shall not exceed 1.5 percent. The combined voltage drop of feeder and branch-circuit conductors shall not exceed 2.5 percent.

(1) Fixed Equipment

The voltage drop on branch circuits supplying equipment connected using wiring methods in Chapter 3 shall not exceed 1.5 percent. The combined voltage drop of feeder and branch-circuit conductors shall not exceed 2.5 percent.

(2) Cord-Connected Equipment

The voltage drop on branch circuits supplying receptacles shall not exceed 1 percent. For the purposes of making this calculation, the load connected to the receptacle outlet shall be considered to be 50 percent of the branch-circuit rating. The combined voltage drop of feeder and branch-circuit conductors shall not exceed 2.0 percent.

Informational Note: The purpose of this provision is to limit voltage drop to 1.5 percent where portable cords may be used as a means of connecting equipment.

647.5 Three-Phase Systems

Where 3-phase power is supplied, a separately derived 6-phase "wye" system with 60 volts to ground installed under this article shall be configured as three separately derived 120-volt single-phase systems having a combined total of no more than six disconnects.

647.6 Grounding

(A) General

The transformer secondary center tap of the 60/120-volt, 3-wire system shall be grounded as provided in 250.30.

(B) Equipment Grounding Conductors Required

Permanently wired utilization equipment and receptacles shall be grounded by means of an equipment grounding conductor run with the circuit conductors and connected to an equipment grounding bus prominently marked "Technical Equipment Ground" in the branch-circuit panelboard. The equipment grounding bus shall be connected to the grounded conductor on the line side of disconnecting means supplied by the separately derived system. The equipment grounding conductor shall not be smaller than that specified in Table 250.122 and run with the feeder conductors. The technical equipment grounding bus shall not be required to be bonded to the panelboard enclosure. Other equipment grounding methods authorized elsewhere in this Code shall be permitted where the impedance of the equipment grounding return path does not exceed the impedance of equipment grounding conductors sized and installed in accordance with this article.

Informational Note No. 1: See 250.122 for equipment grounding conductor sizing requirements where circuit conductors are adjusted in size to compensate for voltage drop.

Informational Note No. 2: These requirements limit the impedance of the ground fault return path where only 60 volts apply to a fault condition instead of the usual 120 volts.

647.7 Receptacles

(A) General

Where receptacles are used as a means of connecting equipment, the following conditions shall be met:

All 15- and 20-ampere receptacles shall be GFCI protected.

All receptacle outlet strips, adapters, receptacle covers, and faceplates shall be marked with the following words or equivalent:

WARNING — TECHNICAL POWER

Do not connect to lighting equipment.

For electronic equipment use only.

60/120 V. 1Φac

GFCI protected

The warning sign(s) or label(s) shall comply with 110.21(B).

A 125-volt, single-phase, 15- or 20-ampere-rated receptacle having one of its current-carrying poles connected to a grounded circuit conductor shall be located within 1.8 m (6 ft) of all permanently installed 15- or 20-ampere-rated 60/120-volt technical power-system receptacles.

All 125-volt receptacles used for 60/120-volt technical power shall have a unique configuration and be identified for use with this class of system.

Exception: Receptacles and attachment plugs rated 125-volt, single-phase, 15- or 20-amperes, and that are identified for use with grounded circuit conductors, shall be permitted in machine rooms, control rooms, equipment rooms, equipment racks, and other similar locations that are restricted to use by qualified personnel.

(B) Isolated Ground Receptacles

Isolated ground receptacles shall be permitted as described in 250.146(D); however, the branch-circuit equipment grounding conductor shall be terminated as required in 647.6(B).

647.8 Lighting Equipment

Lighting equipment installed under this article for the purpose of reducing electrical noise originating from lighting equipment shall meet the conditions of 647.8(A) through (C).

(A) Disconnecting Means

All luminaires connected to separately derived systems operating at 60 volts to ground, and associated control equipment if provided, shall have a disconnecting means that simultaneously opens all ungrounded conductors. The disconnecting means shall be located within sight of the luminaire or be lockable open in accordance with 110.25.

(B) Luminaires

All luminaires shall be permanently installed and listed for connection to a separately derived system at 120 volts line-to-line and 60 volts to ground.

(C) Screw Shell

Luminaires installed under this section shall not have an exposed lamp screw shell.

Article 650 Pipe Organs

650.1 Scope

This article covers those electrical circuits and parts of electrically operated pipe organs that are employed for the control of the keyboards and of the pipe organ sounding apparatus, typically organ pipes.

Informational Note: The typical pipe organ is a very large musical instrument that is built as part of a building or structure.

650.2 Definitions

The definitions in this section shall apply within this article and throughout the Code.

Electronic Organ. A musical instrument that imitates the sound of a pipe organ by producing sound electronically.

Informational Note: Most new electronic organs produce sound digitally and are called digital organs.

Pipe Organ. A musical instrument that produces sound by driving pressurized air (called wind) through pipes selected via a keyboard.

Pipe Organ Sounding Apparatus. The sound-producing part of a pipe organ, including, but not limited to, pipes, chimes, bells, the pressurized air (wind)-producing equipment (blower), associated controls, and power equipment.

Informational Note: The pipe organ sounding apparatus is also referred to as the "pipe organ chamber."

650.3 Other Articles

Installations of circuits and equipment shall comply with 650.3(A) and (B) as applicable. Wherever the requirements of other articles in Chapters 1 through 7 of this Code and Article 650 differ, the requirements of Article 650 shall apply.

(A) Electronic Organ Equipment

Installations of digital/analog—sampled sound production technology and associated audio signal processing, amplification, reproduction equipment, and wiring installed as part of a pipe organ shall be in accordance with Article 640.

(B) Optical Fiber Cable

Installations of optical fiber cables shall be in accordance with Parts I and V of Article 770.

650.4 Source of Energy

DC power shall be supplied by a listed dc power supply with a maximum output of 30 volts.

Informational Note: Class 1 power-limited power supplies are often utilized in pipe organ applications.

650.5 Grounding or Double Insulation of the DC Power Supply

The installation of the dc power supply shall comply with either of the following:

The dc power supply shall be double insulated.

The metallic case of the dc power supply shall be bonded to the input equipment grounding conductor.

650.6 Conductors

Conductors shall comply with 650.6(A) through (D).

(A) Size

The minimum conductor size shall be not less than 28 AWG for electronic signal circuits and not less than 26 AWG for electromagnetic valve supply and the like. The minimum conductor size of a main common-return conductor in the electromagnetic supply shall not be less than 14 AWG.

(B) Insulation

Conductors shall have thermoplastic or thermosetting insulation.

(C) Conductors to Be Cabled

Except for the common-return conductor and conductors inside the organ proper, the organ sections and the organ console conductors shall be cabled. The common-return conductors shall be permitted under an additional covering enclosing both cable and return conductor, or they shall be permitted as a separate conductor and shall be permitted to be in contact with the cable.

(D) Cable Covering

Each cable shall be provided with an outer covering, either overall or on each of any subassemblies of grouped conductors. Tape shall be permitted in place of a covering. Where not installed in metal raceway, the covering shall be resistant to flame spread, or the cable or each cable subassembly shall be covered with a closely wound listed fireproof tape.

Informational Note: One method of determining that cable is resistant to flame spread is by testing the cable to the VW-1 (vertical-wire) flame test in ANSI/UL 1581-2017, Reference Standard for Electrical Wires, Cables and Flexible Cords.

650.7 Installation of Conductors

Cables shall be securely fastened in place and shall be permitted to be attached directly to the organ structure without insulating supports. Splices shall not be required to be enclosed in boxes or other enclosures. Control equipment and busbars connecting common-return conductors shall be permitted to be attached directly to the organ structure without insulation supports. Abandoned cables that are not terminated at equipment shall be identified with a tag of sufficient durability to withstand the environment involved.

650.8 Overcurrent Protection

Circuits shall be so arranged that 20 AWG through 28 AWG conductors shall be protected by an overcurrent device rated at not more than 6 amperes. Other conductor sizes shall be protected in accordance with their ampacity. A common return conductor shall not require overcurrent protection.

650.9 Protection From Accidental Contact

The wiring of the pipe organ sounding apparatus shall be within the lockable enclosure (organ chamber) where the exterior pipes shall be permitted to form part of the enclosure.

Informational Note: Access to the pipe organ sounding apparatus and the associated circuitry is restricted by an enclosure. In most pipe organ installations, exterior pipes form part of the enclosure. In other installations, the pipes are covered by mill-work that permits the passage of sound.

Article 660 X-Ray Equipment

Part I General

660.1 Scope

This article covers all X-ray equipment operating at any frequency or voltage for industrial or other nonmedical or nondental use.

Informational Note: See Article 517, Part V, for X-ray installations in health care facilities.

Nothing in this article shall be construed as specifying safeguards against the useful beam or stray X-ray radiation.

Informational Note No. 1: Radiation safety and performance requirements of several classes of X-ray equipment are regulated under Public Law 90-602 and are enforced by the Department of Health and Human Services.

Informational Note No. 2: In addition, information on radiation protection by the National Council on Radiation Protection and Measurements is published as Reports of the National Council on Radiation Protection and Measurement. These reports can be obtained from NCRP Publications, 7910 Woodmont Ave., Suite 1016, Bethesda, MD 20814.

660.2 Definitions

The following definitions shall apply only within this article.

Long-Time Rating. A rating based on an operating interval of 5 minutes or longer.

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

Momentary Rating. A rating based on an operating interval that does not exceed 5 seconds.

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

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

660.3 Hazardous (Classified) Locations

Unless identified for the location, X-ray and related equipment shall not be installed or operated in hazardous (classified) locations.

Informational Note: See Article 517, Part IV.

660.4 Connection to Supply Circuit

(A) Fixed and Stationary Equipment

Fixed and stationary X-ray equipment shall be connected to the power supply by means of a wiring method meeting the general requirements of this Code. Equipment properly supplied by a branch circuit rated at not over 30 amperes shall be permitted to be supplied through a suitable attachment plug cap and hard-service cable or cord.

(B) Portable, Mobile, and Transportable Equipment

Individual branch circuits shall not be required for portable, mobile, and transportable X-ray equipment requiring a capacity of not over 60 amperes. Portable and mobile types of X-ray equipment of any capacity shall be supplied through a suitable hard-service cable or cord. Transportable X-ray equipment of any capacity shall be permitted to be connected to its power supply by suitable connections and hard-service cable or cord.

(C) Over 1000 Volts, Nominal

Circuits and equipment operated at more than 1000 volts, nominal, shall comply with Article 490.

660.5 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 located within sight from the X-ray control and readily accessible.

Exception: The disconnecting means for the X-ray equipment shall not be required under either of the following conditions, provided that the controller disconnecting means is lockable open in accordance with 110.25:

Where such a location of the disconnecting means for the X-ray equipment is impracticable or introduces additional or increased hazards to persons or property

In industrial installations, with written safety procedures, where conditions of maintenance and supervision ensure that only qualified persons service the equipment

660.6 Rating of Supply Conductors and Overcurrent Protection

(A) Branch-Circuit Conductors

The ampacity of supply branch-circuit conductors and the overcurrent protective devices shall not be less than 50 percent of the momentary rating or 100 percent of the long-time rating, whichever is greater.

(B) Feeder Conductors

The ampacity of conductors and the rating of overcurrent devices of a feeder for two or more branch circuits supplying X-ray units shall not be less than 100 percent of the momentary demand rating [as determined by 660.6(A)] of the two largest X-ray apparatus plus 20 percent of the momentary ratings of other X-ray apparatus.

Informational Note: The minimum conductor size for branch and feeder circuits is also governed by voltage regulation requirements. For a specific installation, the manufacturer usually specifies minimum distribution transformer and conductor sizes, rating of disconnect means, and overcurrent protection.

660.7 Wiring Terminals

X-ray equipment not provided with a permanently attached cord or cord set shall be provided with suitable wiring terminals or leads for the connection of power-supply conductors of the size required by the rating of the branch circuit for the equipment.

660.9 Minimum Size of Conductors

Size 18 AWG or 16 AWG fixture wires, as specified in 725.49, and flexible cords shall be permitted for the control and operating circuits of X-ray and auxiliary equipment where protected by not larger than 20-ampere overcurrent devices.

660.10 Equipment Installations

All equipment for new X-ray installations and all used or reconditioned X-ray equipment moved to and reinstalled at a new location shall be of an approved type.

Part II Control

660.20 Fixed and Stationary Equipment

(A) Separate Control Device

A separate control device, in addition to the disconnecting means, shall be incorporated in the X-ray control supply or in the primary circuit to the high-voltage transformer. This device shall be a part of the X-ray equipment but shall be permitted in a separate enclosure immediately adjacent to the X-ray control unit.

(B) Protective Device

A protective device, which shall be permitted to be incorporated into the separate control device, shall be provided to control the load resulting from failures in the high-voltage circuit.

660.21 Portable and Mobile Equipment

Portable and mobile equipment shall comply with 660.20, but the manually controlled device shall be located in or on the equipment.

660.23 Industrial and Commercial Laboratory Equipment

(A) 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.

(B) Diffraction and Irradiation Types

Diffraction-and irradiation-type equipment or installations not effectively enclosed or not provided with interlocks to prevent access to uninsulated live 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.

660.24 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.

Part III Transformers and Capacitors

660.35 General

Transformers and capacitors that are part of an X-ray equipment shall not be required to comply with Articles 450 and 460.

660.36 Capacitors

Capacitors shall be mounted within enclosures of insulating material or grounded metal.

Part IV Guarding and Grounding

660.47 General

(A) High-Voltage Parts

All high-voltage parts, including X-ray tubes, shall be mounted within grounded enclosures. Air, oil, gas, or other suitable insulating media shall be used to insulate the high voltage from the grounded enclosure. The connection from the high-voltage equipment to X-ray tubes and other high-voltage components shall be made with high-voltage shielded cables.

(B) Low-Voltage Cables

Low-voltage cables connecting to oil-filled units that are not completely sealed, such as transformers, condensers, oil coolers, and high-voltage switches, shall have insulation of the oil-resistant type.

660.48 Grounding

Non—current-carrying metal parts of X-ray and associated equipment (controls, tables, X-ray tube supports, transformer tanks, shielded cables, X-ray tube heads, and so forth) shall be grounded in the manner specified in Article 250. Portable and mobile equipment shall be provided with an approved grounding-type attachment plug cap.

Exception: Battery-operated equipment.

Article 665 Induction and Dielectric Heating Equipment

Part I General

665.1 Scope

This article covers the construction and installation of dielectric heating, induction heating, induction melting, and induction welding equipment and accessories for industrial and scientific applications. Medical or dental applications, appliances, or line frequency pipeline and vessel heating are not covered in this article.

Informational Note: See Article 427, Part V, for line frequency induction heating of pipelines and vessels.

665.2 Definitions

The following definitions shall apply only within this article.

Applicator. The device used to transfer energy between the output circuit and the object or mass to be heated.

Converting Device. That part of the heating equipment that converts input mechanical or electrical energy to the voltage, current, and frequency used for the heating applicator. A converting device consists of equipment using line frequency, all static multipliers, oscillator-type units using vacuum tubes, inverters using solid-state devices, or motor-generator equipment.

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

Heating Equipment. Any equipment that is used for heating purposes and whose heat is generated by induction or dielectric methods.

Induction Heating, Melting, and Welding. The heating, melting, or welding of a nominally conductive material due to its own I2R losses when the material is placed in a varying electromagnetic field.

665.4 Hazardous (Classified) Locations

Heating equipment shall not be installed in hazardous (classified) locations as defined in Article 500 unless the equipment and wiring are designed and approved for the hazardous (classified) locations.

665.5 Output Circuit

The output circuit shall include all output components external to the converting device, including contactors, switches, busbars, and other conductors. The current flow from the output circuit to ground under operating and ground-fault conditions shall be limited to a value that does not cause 50 volts or more to ground to appear on any accessible part of the heating equipment and its load. The output circuit shall be permitted to be isolated from ground.

665.7 Remote Control

(A) Multiple Control Points

Where multiple control points are used for applicator energization, a means shall be provided and interlocked so that the applicator can be energized from only one control point at a time. A means for de-energizing the applicator shall be provided at each control point.

(B) Foot Switches

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

665.10 Ampacity of Supply Conductors

The ampacity of supply conductors shall be determined by 665.10(A) or (B).

(A) Nameplate Rating

The ampacity of conductors supplying one or more pieces of equipment shall be not less than the sum of the nameplate ratings for the largest group of machines capable of simultaneous operation, plus 100 percent of the standby currents of the remaining machines. Where standby currents are not given on the nameplate, the nameplate rating shall be used as the standby current.

(B) Motor-Generator Equipment

The ampacity of supply conductors for motor-generator equipment shall be determined in accordance with Article 430, Part II.

665.11 Overcurrent Protection

Overcurrent protection for the heating equipment shall be provided as specified in Article 240. This overcurrent protection shall be permitted to be provided separately or as a part of the equipment.

665.12 Disconnecting Means

A readily accessible disconnecting means shall be provided to disconnect each heating equipment from its supply circuit. The disconnecting means shall be located within sight from the controller or be lockable open in accordance with 110.25.

The rating of this disconnecting means shall not be less than the nameplate rating of the heating equipment. Motor-generator equipment shall comply with Article 430, Part IX. The supply circuit disconnecting means shall be permitted to serve as the heating equipment disconnecting means where only one heating equipment is supplied.

Part II Guarding, Grounding, and Labeling

665.19 Component Interconnection

The interconnection components required for a complete heating equipment installation shall be guarded.

665.20 Enclosures

The converting device (excluding the component interconnections) shall be completely contained within an enclosure(s) of noncombustible material.

665.21 Control Panels

All control panels shall be of dead-front construction.

665.22 Access to Internal Equipment

Access doors or detachable access panels shall be employed for internal access to heating equipment. Access doors to internal compartments containing equipment employing voltages from 150 volts to 1000 volts ac or dc shall be capable of being locked closed or shall be interlocked to prevent the supply circuit from being energized while the door(s) is open. The provision for locking or adding a lock to the access doors shall be installed on or at the access door and shall remain in place with or without the lock installed.

Access doors to internal compartments containing equipment employing voltages exceeding 1000 volts ac or dc shall be provided with a disconnecting means equipped with mechanical lockouts to prevent access while the heating equipment is energized, or the access doors shall be capable of being locked closed and interlocked to prevent the supply circuit from being energized while the door(s) is open. Detachable panels not normally used for access to such parts shall be fastened in a manner that makes them inconvenient to remove.

665.23 Hazard Labels or Signs

Labels or signs that read "DANGER — HIGH VOLTAGE — KEEP OUT" shall be attached to the equipment and shall be plainly visible where persons might come in contact with energized parts when doors are open or closed or when panels are removed from compartments containing over 150 volts ac or dc. Hazard signs or labels shall comply with 110.21(B).

665.24 Capacitors

The time and means of discharge shall be in accordance with 460.6 for capacitors rated 600 volts, nominal, and under. The time and means of discharge shall be in accordance with 460.28 for capacitors rated over 600 volts, nominal. Capacitor internal pressure switches connected to a circuit-interrupter device shall be permitted for capacitor over-current protection.

665.25 Dielectric Heating Applicator Shielding

Protective cages or adequate shielding shall be used to guard dielectric heating applicators. 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.

665.26 Grounding and Bonding

Bonding to the equipment grounding conductor or inter-unit bonding, or both, shall be used wherever required for circuit operation, and for limiting to a safe value radio frequency voltages between all exposed non—current-carrying parts of the equipment and earth ground, between all equipment parts and surrounding objects, and between such objects and earth ground. Such connection to the equipment grounding conductor and bonding shall be installed in accordance with Article 250, Parts II and V.

Informational Note: Under certain conditions, contact between the object being heated and the applicator results in an unsafe condition, such as eruption of heated materials. Grounding of the object being heated and ground detection can be used to prevent this unsafe condition.

665.27 Marking

Each heating equipment shall be provided with a nameplate giving the manufacturer's name and model identification and the following input data: line volts, frequency, number of phases, maximum current, full-load kilovolt-amperes (kVA), and full-load power factor. Additional data shall be permitted.

Article 668 Electrolytic Cells

668.1 Scope

This article applies 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.

Not covered by this article are cells used as a source of electric energy and for electroplating processes and cells used for the production of hydrogen.

Informational Note No. 1: In general, any cell line or group of cell lines operated as a unit for the production of a particular metal, gas, or chemical compound may differ from any other cell lines producing the same product because of variations in the particular raw materials used, output capacity, use of proprietary methods or process practices, or other modifying factors to the extent that detailed Code requirements become overly restrictive and do not accomplish the stated purpose of this Code.

Informational Note No. 2: For further information, see IEEE 463-2013, Standard for Electrical Safety Practices in Electrolytic Cell Line Working Zones.

668.2 Definitions

The following definitions shall apply only within this article.

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

Cell Line Attachments and Auxiliary Equipment. A term that includes, but is 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.

Electrically Connected. A connection capable of carrying current as distinguished from connection through electromagnetic induction.

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

Electrolytic Cell Line Working Zone. 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.

668.3 Other Articles

(A) Lighting, Ventilating, Material Handling

Chapters 1 through 4 shall apply to services, feeders, branch circuits, and apparatus for supplying lighting, ventilating, material handling, and the like that are outside the electrolytic cell line working zone.

(B) Systems Not Electrically Connected

Those elements of a cell line power-supply system that are not electrically connected to the cell supply system, such as the primary winding of a two-winding transformer, the motor of a motor-generator set, feeders, branch circuits, disconnecting means, motor controllers, and overload protective equipment, shall be required to comply with all applicable sections of this Code.

(C) Electrolytic Cell Lines

Electrolytic cell lines shall comply with the provisions of Chapters 1 through 4 except as amended in 668.3(C)(1) through (C)(4).

(1) Conductors

The electrolytic cell line conductors shall not be required to comply with Articles 110, 210, 215, 220, and 225. See 668.12.

(2) Overcurrent Protection

Overcurrent protection of electrolytic cell dc process power circuits shall not be required to comply with the requirements of Article 240.

(3) Grounding

Except as required by this article, 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 Article 250.

(4) Working Zone

The electrolytic cells, cell line attachments, and the wiring of auxiliary equipment and devices within the cell line working zone shall not be required to comply with Articles 110, 210, 215, 220, and 225. See 668.30.

Informational Note: See 668.15 for equipment, apparatus, and structural component grounding.

668.10 Cell Line Working Zone

(A) Area Covered

The space envelope of the cell line working zone shall encompass spaces that meet any of the following conditions:

Is within 2.5 m (96 in.) above energized surfaces of electrolytic cell lines or their energized attachments

Is below energized surfaces of electrolytic cell lines or their energized attachments, provided the headroom in the space beneath is less than 2.5 m (96 in.)

Is within 1.0 m (42 in.) horizontally from energized surfaces of electrolytic cell lines or their energized attachments or from the space envelope described in 668.10(A)(1) or (A)(2)

(B) Area Not Covered

The cell line working zone shall not be required to extend through or beyond walls, floors, roofs, partitions, barriers, or the like.

668.11 Direct-Current Cell Line Process Power Supply

(A) Not Grounded

The direct-current cell line process power-supply conductors shall not be required to be grounded.

(B) Metal Enclosures Grounded

All metal enclosures of power-supply apparatus for the direct-current cell line process operating with a power supply over 50 volts shall be grounded by either of the following means:

Through protective relaying equipment

By a minimum 2/0 AWG copper grounding electrode conductor or a conductor of equal or greater conductance

(C) Grounding Requirements

The grounding electrode connections required by 668.11(B) shall be installed in accordance with 250.8, 250.10, 250.12, 250.68, and 250.70.

668.12 Cell Line Conductors

(A) Insulation and Material

Cell line conductors shall be either bare, covered, or insulated and of copper, aluminum, copper-clad aluminum, steel, or other suitable material.

(B) Size

Cell line conductors shall be of such cross-sectional area that the temperature rise under maximum load conditions and at maximum ambient shall not exceed the safe operating temperature of the conductor insulation or the material of the conductor supports.

(C) Connections

Cell line conductors shall be joined by bolted, welded, clamped, or compression connectors.

668.13 Disconnecting Means

(A) More Than One Process Power Supply

Where more than one direct-current 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.

(B) Removable Links or Conductors

Removable links or removable conductors shall be permitted to be used as the disconnecting means.

668.14 Shunting Means

(A) Partial or Total Shunting

Partial or total shunting of cell line circuit current around one or more cells shall be permitted.

(B) Shunting One or More Cells

The conductors, switches, or combination of conductors and switches used for shunting one or more cells shall comply with the applicable requirements of 668.12.

668.15 Grounding

For equipment, apparatus, and structural components that are required to be grounded in accordance with Article 668, Article 250, Part III, for a local grounding electrode system shall apply, except a water pipe electrode shall not be required to be used. Any electrode or combination of electrodes described in 250.52 shall be permitted.

668.20 Portable Electrical Equipment

(A) Portable Electrical Equipment Not to Be Grounded

The frames and enclosures of portable electrical 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.

(B) Isolating Transformers

Electrically powered, hand-held, cord-connected portable equipment with ungrounded frames or enclosures used within the cell line working zone shall be connected to receptacle circuits that have only ungrounded conductors such as a branch circuit supplied by an isolating transformer with an ungrounded secondary.

(C) Marking

Ungrounded portable electrical 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 equipment.

668.21 Power-Supply Circuits and Receptacles for Portable Electrical Equipment

(A) Isolated Circuits

Circuits supplying power to ungrounded receptacles for hand-held, cord-connected equipment 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 1000 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.

(B) Noninterchangeability

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

(C) Marking

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

668.30 Fixed and Portable Electrical Equipment

(A) Electrical Equipment Not Required to Be Grounded

Alternating-current systems supplying fixed and portable electrical equipment within the cell line working zone shall not be required to be grounded.

(B) Exposed Conductive Surfaces Not Required to Be Grounded

Exposed conductive surfaces, such as electrical equipment housings, cabinets, boxes, motors, raceways, and the like, that are within the cell line working zone shall not be required to be grounded.

(C) 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:

Multiconductor hard usage cord.

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 do not cause a potentially hazardous electrical condition.

(D) Circuit Protection

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

(E) Bonding

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

668.31 Auxiliary Nonelectrical Connections

Auxiliary nonelectrical connections, such as air hoses, water hoses, and the like, to an electrolytic cell, its attachments, or auxiliary equipment shall not have continuous conductive reinforcing wire, armor, braids, and the like. Hoses shall be of a nonconductive material.

668.32 Cranes and Hoists

(A) 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.

(B) Hazardous Electrical Conditions

Remote crane or hoist controls that could introduce hazardous electrical conditions into the cell line working zone shall employ one or more of the following systems:

Isolated and ungrounded control circuit in accordance with 668.21(A)

Nonconductive rope operator

Pendant pushbutton with nonconductive supporting means and having nonconductive surfaces or ungrounded exposed conductive surfaces

Radio

668.40 Enclosures

General-purpose electrical equipment enclosures shall be permitted where a natural draft ventilation system prevents the accumulation of gases.

Article 669 Electroplating

669.1 Scope

This article applies to the installation of the electrical components and accessory equipment that supply the power and controls for electroplating, anodizing, electropolishing, and electrostripping. For purposes of this article, the term electroplating shall be used to identify any or all of these processes.

669.3 General

Equipment for use in electroplating processes shall be identified for such service.

669.5 Branch-Circuit Conductors

Branch-circuit conductors supplying one or more units of equipment shall have an ampacity of not less than 125 percent of the total connected load. The ampacities for busbars shall be in accordance with 366.23.

669.6 Wiring Methods

Conductors connecting the electrolyte tank equipment to the conversion equipment shall be in accordance with 669.6(A) and (B).

(A) Systems Not Exceeding 60 Volts Direct Current

Insulated conductors shall be permitted to be run without insulated support, provided they are protected from physical damage. Bare copper or aluminum conductors shall be permitted where supported on insulators.

(B) Systems Exceeding 60 Volts Direct Current

Insulated conductors shall be permitted to be run on insulated supports, provided they are protected from physical damage. Bare copper or aluminum conductors shall be permitted where supported on insulators and guarded against accidental contact up to the point of termination in accordance with 110.27.

669.7 Warning Signs

Warning signs shall be posted to indicate the presence of bare conductors. The warning sign(s) or label(s) shall comply with 110.21(B).

669.8 Disconnecting Means

(A) More Than One Power Supply

Where more than one power supply serves the same dc system, a disconnecting means shall be provided on the dc side of each power supply.

(B) Removable Links or Conductors

Removable links or removable conductors shall be permitted to be used as the disconnecting means.

669.9 Overcurrent Protection

Direct-current conductors shall be protected from overcurrent by one or more of the following:

Fuses or circuit breakers

A current-sensing device that operates a disconnecting means

Other approved means

Article 670 Industrial Machinery

670.1 Scope

This article covers the definition of, the nameplate data for, and the size and overcurrent protection of supply conductors to industrial machinery.

Informational Note No. 1: For further information, see NFPA 79-2018, Electrical Standard for Industrial Machinery.

Informational Note No. 2: For information on the workspace requirements for equipment containing supply conductor terminals, see 110.26. For information on the workspace requirements for machine power and control equipment, see NFPA 79-2018, Electrical Standard for Industrial Machinery.

670.2 Definition

This definition shall apply within this article and throughout the Code.

Industrial Machinery (Machine). A power-driven machine (or a group of machines working together in a coordinated manner), not portable by hand while working, that is used to process material by cutting; forming; pressure; electrical, thermal, or optical techniques; lamination; or a combination of these processes. It can include associated equipment used to transfer material or tooling, including fixtures, to assemble/disassemble, to inspect or test, or to package. [The associated electrical equipment, including the logic controller(s) and associated software or logic together with the machine actuators and sensors, are considered as part of the industrial machine.]

670.3 Machine Nameplate Data

Informational Note: See 430.22(E) and 430.26 for duty cycle requirements.

(A) Permanent Nameplate

A permanent nameplate shall be attached to the control equipment enclosure or machine and shall be plainly visible after installation. The nameplate shall include the following information:

Supply voltage, number of phases, frequency, and full-load current

Maximum ampere rating of the short-circuit and ground-fault protective device

Ampere rating of largest motor, from the motor nameplate, or load

Short-circuit current rating of the machine industrial control panel based on one of the following:

Short-circuit current rating of a listed and labeled machine control enclosure or assembly

Short-circuit current rating established utilizing an approved method

Informational Note: UL 508A-2017, Standard for Industrial Control Panels, Supplement SB, is an example of an approved method.

Electrical diagram number(s) or the number of the index to the electrical drawings

The full-load current shown on the nameplate shall not be less than the sum of the full-load currents required for all motors and other equipment that may be in operation at the same time under normal conditions of use. Where unusual type loads, duty cycles, and so forth require oversized conductors or permit reduced-size conductors, the required capacity shall be included in the marked "full-load current." Where more than one incoming supply circuit is to be provided, the nameplate shall state the preceding information for each circuit.

(B) Overcurrent Protection

Where overcurrent protection is provided in accordance with 670.4(C), the machine shall be marked "overcurrent protection provided at machine supply terminals."

670.4 Supply Conductors and Overcurrent Protection

(A) Size

The size of the supply conductor shall be such as to have an ampacity not less than 125 percent of the full-load current rating of all resistance heating loads plus 125 percent of the full-load current rating of the highest rated motor plus the sum of the full-load current ratings of all other connected motors and apparatus, based on their duty cycle, that may be in operation at the same time.

Informational Note No. 1: See Table 310.16 through Table 310.20 for ampacity of conductors rated 2000 volts and below.

Informational Note No. 2: See 430.22(E) and 430.26 for duty cycle requirements.

(B) Disconnecting Means

A machine shall be considered as an individual unit and therefore shall be provided with disconnecting means. The disconnecting means shall be permitted to be supplied by branch circuits protected by either fuses or circuit breakers. The disconnecting means shall not be required to incorporate overcurrent protection.

(C) Overcurrent Protection

Where furnished as part of the machine, overcurrent protection for each supply circuit shall consist of a single circuit breaker or set of fuses, the machine shall bear the marking required in 670.3, and the supply conductors shall be considered either as feeders or as taps as covered by 240.21.

The rating or setting of the overcurrent protective device for the circuit supplying the machine shall not be greater than the sum of the largest rating or setting of the branch-circuit short-circuit and ground-fault protective device provided with the machine, plus 125 percent of the full-load current rating of all resistance heating loads, plus the sum of the full-load currents of all other motors and apparatus that could be in operation at the same time.

Exception: Where one or more instantaneous trip circuit breakers or motor short-circuit protectors are used for motor branch-circuit short-circuit and ground-fault protection as permitted by 430.52(C), the procedure specified in 670.4(C) for determining the maximum rating of the protective device for the circuit supplying the machine shall apply with the following provision: For the purpose of the calculation, each instantaneous trip circuit breaker or motor short-circuit protector shall be assumed to have a rating not exceeding the maximum percentage of motor full-load current permitted by Table 430.52 for the type of machine supply circuit protective device employed.

Where no branch-circuit short-circuit and ground-fault protective device is provided with the machine, the rating or setting of the overcurrent protective device shall be based on 430.52 and 430.53, as applicable.

670.5 Short-Circuit Current Rating

(1)

Industrial machinery shall not be installed where the available fault current exceeds its short-circuit current rating as marked in accordance with 670.3(A)(4).

(2)

Industrial machinery shall be legibly marked in the field with the available fault current. The field marking(s) shall include the date the available fault current calculation was performed and be of sufficient durability to withstand the environment involved.

670.6 Surge Protection

Industrial machinery with safety interlock control devices not effectively protected from voltage surges on the incoming supply circuit shall have surge protection installed.

Article 675 Electrically Driven or Controlled Irrigation Machines

Part I General

675.1 Scope

This article applies to electrically driven or controlled irrigation machines, and to the branch circuits and controllers for such equipment.

675.2 Definitions

The definitions in this section shall apply only within this article.

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.

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

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.

675.4 Irrigation Cable

(A) Construction

The cable used to interconnect enclosures on the structure of an irrigation machine shall be an assembly of stranded, insulated conductors with nonhygroscopic and nonwicking filler in a core of moisture-and flame-resistant nonmetallic material overlaid with a metallic covering and jacketed with a moisture-, corrosion-, and sunlight-resistant nonmetallic material.

The conductor insulation shall be of a type listed in Table 310.4(A) for an operating temperature of 75°C (167°F) or higher and for use in wet locations. The core insulating material thickness shall not be less than 0.76 mm (30 mils), and the metallic overlay thickness shall be not less than 0.20 mm (8 mils). The jacketing material thickness shall be not less than 1.27 mm (50 mils).

A composite of power, control, and grounding conductors in the cable shall be permitted.

(B) Alternate Wiring Methods

Installation of other listed cables complying with the construction requirements of 675.4(A) shall be permitted.

(C) Supports

Irrigation cable shall be secured by straps, hangers, or similar fittings identified for the purpose and so installed as not to damage the cable. Cable shall be supported at intervals not exceeding 1.2 m (4 ft).

(D) Fittings

Fittings shall be used at all points where irrigation cable terminates. The fittings shall be designed for use with the cable and shall be suitable for the conditions of service.

675.5 More Than Three Conductors in a Raceway or Cable

The signal and control conductors of a raceway or cable shall not be counted for the purpose of ampacity adjustment as required in 310.15(C)(1).

675.6 Marking on Main Control Panel

The main control panel shall be provided with a nameplate giving the following information:

The manufacturer's name, the rated voltage, the phase, and the frequency

The current rating of the machine

The rating of the main disconnecting means and size of overcurrent protection required

675.7 Equivalent Current Ratings

Where intermittent duty is not involved, Article 430 shall be used for determining ratings for controllers, disconnecting means, conductors, and the like. Where irrigation machines have inherent intermittent duty, the determinations of equivalent current ratings in 675.7(A) and (B) shall be used.

(A) Continuous-Current Rating

The equivalent continuous-current rating for the selection of branch-circuit conductors and overcurrent protection shall be equal to 125 percent of the motor nameplate full-load current rating of the largest motor, plus a quantity equal to the sum of each of the motor nameplate full-load current ratings of all remaining motors on the circuit, multiplied by the maximum percent duty cycle at which they can continuously operate.

(B) Locked-Rotor Current

The equivalent locked-rotor current rating shall be equal to the numerical sum of the locked-rotor current of the two largest motors plus 100 percent of the sum of the motor nameplate full-load current ratings of all the remaining motors on the circuit.

675.8 Disconnecting Means

(A) Main Controller

A controller that is used to start and stop the complete machine shall meet all of the following requirements:

An equivalent continuous current rating not less than specified in 675.7(A) or 675.22(A)

A horsepower rating not less than the value from Table 430.251(A) and Table 430.251(B), based on the equivalent locked-rotor current specified in 675.7(B) or 675.22(B)

Exception: A listed molded case switch shall not require a horsepower rating.

(B) Main Disconnecting Means

The main disconnecting means for the machine shall provide overcurrent protection, shall be at the point of connection of electric power to the machine, or shall be in sight from the machine, and it shall be readily accessible and lockable open in accordance with 110.25. This disconnecting means shall have a horsepower and current rating not less than required for the main controller.

Exception No. 1: Circuit breakers without marked horsepower ratings shall be permitted in accordance with 430.109.

Exception No. 2: A listed molded case switch without marked horsepower ratings shall be permitted.

(C) Disconnecting Means for Individual Motors and Controllers

A disconnecting means shall be provided to simultaneously disconnect all ungrounded conductors for each motor and controller and shall be located as required by Article 430, Part IX. The disconnecting means shall not be required to be readily accessible.

675.9 Branch-Circuit Conductors

The branch-circuit conductors shall have an ampacity not less than specified in 675.7(A) or 675.22(A).

675.10 Several Motors on One Branch Circuit

(A) Protection Required

Several motors, each not exceeding 2 hp rating, shall be permitted to be used on an irrigation machine circuit protected at not more than 30 amperes at 1000 volts, nominal, or less, provided all of the following conditions are met:

The full-load rating of any motor in the circuit shall not exceed 6 amperes.

Each motor in the circuit shall have individual overload protection in accordance with 430.32.

Taps to individual motors shall not be smaller than 14 AWG copper and not more than 7.5 m (25 ft) in length.

(B) Individual Protection Not Required

Individual branch-circuit short-circuit protection for motors and motor controllers shall not be required where the requirements of 675.10(A) are met.

675.11 Collector Rings

(A) Transmitting Current for Power Purposes

Collector rings shall have a current rating not less than 125 percent of the full-load current of the largest device served plus the full-load current of all other devices served, or as determined from 675.7(A) or 675.22(A).

(B) Control and Signal Purposes

Collector rings for control and signal purposes shall have a current rating not less than 125 percent of the full-load current of the largest device served plus the full-load current of all other devices served.

(C) Grounding

The collector ring used for grounding shall have a current rating not less than that sized in accordance with 675.11(A).

(D) Protection

Collector rings shall be protected from the expected environment and from accidental contact by means of a suitable enclosure.

675.12 Grounding

The following equipment shall be grounded:

All electrical equipment on the irrigation machine

All electrical equipment associated with the irrigation machine

Metal junction boxes and enclosures

Control panels or control equipment that supplies or controls electrical equipment to the irrigation machine

Exception: Grounding shall not be required on machines where all of the following provisions are met:

The machine is electrically controlled but not electrically driven.

The control voltage is 30 volts or less.

The control or signal circuits are current limited as specified in Chapter 9, Tables 11(A) and 11(B).

675.13 Methods of Grounding

Machines that require grounding shall have a non—current-carrying equipment grounding conductor provided as an integral part of each cord, cable, or raceway. This equipment grounding conductor shall be sized not less than the largest supply conductor in each cord, cable, or raceway. Feeder circuits supplying power to irrigation machines shall have an equipment grounding conductor sized according to Table 250.122.

675.14 Bonding

Where electrical grounding is required on an irrigation machine, the metallic structure of the machine, metallic conduit, or metallic sheath of cable shall be connected to the equipment grounding conductor. Metal-to-metal contact with a part that is connected to the equipment grounding conductor and the non—current-carrying parts of the machine shall be considered as an acceptable bonding path.

675.15 Lightning Protection

If an irrigation machine has a stationary point, a grounding electrode system in accordance with Article 250, Part III, shall be connected to the machine at the stationary point for lightning protection.

675.16 Energy From More Than One Source

Equipment within an enclosure receiving electric energy from more than one source shall not be required to have a disconnecting means for the additional source if its voltage is 30 volts or less and it meets the requirements of Part III of Article 725.

675.17 Connectors

External plugs and connectors on the equipment shall be of the weatherproof type.

Unless provided solely for the connection of circuits meeting the requirements of Part III of Article 725, external plugs and connectors shall be constructed as specified in 250.124(A).

Part II Center Pivot Irrigation Machines

675.21 General

Part II covers additional special requirements that are peculiar to center pivot irrigation machines. See 675.2 for the definition of Center Pivot Irrigation Machine.

675.22 Equivalent Current Ratings

To establish ratings of controllers, disconnecting means, conductors, and the like, for the inherent intermittent duty of center pivot irrigation machines, the determinations in 675.22(A) and (B) shall be used.

(A) Continuous-Current Rating

The equivalent continuous-current rating for the selection of branch-circuit conductors and branch-circuit devices shall be equal to 125 percent of the motor nameplate full-load current rating of the largest motor plus 60 percent of the sum of the motor nameplate full-load current ratings of all remaining motors on the circuit.

(B) Locked-Rotor Current

The equivalent locked-rotor current rating shall be equal to the numerical sum of two times the locked-rotor current of the largest motor plus 80 percent of the sum of the motor nameplate full-load current ratings of all the remaining motors on the circuit.

Article 680 Swimming Pools, Fountains, and Similar Installations

Upcodes Diagrams

Part I General

680.1 Scope

The provisions of this article apply to the construction and installation of electrical 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. The term body of water used throughout Part I applies to all bodies of water covered in this scope unless otherwise amended.

680.2 Definitions

The definitions in this section shall apply only within this article.

Cord-and-Plug-Connected Lighting Assembly. A lighting assembly consisting of a luminaire intended for installation in the wall of a spa, hot tub, or storable pool, and a cord-and-plug-connected transformer.

Corrosive Environment. Areas where pool sanitation chemicals are stored, handled, or dispensed, and confined areas under decks adjacent to such areas, as well as areas with circulation pumps, automatic chlorinators, filters, open areas under decks adjacent to or abutting the pool structure, and similar locations.

Informational Note: Sanitation chemicals and pool water are considered to pose a risk of corrosion (gradually damage or destroy materials) due to the presence of oxidizers (e.g., calcium hypochlorite, sodium hypochlorite, bromine, chlorinated isocyanurates) and chlorinating agents that release chlorine when dissolved in water. More information about swimming pool chemicals can be found on or in the following:

Environmental Protection Agency website

NFPA 400-2019, Hazardous Materials Code

Advisory: Swimming Pool Chemicals: Chlorine, OSWER 90-008.1, June 1990, available from the EPA National Service Center for Environmental Publications (NSCEP)

Dry-Niche Luminaire. A luminaire intended for installation in the floor or wall of a pool, spa, or fountain in a niche that is sealed against the entry of water.

Electrically Powered Pool Lift. An electrically powered lift that provides accessibility to and from a pool or spa for people with disabilities.

Fixed (as applied to equipment). Equipment that is fastened or otherwise secured at a specific location.

Forming Shell. A structure designed to support a wet-niche luminaire assembly and intended for mounting in a pool or fountain structure.

Fountain. An ornamental structure or recreational water feature from which one or more jets or streams of water are discharged into the air, including splash pads, ornamental pools, display pools, and reflection pools. The definition does not include drinking water fountains or water coolers.

Hydromassage Bathtub. A permanently installed bathtub equipped with a recirculating piping system, pump, and associated equipment. It is designed so it can accept, circulate, and discharge water upon each use.

Immersion Pool. A pool for ceremonial or ritual immersion of users, which is designed and intended to have its contents drained or discharged.

Low Voltage Contact Limit. A voltage not exceeding the following values:

15 volts (RMS) for sinusoidal ac

21.2 volts peak for nonsinusoidal ac

30 volts for continuous dc

12.4 volts peak for dc that is interrupted at a rate of 10 to 200 Hz

Maximum Water Level. The highest level that water can reach before it spills out.

No-Niche Luminaire. A luminaire intended for installation above or below the water without a niche.

Packaged Spa or Hot Tub Equipment Assembly. A factory-fabricated unit consisting of water-circulating, heating, and control equipment mounted on a common base, intended to operate a spa or hot tub. Equipment can include pumps, air blowers, heaters, lights, controls, sanitizer generators, and so forth.

Packaged Therapeutic Tub or Hydrotherapeutic Tank Equipment Assembly. A factory-fabricated unit consisting of water-circulating, heating, and control equipment mounted on a common base, intended to operate a therapeutic tub or hydrotherapeutic tank. Equipment can include pumps, air blowers, heaters, lights, controls, sanitizer generators, and so forth.

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, Immersion, and Therapeutic Pools. Those that are constructed in the ground or partially in the ground, and all others capable of holding water in a depth greater than 1.0 m (42 in.), and all pools installed inside of a building, regardless of water depth, whether or not served by electrical circuits of any nature.

Pool. Manufactured or field-constructed equipment designed to contain water on a permanent or semipermanent basis and used for swimming, wading, immersion, or therapeutic purposes.

Pool Cover, Electrically Operated. Motor-driven equipment designed to cover and uncover the water surface of a pool by means of a flexible sheet or rigid frame.

Portable (as applied to equipment). Equipment that is actually moved or can easily be moved from one place to another in normal use.

Self-Contained Spa or Hot Tub. Factory-fabricated unit consisting of a spa or hot tub vessel with all water-circulating, heating, and control equipment integral to the unit. Equipment can include pumps, air blowers, heaters, lights, controls, sanitizer generators, and so forth.

Self-Contained Therapeutic Tubs or Hydrotherapeutic Tanks. A factory-fabricated unit consisting of a therapeutic tub or hydrotherapeutic tank with all water-circulating, heating, and control equipment integral to the unit. Equipment may include pumps, air blowers, heaters, light controls, sanitizer generators, and so forth.

Spa or Hot Tub. A hydromassage pool, or tub for recreational or therapeutic use, not located in health care facilities, designed for immersion of users, and usually having a filter, heater, and motor-driven blower. It may be installed indoors or outdoors, on the ground or supporting structure, or in the ground or supporting structure. Generally, a spa or hot tub is not designed or intended to have its contents drained or discharged after each use.

Splash Pad. A fountain with a pool depth 25 mm (1 in.) or less, intended for recreational use by pedestrians. This definition does not include showers intended for hygienic rinsing prior to use of a pool, spa, or other water feature.

Stationary (as applied to equipment). Equipment that is not moved from one place to another in normal use.

Storable Swimming, Wading, or Immersion Pools; or Storable/Portable Spas and Hot Tubs. Swimming, wading, or immersion pools that are intended to be stored when not in use, constructed on or above the ground and are capable of holding water to a maximum depth of 1.0 m (42 in.), or a pool, spa, or hot tub constructed on or above the ground, with nonmetallic, molded polymeric walls or inflatable fabric walls regardless of dimension.

Through-Wall Lighting Assembly. A lighting assembly intended for installation above grade, on or through the wall of a pool, consisting of two interconnected groups of components separated by the pool wall.

Wet-Niche Luminaire. A luminaire intended for installation in a forming shell mounted in a pool or fountain structure where the luminaire will be completely surrounded by water.

680.3 Approval of Equipment

All electrical equipment and products covered by this article shall be installed in compliance with this article and shall be listed.

680.4 Inspections After Installation

The authority having jurisdiction shall be permitted to require periodic inspection and testing.

680.5 Ground-Fault Circuit Interrupters

Ground-fault circuit interrupters (GFCIs) shall be self-contained units, circuit-breaker or receptacle types, or other listed types. The GFCI requirements in this article, unless otherwise noted, are in addition to the requirements in 210.8.

680.6 Bonding and Equipment Grounding

Electrical equipment shall be bonded in accordance with Part V of Article 250 and shall meet the equipment grounding requirements of Parts VI and VII of Article 250. The equipment shall be connected by the wiring methods in Chapter 3, except as modified by this article. Equipment subject to these requirements shall include the following:

Through-wall lighting assemblies and underwater luminaires, other than those low-voltage lighting products listed for the application without an equipment grounding conductor

All electrical equipment located within 1.5 m (5 ft) of the inside wall of the specified body of water

All electrical equipment associated with the recirculating system of the specified body of water

Junction boxes

Transformer and power supply enclosures

Ground-fault circuit interrupters

Panelboards that are not part of the service equipment and that supply any electrical equipment associated with the specified body of water

680.7 Bonding and Equipment Grounding Terminals

Terminals used for bonding and equipment grounding shall be identified for use in wet and corrosive environments. Field-installed terminals in a damp, wet, or corrosive environment shall be composed of copper, copper alloy, or stainless steel and shall be listed for direct burial use.

680.8 Cord-and-Plug-Connected Equipment

Fixed or stationary equipment, other than underwater luminaires, for a permanently installed pool shall be permitted to be connected with a flexible cord and plug to facilitate the removal or disconnection for maintenance or repair.

(A) Length

For other than storable pools, the flexible cord shall not exceed 900 mm (3 ft) in length.

(B) Equipment Grounding

The flexible cord shall have a copper equipment grounding conductor sized in accordance with 250.122 but not smaller than 12 AWG. The cord shall terminate in a grounding-type attachment plug.

(C) Construction

The equipment grounding conductors shall be connected to a fixed metal part of the assembly. The removable part shall be mounted on or bonded to the fixed metal part.

680.9 Overhead Conductor Clearances

Overhead conductors shall meet the clearance requirements in this section. Where a minimum clearance from the water level is given, the measurement shall be taken from the maximum water level of the specified body of water.

(A) Power

With respect to overhead conductors and open overhead wiring, swimming pool and similar installations shall comply with the minimum clearances given in Table 680.9(A) and illustrated in Figure 680.9(A).

Informational Note: Open overhead wiring as used in this article refers to conductor(s) not in an enclosed raceway.

FIGURE 680.9(A) Clearances from Pool Structures.

Table 680.9(A) Overhead Conductor Clearances

Clearance Parameters Insulated Cables, 0—750 Volts to Ground, Supported on and Cabled Together with a Solidly Grounded Bare Messenger or Solidly Grounded Neutral Conductor All Other Conductors Voltage to Ground

0 through 15 kV Over 15 through 50 kV

m ft m ft m ft

A. Clearance in any direction to the water level, edge of water surface, base of diving platform, or permanently anchored raft 6.9 22.5 7.5 25 8.0 27

B. Clearance in any direction to the observation stand, tower, or diving platform 4.4 14.5 5.2 17 5.5 18

C. Horizontal limit of clearance measured from inside wall of the pool This limit shall extend to the outer edge of the structures listed in A and B of this table but not less than 3 m (10 ft).

(B) Communications Systems

Communications, radio, and television coaxial cables within the scope of Articles 805 through 820 shall be permitted at a height of not less than 3.0 m (10 ft) above the maximum water level of swimming and wading pools, and diving structures, observation stands, towers, or platforms.

(C) Network-Powered Broadband Communications Systems

The minimum clearances for overhead network-powered broadband communications systems conductors from pools or fountains shall comply with the provisions in Table 680.9(A) for conductors operating at 0 to 750 volts to ground.

680.10 Electric Pool Water Heaters

All electric pool water heaters shall have the heating elements subdivided into loads not exceeding 48 amperes and protected at not over 60 amperes. The ampacity of the branch-circuit conductors and the rating or setting of overcurrent protective devices shall not be less than 125 percent of the total nameplate-rated load.

680.11 Underground Wiring

Underground wiring shall comply with 680.11(A) through (C).

(A) Underground Wiring

Underground wiring within 1.5 m (5 ft) horizontally from the inside wall of the pool shall be permitted. The following wiring methods shall be considered suitable for the conditions in these locations:

Rigid metal conduit

Intermediate metal conduit

Rigid polyvinyl chloride conduit

Reinforced thermosetting resin conduit

Jacketed Type MC cable that is listed for burial use

Liquidtight flexible nonmetallic conduit listed for direct burial use

Liquidtight flexible metal conduit listed for direct burial use

(B) Wiring Under Pools

Underground wiring shall not be permitted under the pool unless this wiring is necessary to supply pool equipment permitted by this article.

(C) Minimum Cover Requirements

Minimum cover depths shall be as given in Table 300.5.

680.12 Equipment Rooms and Pits

Electrical equipment shall not be installed in rooms or pits that do not have drainage that prevents water accumulation during normal operation or filter maintenance. Equipment shall be suitable for the environment in accordance with 300.6.

Informational Note: Chemicals such as chlorine cause severe corrosive and deteriorating effects on electrical connections, equipment, and enclosures when stored and kept in the same vicinity. Adequate ventilation of indoor spaces such as equipment and storage rooms is addressed by ANSI/APSP-11, Standard for Water Quality in Public Pools and Spas, and can reduce the likelihood of the accumulation of corrosive vapors.

680.13 Maintenance Disconnecting Means

One or more means to simultaneously disconnect all ungrounded conductors shall be provided for all utilization equipment other than lighting. Each means shall be readily accessible and within sight from its equipment and shall be located at least 1.5 m (5 ft) horizontally from the inside walls of a pool, spa, fountain, or hot tub unless separated from the open water by a permanently installed barrier that provides a 1.5 m (5 ft) reach path or greater. This horizontal distance shall be measured from the water's edge along the shortest path required to reach the disconnect.

680.14 Wiring Methods in Corrosive Environment

Wiring methods in a corrosive environment shall be listed and identified for use in such areas. Rigid metal conduit, intermediate metal conduit, rigid polyvinyl chloride conduit, and reinforced thermosetting resin conduit shall be considered to be resistant to the corrosive environment.

Part II Permanently Installed Pools

680.20 General

Electrical installations at permanently installed pools shall comply with the provisions of Part I and Part II of this article.

680.21 Motors

(A) Wiring Methods

The wiring to a pool motor shall comply with 680.21(A)(1) unless modified for specific circumstances by (A)(2) or (A)(3).

(1) General

Wiring methods installed in a corrosive environment shall comply with 680.14 or shall be Type MC cable listed for that location. Wiring methods installed in these locations shall contain an insulated copper equipment grounding conductor sized in accordance with Table 250.122 but not smaller than 12 AWG.

Where installed in noncorrosive environments, the wiring methods of branch circuits shall comply with the general requirements in Chapter 3.

(2) Flexible Connections

Where necessary to employ flexible connections at or adjacent to the motor, liquidtight flexible metal or liquidtight flexible nonmetallic conduit with listed fittings shall be permitted.

(3) Cord-and-Plug Connections

Pool-associated motors shall be permitted to employ cord-and-plug connections. The flexible cord shall not exceed 900 mm (3 ft) in length. The flexible cord shall include a copper equipment grounding conductor sized in accordance with 250.122 but not smaller than 12 AWG. The cord shall terminate in a grounding-type attachment plug.

(B) Double-Insulated Pool Pumps

A listed cord-and-plug-connected pool pump incorporating an approved system of double insulation that provides a means for grounding only the internal and nonaccessible, non—current-carrying metal parts of the pump shall be connected to any wiring method recognized in Chapter 3 that is suitable for the location. Where the equipment grounding conductor of the motor circuit is connected to the equipotential bonding means in accordance with the second sentence of 680.26(B)(6)(a), the branch-circuit wiring shall comply with 680.21(A).

(C) GFCI Protection

Outlets supplying all pool motors on branch circuits rated 150 volts or less to ground and 60 amperes or less, single-or 3-phase, shall be provided with Class A ground-fault circuit-interrupter protection.

Exception: Listed low-voltage motors not requiring grounding, with ratings not exceeding the low-voltage contact limit that are supplied by listed transformers or power supplies that comply with 680.23(A)(2), shall be permitted to be installed without GFCI protection.

(D) Pool Pump Motor Replacement

Where a pool pump motor in 680.21(C) is replaced for maintenance or repair, the replacement pump motor shall be provided with ground-fault circuit-interrupter protection.

680.22 Lighting, Receptacles, and Equipment

(A) Receptacles

(1) Required Receptacle, Location

Where a permanently installed pool is installed, no fewer than one 125-volt, 15- or 20-ampere receptacle on a general-purpose branch circuit shall be located not less than 1.83 m (6 ft) from, and not more than 6.0 m (20 ft) from, the inside wall of the pool. This receptacle shall be located not more than 2.0 m (6 ft 6 in.) above the floor, platform, or grade level serving the pool.

(2) Circulation and Sanitation System, Location

Receptacles that provide power for water-pump motors or for other loads directly related to the circulation and sanitation system shall be located at least 1.83 m (6 ft) from the inside walls of the pool. These receptacles shall have GFCI protection and be of the grounding type.

(3) Other Receptacles, Location

Other receptacles shall be not less than 1.83 m (6 ft) from the inside walls of a pool.

(4) GFCI Protection

All 15- and 20-ampere, single-phase, 125-volt receptacles located within 6.0 m (20 ft) of the inside walls of a pool shall be protected by a Class A ground-fault circuit interrupter. Also see 680.22(A)(5).

(5) Pool Equipment Room

At least one GFCI-protected 125-volt, 15- or 20-ampere receptacle on a general-purpose circuit shall be located within a pool equipment room, and all other receptacles supplied by branch circuits rated 150 volts or less to ground within a pool equipment room shall be GFCI protected.

(6) Measurements

In determining the dimensions in this section addressing receptacle spacings, the distance to be measured shall be 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.

(B) Luminaires, Lighting Outlets, and Ceiling-Suspended (Paddle) Fans

(1) New Outdoor Installation Clearances

In outdoor pool areas, luminaires, lighting outlets, and ceiling-suspended (paddle) fans installed above the pool or the area extending 1.5 m (5 ft) horizontally from the inside walls of the pool shall be installed at a height not less than 3.7 m (12 ft) above the maximum water level of the pool.

(2) Indoor Clearances

For installations in indoor pool areas, the clearances shall be the same as for outdoor areas unless modified as provided in this paragraph. If the branch circuit supplying the equipment is protected by a ground-fault circuit interrupter, the following equipment shall be permitted at a height not less than 2.3 m (7 ft 6 in.) above the maximum pool water level:

Totally enclosed luminaires

Ceiling-suspended (paddle) fans identified for use beneath ceiling structures such as provided on porches or patios

(3) Existing Installations

Existing luminaires and lighting outlets located less than 1.5 m (5 ft) measured horizontally from the inside walls of a pool shall be not less than 1.5 m (5 ft) 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) GFCI Protection in Adjacent Areas

Luminaires, lighting outlets, and ceiling-suspended (paddle) fans installed in the area extending between 1.5 m (5 ft) and 3.0 m (10 ft) horizontally from the inside walls of a pool shall be protected by a ground-fault circuit interrupter unless installed not less than 1.5 m (5 ft) above the maximum water level and rigidly attached to the structure adjacent to or enclosing the pool.

(5) Cord-and-Plug-Connected Luminaires

Cord-and-plug-connected luminaires shall comply with the requirements of 680.8 where installed within 4.9 m (16 ft) of any point on the water surface, measured radially.

(6) Low-Voltage Luminaires

Listed low-voltage luminaires not requiring grounding, not exceeding the low-voltage contact limit, and supplied by listed transformers or power supplies that comply with 680.23(A)(2) shall be permitted to be located less than 1.5 m (5 ft) from the inside walls of the pool.

(7) Low-Voltage Gas-Fired Luminaires, Decorative Fireplaces, Fire Pits, and Similar Equipment

Listed low-voltage gas-fired-luminaires, decorative fireplaces, fire pits, and similar equipment using low-voltage ignitors that do not require grounding, and are supplied by listed transformers or power supplies that comply with 680.23(A)(2) with outputs that do not exceed the low-voltage contact limit shall be permitted to be located less than 1.5 m (5 ft) from the inside walls of the pool. Metallic equipment shall be bonded in accordance with the requirements in 680.26(B). Transformers or power supplies supplying this type of equipment shall be installed in accordance with the requirements in 680.24. Metallic gas piping shall be bonded in accordance with the requirements in 250.104(B) and 680.26(B)(7).

(8) Measurements

In determining the dimensions in this section addressing luminaires, the distance to be measured shall be the shortest path an imaginary cord connected to the luminaire would follow without piercing a floor, wall, ceiling, doorway with hinged or sliding door, window opening, or other effective permanent barrier.

(C) Switching Devices

Switching devices shall be located at least 1.5 m (5 ft) horizontally from the inside walls of a pool unless separated from the pool by a solid fence, wall, or other permanent barrier that provides at least a 1.5 m (5 ft) reach distance. Alternatively, a switch that is listed as being acceptable for use within 1.5 m (5 ft) shall be permitted.

(D) Other Outlets

Other outlets shall be not less than 3.0 m (10 ft) from the inside walls of the pool. Measurements shall be determined in accordance with 680.22(A)(6).

Informational Note: Other outlets may include, but are not limited to, remote-control, signaling, fire alarm, and communications circuits.

(E) Other Equipment

Other equipment with ratings exceeding the low-voltage contact limit shall be located at least 1.5 m (5 ft) horizontally from the inside walls of a pool unless separated from the pool by a solid fence, wall, or other permanent barrier.

680.23 Underwater Luminaires

This section covers all luminaires installed below the maximum water level of the pool.

Upcodes Diagrams

(A) General

(1) Luminaire Design, Normal Operation

The design of an underwater luminaire supplied from a branch circuit either directly or by way of a transformer or power supply meeting the requirements of this section shall be such that, where the luminaire 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).

(2) Transformers and Power Supplies

Transformers and power supplies used for the supply of underwater luminaires, together with the transformer or power supply enclosure, shall be listed, labeled, and identified for swimming pool and spa use. The transformer or power supply shall incorporate either a transformer of the isolated winding type, with an ungrounded secondary that has a grounded metal barrier between the primary and secondary windings, or one that incorporates an approved system of double insulation between the primary and secondary windings.

(3) GFCI Protection, Lamping, Relamping, and Servicing

Ground-fault circuit-interrupter protection for personnel shall be installed in the branch circuit supplying luminaires operating at voltages greater than the low-voltage contact limit.

(4) Voltage Limitation

No luminaires shall be installed for operation on supply circuits over 150 volts between conductors.

(5) Location, Wall-Mounted Luminaires

Luminaires mounted in walls shall be installed with the top of the luminaire lens not less than 450 mm (18 in.) below the normal water level of the pool, unless the luminaire is listed and identified for use at lesser depths. No luminaire shall be installed less than 100 mm (4 in.) below the normal water level of the pool.

(6) Bottom-Mounted Luminaires

A luminaire facing upward shall comply with either (1) or (2):

Have the lens guarded to prevent contact by any person

Be listed for use without a guard

(7) Dependence on Submersion

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

(8) Compliance

Compliance with these requirements shall be obtained by the use of a listed underwater luminaire and by installation of a listed ground-fault circuit interrupter in the branch circuit or a listed transformer or power supply for luminaires operating at not more than the low voltage contact limit.

(B) Wet-Niche Luminaires

(1) Forming Shells

Forming shells shall be installed for the mounting of all wet-niche underwater luminaires and shall be equipped with provisions for conduit entries. Metal parts of the luminaire and forming shell in contact with the pool water shall be of brass or other approved corrosion-resistant metal. All forming shells used with nonmetallic conduit systems, other than those that are part of a listed low-voltage lighting system not requiring grounding, shall include provisions for terminating an 8 AWG copper conductor.

(2) Wiring Extending Directly to the Forming Shell

Conduit shall be installed from the forming shell to a junction box or other enclosure conforming to the requirements in 680.24. Conduit shall be rigid metal, intermediate metal, liquidtight flexible nonmetallic, or rigid nonmetallic.

(a) Metal Conduit. Metal conduit shall be listed and identified as red brass or stainless steel.

(b) Nonmetallic Conduit. Where a nonmetallic conduit is used, an 8 AWG insulated solid or stranded copper bonding jumper shall be installed in this conduit unless a listed low-voltage lighting system not requiring grounding is used. The bonding jumper shall be terminated in the forming shell, junction box or transformer enclosure, or ground-fault circuit-interrupter enclosure. The termination of the 8 AWG bonding jumper in the forming shell shall be covered with, or encapsulated in, a listed potting compound to protect the connection from the possible deteriorating effect of pool water.

(3) Equipment Grounding Provisions for Cords

Other than listed low-voltage lighting systems not requiring grounding, wet-niche luminaires that are supplied by a flexible cord or cable shall have all exposed non—current-carrying metal parts connected to an insulated copper equipment grounding conductor that is an integral part of the cord or cable. This equipment grounding conductor shall be connected to a grounding terminal in the supply junction box, transformer enclosure, or other enclosure. The equipment grounding conductor shall not be smaller than the supply conductors and not smaller than 16 AWG.

(4) Luminaire Grounding Terminations

The end of the flexible-cord jacket and the flexible-cord conductor terminations within a luminaire shall be covered with, or encapsulated in, a suitable potting compound to prevent the entry of water into the luminaire through the cord or its conductors. If present, the connection of the equipment grounding conductor within a luminaire shall be similarly treated to protect such connection from the deteriorating effect of pool water in the event of water entry into the luminaire.

(5) Luminaire Bonding

The luminaire shall be bonded to, and secured to, the forming shell by a positive locking device that ensures a low-resistance contact and requires a tool to remove the luminaire from the forming shell. Bonding shall not be required for luminaires that are listed for the application and have no non—current-carrying metal parts.

(6) Servicing

Wet-niche luminaires shall be removable from the water for inspection, relamping, or other maintenance. The forming shell location and length of cord in the forming shell shall permit personnel to place the removed luminaire on the deck or other dry location for such maintenance. The luminaire maintenance location shall be accessible without entering or going in the pool water.

In spa locations where wet-niche luminaires are installed low in the foot well of the spa, the luminaire shall only be required to reach the bench location, where the spa can be drained to make the bench location dry.

(C) Dry-Niche Luminaires

(1) Construction

A dry-niche luminaire shall have provision for drainage of water. Other than listed low voltage luminaires not requiring grounding, a dry-niche luminaire shall have means for accommodating one equipment grounding conductor for each conduit entry.

(2) Junction Box

A junction box shall not be required but, if used, shall not be required to be elevated or located as specified in 680.24(A)(2) if the luminaire is specifically identified for the purpose.

(D) No-Niche Luminaires

A no-niche luminaire shall meet the construction requirements of 680.23(B)(3) and be installed in accordance with the requirements of 680.23(B). Where connection to a forming shell is specified, the connection shall be to the mounting bracket.

(E) Through-Wall Lighting Assembly

A through-wall lighting assembly shall be equipped with a threaded entry or hub, or a nonmetallic hub, for the purpose of accommodating the termination of the supply conduit. A through-wall lighting assembly shall meet the construction requirements of 680.23(B)(3) and be installed in accordance with the requirements of 680.23. Where connection to a forming shell is specified, the connection shall be to the conduit termination point.

(F) Branch-Circuit Wiring

(1) Wiring Methods

Where branch-circuit wiring on the supply side of enclosures and junction boxes connected to conduits run to underwater luminaires are installed in corrosive environments as described in 680.2, the wiring method of that portion of the branch circuit shall be in accordance with 680.14 or shall be liquidtight flexible nonmetallic conduit. Wiring methods installed in corrosive environments as described in 680.14 shall contain an insulated copper equipment grounding conductor sized in accordance with 250.122, but not smaller than 12 AWG.

Where installed in noncorrosive environments, branch circuits shall comply with the general requirements in Chapter 3.

Exception: Where connecting to transformers or power supplies for pool lights, liquidtight flexible metal conduit shall be permitted. The length shall not exceed 1.8 m (6 ft) for any one length or exceed 3.0 m (10 ft) in total length used.

(2) Equipment Grounding

Other than listed low-voltage luminaires not requiring grounding, all through-wall lighting assemblies, wet-niche, dry-niche, or no-niche luminaires shall be connected to an insulated copper equipment grounding conductor installed with the circuit conductors. The equipment grounding conductor shall be installed without joint or splice except as permitted in 680.23(F)(2)(a) and (F)(2)(b). The equipment grounding conductor shall be sized in accordance with 250.122 but shall not be smaller than 12 AWG.

Exception: An equipment grounding conductor between the wiring chamber of the secondary winding of a transformer and a junction box shall be sized in accordance with the transformer secondary overcurrent protection provided.

(a) If more than one underwater luminaire is supplied by the same branch circuit, the equipment grounding conductor, installed between the junction boxes, transformer enclosures, or other enclosures in the supply circuit to wet-niche luminaires, or between the field-wiring compartments of dry-niche luminaires, shall be permitted to be terminated on grounding terminals.

(b) If the underwater luminaire is supplied from a transformer, ground-fault circuit interrupter, clock-operated switch, or a manual snap switch that is located between the panelboard and a junction box connected to the conduit that extends directly to the underwater luminaire, the equipment grounding conductor shall be permitted to terminate on grounding terminals on the transformer, ground-fault circuit interrupter, clock-operated switch enclosure, or an outlet box used to enclose a snap switch.

(3) Conductors

Conductors on the load side of a ground-fault circuit interrupter or of a transformer, used to comply with the provisions of 680.23(A)(8), shall not occupy raceways, boxes, or enclosures containing other conductors unless one of the following conditions applies:

The other conductors are protected by ground-fault circuit interrupters.

The other conductors are equipment grounding conductors and bonding jumpers as required per 680.23(B)(2)(b).

The other conductors are supply conductors to a feed-through-type ground-fault circuit interrupter.

Ground-fault circuit interrupters shall be permitted in a panelboard that contains circuits protected by other than ground-fault circuit interrupters.

680.24 Junction Boxes and Electrical Enclosures for Transformers or Ground-Fault Circuit Interrupters

(A) Junction Boxes

A junction box connected to a conduit that extends directly to a forming shell or mounting bracket of a no-niche luminaire shall meet the requirements of this section.

(1) Construction

The junction box shall be listed, labeled, and identified as a swimming pool junction box and shall comply with the following conditions:

Be equipped with threaded entries or hubs or a nonmetallic hub

Be comprised of copper, brass, suitable plastic, or other approved corrosion-resistant material

Be provided with electrical continuity between every connected metal conduit and the grounding terminals by means of copper, brass, or other approved corrosion-resistant metal that is integral with the box

(2) Installation

Where the luminaire operates over the low voltage contact limit, the junction box location shall comply with 680.24(A)(2)(a) and (A)(2)(b). Where the luminaire operates at the low voltage contact limit or less, the junction box location shall be permitted to comply with 680.24(A)(2)(c).

(a) Vertical Spacing. The junction box shall be located not less than 100 mm (4 in.), measured from the inside of the bottom of the box, above the ground level, or pool deck, or not less than 200 mm (8 in.) above the maximum pool water level, whichever provides the greater elevation.

(b) Horizontal Spacing. The junction box shall be located not less than 1.2 m (4 ft) from the inside wall of the pool, unless separated from the pool by a solid fence, wall, or other permanent barrier.

(c) Flush Deck Box. If used on a lighting system operating at the low voltage contact limit or less, a flush deck box shall be permitted if both of the following conditions are met:

An approved potting compound is used to fill the box to prevent the entrance of moisture.

The flush deck box is located not less than 1.2 m (4 ft) from the inside wall of the pool.

(B) Other Enclosures

An enclosure for a transformer, ground-fault circuit interrupter, or a similar device connected to a conduit that extends directly to a forming shell or mounting bracket of a no-niche luminaire shall meet the requirements of this section.

(1) Construction

The enclosure shall be listed and labeled for the purpose and meet the following requirements:

Equipped with threaded entries or hubs or a nonmetallic hub

Comprised of copper, brass, suitable plastic, or other approved corrosion-resistant material

Provided with an approved seal, such as duct seal at the conduit connection, that prevents circulation of air between the conduit and the enclosures

Provided with electrical continuity between every connected metal conduit and the grounding terminals by means of copper, brass, or other approved corrosion-resistant metal that is integral with the box

(2) Installation

(a) Vertical Spacing. The enclosure shall be located not less than 100 mm (4 in.), measured from the inside of the bottom of the box, above the ground level, or pool deck, or not less than 200 mm (8 in.) above the maximum pool water level, whichever provides the greater elevation.

(b) Horizontal Spacing. The enclosure shall be located not less than 1.2 m (4 ft) from the inside wall of the pool, unless separated from the pool by a solid fence, wall, or other permanent barrier.

(C) Protection

Junction boxes and enclosures mounted above the grade of the finished walkway around the pool shall not be located in the walkway unless afforded additional protection, such as by location under diving boards, adjacent to fixed structures, and the like.

(D) Grounding Terminals

Junction boxes, transformer and power-supply enclosures, and ground-fault circuit-interrupter enclosures connected to a conduit that extends directly to a forming shell or mounting bracket of a no-niche luminaire shall be provided with a number of grounding terminals that shall be no fewer than one more than the number of conduit entries.

(E) Strain Relief

The termination of a flexible cord of an underwater luminaire within a junction box, transformer or power-supply enclosure, ground-fault circuit interrupter, or other enclosure shall be provided with a strain relief.

(F) Grounding

The grounding terminals of a junction box, transformer enclosure, or other enclosure in the supply circuit to a wet-niche or no-niche luminaire and the field-wiring chamber of a dry-niche luminaire shall be connected to the equipment grounding terminal of the panelboard. This terminal shall be directly connected to the panelboard enclosure.

680.25 Feeders

These provisions shall apply to any feeder on the supply side of panelboards supplying branch circuits for pool equipment covered in Part II of this article and on the load side of the service equipment or the source of a separately derived system.

(A) Feeders

Where feeders are installed in corrosive environments as described in 680.2, Corrosive Environment, the wiring method of that portion of the feeder shall be in accordance with 680.14 or shall be liquidtight flexible nonmetallic conduit. Wiring methods installed in corrosive environments shall contain an insulated copper equipment grounding conductor sized in accordance with Table 250.122, but not smaller than 12 AWG.

Where installed in noncorrosive environments, feeders shall comply with the general requirements in Chapter 3.

(B) Aluminum Conduit

Aluminum conduit shall not be permitted in the pool area where subject to corrosion.

680.26 Equipotential Bonding

Diagram

Upcodes Diagrams

(A) Performance

The equipotential bonding required by this section shall be installed to reduce voltage gradients in the pool area.

(B) Bonded Parts

The parts specified in 680.26(B)(1) through (B)(7) shall be bonded together using solid copper conductors, insulated covered, or bare, not smaller than 8 AWG or with rigid metal conduit of brass or other identified corrosion-resistant metal. Connections to bonded parts shall be made in accordance with 250.8. An 8 AWG or larger solid copper bonding conductor provided to reduce voltage gradients in the pool area shall not be required to be extended or attached to remote panelboards, service equipment, or electrodes.

(1) Conductive Pool Shells

Bonding to conductive pool shells shall be provided as specified in 680.26(B)(1)(a) or (B)(1)(b). Cast-in-place concrete, pneumatically applied or sprayed concrete, and concrete block with painted or plastered coatings shall all be considered conductive materials due to water permeability and porosity. Vinyl liners and fiberglass composite shells shall be considered to be nonconductive materials. Reconstructed pool shells shall also meet the requirements of this section.

(a) Structural Reinforcing Steel. Unencapsulated structural reinforcing steel shall be bonded together by steel tie wires or the equivalent. Where structural reinforcing steel is encapsulated in a nonconductive compound, a copper conductor grid shall be installed in accordance with 680.26(B)(1)(b)

(b) Copper Conductor Grid. A copper conductor grid shall be provided and shall comply with the following:

Be constructed of minimum 8 AWG bare solid copper conductors bonded to each other at all points of crossing in accordance with 250.8 or other approved means

Conform to the contour of the pool

Be arranged in a 300 mm (12 in.) by 300 mm (12 in.) network of conductors in a uniformly spaced perpendicular grid pattern with a tolerance of 100 mm (4 in.)

Be secured within or under the pool no more than 150 mm (6 in.) from the outer contour of the pool shell

(2) Perimeter Surfaces

The perimeter surface to be bonded shall be considered to extend for 1 m (3 ft) horizontally beyond the inside walls of the pool and shall include unpaved surfaces and other types of paving. Perimeter surfaces separated from the pool by a permanent wall or building 1.5 m (5 ft) in height or more shall require equipotential bonding only on the pool side of the permanent wall or building. Bonding to perimeter surfaces shall be provided as specified in 680.26(B)(2)(a), (B)(2)(b), or (B)(2)(c) and shall be attached to the pool reinforcing steel or copper conductor grid at a minimum of four points uniformly spaced around the perimeter of the pool. For nonconductive pool shells, bonding at four points shall not be required.

(a) Structural Reinforcing Steel. Structural reinforcing steel shall be bonded in accordance with 680.26(B)(1)(a).

(b) Copper Ring. Where structural reinforcing steel is not available or is encapsulated in a nonconductive compound, a copper conductor(s) shall be utilized where the following requirements are met:

At least one minimum 8 AWG bare solid copper conductor shall be provided.

The conductors shall follow the contour of the perimeter surface.

Only listed splicing devices or exothermic welding shall be permitted.

The required conductor shall be 450 mm to 600 mm (18 in. to 24 in.) from the inside walls of the pool.

The required conductor shall be secured within or under the perimeter surface 100 mm to 150 mm (4 in. to 6 in.) below the subgrade.

(c) Copper Grid. Where structural reinforcing steel is not available or is encapsulated in a nonconductive compound, copper grid shall be utilized where the following requirements are met:

The copper grid shall be constructed of 8 AWG solid bare copper and be arranged in accordance with 680.26(B)(1)(b)(3).

The copper grid shall follow the contour of the perimeter surface extending 1 m (3 ft) horizontally beyond the inside walls of the pool.

Only listed splicing devices or exothermic welding shall be permitted.

The copper grid shall be secured within or under the deck or unpaved surfaces between 100 mm to 150 mm (4 in. to 6 in.) below the subgrade.

(3) Metallic Components

All metallic parts of the pool structure, including reinforcing metal not addressed in 680.26(B)(1)(a), shall be bonded. Where reinforcing steel is encapsulated with a nonconductive compound, the reinforcing steel shall not be required to be bonded.

(4) Underwater Lighting

All metal forming shells and mounting brackets of no-niche luminaires shall be bonded.

Exception: Listed low-voltage lighting systems with non metallic forming shells shall not require bonding.

(5) Metal Fittings

All metal fittings within or attached to the pool structure shall be bonded. Isolated parts that are not over 100 mm (4 in.) in any dimension and do not penetrate into the pool structure more than 25 mm (1 in.) shall not require bonding. Metallic pool cover anchors intended for insertion in a concrete or masonry deck surface, 25 mm (1 in.) or less in any dimension and 51 mm (2 in.) or less in length, and metallic pool cover anchors intended for insertion in a wood or composite deck surface, 51 mm (2 in.) or less in any flange dimension and 51 mm (2 in.) or less in length, shall not require bonding.

(6) Electrical Equipment

Metal parts of electrical equipment associated with the pool water circulating system, including pump motors and metal parts of equipment associated with pool covers, including electric motors, shall be bonded.

Exception: Metal parts of listed equipment incorporating an approved system of double insulation shall not be bonded.

(a) Double-Insulated Water Pump Motors. Where a double-insulated water pump motor is installed under the provisions of this rule, a solid 8 AWG copper conductor of sufficient length to make a bonding connection to a replacement motor shall be extended from the swimming pool equipotential bonding means to an accessible point in the vicinity of the pool pump motor. Where there is no connection between the swimming pool equipotential bonding means and the equipment grounding system for the premises, this bonding conductor shall be connected to the equipment grounding conductor of the motor circuit.

(b) Pool Water Heaters. For pool water heaters rated at more than 50 amperes and having specific instructions regarding bonding and grounding, only those parts designated to be bonded shall be bonded and only those parts designated to be grounded shall be grounded.

(7) Fixed Metal Parts

All fixed metal parts shall be bonded including, but not limited to, metal-sheathed cables and raceways, metal piping, metal awnings, metal fences, and metal door and window frames.

Exception No. 1: Those separated from the pool by a permanent barrier that prevents contact by a person shall not be required to be bonded.

Exception No. 2: Those greater than 1.5 m (5 ft) horizontally from the inside walls of the pool shall not be required to be bonded.

Exception No. 3: Those greater than 3.7 m (12 ft) measured vertically above the maximum water level of the pool, or as measured vertically above any observation stands, towers, or platforms, or any diving structures, shall not be required to be bonded.

(C) Pool Water

Where none of the bonded parts are in direct connection with the pool water, the pool water shall be in direct contact with an approved corrosion-resistant conductive surface that exposes not less than 5800 mm2 (9 in.2) of surface area to the pool water at all times. The conductive surface shall be located where it is not exposed to physical damage or dislodgement during usual pool activities, and it shall be bonded in accordance with 680.26(B).

680.27 Specialized Pool Equipment

(A) Underwater Audio Equipment

All underwater audio equipment shall be identified as underwater audio equipment.

(1) Speakers

Each speaker shall be mounted in an approved metal forming shell, the front of which is enclosed by a captive metal screen, or equivalent, that is bonded to, and secured to, the forming shell by a positive locking device that ensures a low-resistance contact and requires a tool to open for installation or servicing of the speaker. The forming shell shall be installed in a recess in the wall or floor of the pool.

(2) Wiring Methods

Rigid metal conduit of brass or other identified corrosion-resistant metal, liquidtight flexible nonmetallic conduit (LFNC), rigid polyvinyl chloride conduit, or reinforced thermosetting resin conduit shall extend from the forming shell to a listed junction box or other enclosure as provided in 680.24. Where rigid polyvinyl chloride conduit, reinforced thermosetting resin conduit, or liquidtight flexible nonmetallic conduit is used, an 8 AWG insulated solid or stranded copper bonding jumper shall be installed in this conduit. The bonding jumper shall be terminated in the forming shell and the junction box. The termination of the 8 AWG bonding jumper in the forming shell shall be covered with, or encapsulated in, a listed potting compound to protect such connection from the possible deteriorating effect of pool water.

(3) Forming Shell and Metal Screen

The forming shell and metal screen shall be of brass or other approved corrosion-resistant metal. All forming shells shall include provisions for terminating an 8 AWG copper conductor.

(B) Electrically Operated Pool Covers

(1) Motors and Controllers

The electric motors, controllers, and wiring shall be located not less than 1.5 m (5 ft) from the inside wall of the pool unless separated from the pool by a wall, cover, or other permanent barrier. Electric motors installed below grade level shall be of the totally enclosed type. The device that controls the operation of the motor for an electrically operated pool cover shall be located such that the device operator has full view of the pool.

Exception: Motors that are part of listed systems with ratings not exceeding the low-voltage contact limit that are supplied by listed transformers or power supplies that comply with 680.23(A)(2) shall be permitted to be located less than 1.5 m (5 ft) from the inside walls of the pool.

(2) Protection

The electric motor and controller shall be connected to a branch circuit protected with ground-fault circuit-interrupter protection.

Exception: Motors that are part of listed systems with ratings not exceeding the low-voltage contact limit that are supplied by listed transformers or power supplies that comply with 680.23(A)(2).

(C) Deck Area Heating

The provisions of this section shall apply to all pool deck areas, including a covered pool, where electrically operated comfort heating units are installed within 6.0 m (20 ft) of the inside wall of the pool.

(1) Unit Heaters

Unit heaters shall be rigidly mounted to the structure and shall be of the totally enclosed or guarded type. Unit heaters shall not be mounted over the pool or within the area extending 1.5 m (5 ft) horizontally from the inside walls of a pool.

(2) Permanently Wired Radiant Heaters

Radiant electric heaters shall be suitably guarded and securely fastened to their mounting device(s). Heaters shall not be installed over a pool or within the area extending 1.5 m (5 ft) horizontally from the inside walls of the pool and shall be mounted at least 3.7 m (12 ft) vertically above the pool deck unless otherwise approved.

(3) Radiant Heating Cables Not Permitted

Radiant heating cables embedded in or below the deck shall not be permitted.

680.28 Gas-Fired Water Heater

Circuits serving gas-fired swimming pool and spa water heaters operating at voltages above the low-voltage contact limit shall be provided with ground-fault circuit-interrupter protection for personnel.

Part III Storable Pools, Storable Spas, Storable Hot Tubs, and Storable Immersion Pools

680.30 General

Electrical installations at storable pools, storable spas, storable hot tubs, or storable immersion pools shall comply with the provisions of Part I and Part III of this article.

680.31 Pumps

A cord-connected pool filter pump shall incorporate an approved system of double insulation or its equivalent and shall be provided with means for the termination of an equipment grounding conductor for the connection to the internal and nonaccessible non—current-carrying metal parts of the pump.

An equipment grounding conductor run with the power-supply conductors in the flexible cord shall terminate in a grounding-type attachment plug having a fixed grounding contact member.

Cord-connected pool filter pumps shall be provided with a ground-fault circuit interrupter that is an integral part of the attachment plug or located in the power-supply cord within 300 mm (12 in.) of the attachment plug.

680.32 Ground-Fault Circuit Interrupters Required

All electrical equipment, including power-supply cords, used with storable pools shall be protected by ground-fault circuit interrupters.

All 125-volt, 15- and 20-ampere receptacles located within 6.0 m (20 ft) of the inside walls of a storable pool, storable spa, or storable hot tub shall be protected by a ground-fault circuit interrupter. In determining these dimensions, the distance to be measured shall be 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.

Informational Note: For flexible cord usage, see 400.4.

680.33 Luminaires

An underwater luminaire, if installed, shall be installed in or on the wall of the storable pool, storable spa, or storable hot tub. It shall comply with either 680.33(A) or (B).

(A) Within the Low Voltage Contact Limit

A luminaire shall be part of a cord-and plug connected lighting assembly. This assembly shall be listed as an assembly for the purpose and have the following construction features:

No exposed metal parts

A luminaire lamp that is suitable for use at the supplied voltage

An impact-resistant polymeric lens, luminaire body, and transformer enclosure

A transformer or power supply meeting the requirements of 680.23(A)(2) with a primary rating not over 150 V

(B) Over the Low Voltage Contact Limit but Not Over 150 Volts

A lighting assembly without a transformer or power supply and with the luminaire lamp(s) operating at not over 150 volts shall be permitted to be cord-and-plug-connected where the assembly is listed as an assembly for the purpose. The installation shall comply with 680.23(A)(5), and the assembly shall have the following construction features:

No exposed metal parts

An impact-resistant polymeric lens and luminaire body

A ground-fault circuit interrupter with open neutral conductor protection as an integral part of the assembly

The luminaire lamp permanently connected to the ground-fault circuit interrupter with open-neutral protection

Compliance with the requirements of 680.23(A)

680.34 Receptacle Locations

Receptacles shall not be located less than 1.83 m (6 ft) from the inside walls of a storable pool, storable spa, or storable hot tub. In determining these dimensions, the distance to be measured shall be 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.

680.35 Storable and Portable Immersion Pools

Storable and portable immersion pools shall additionally comply with 680.35(A) through (G).

(A) Cord Connection for Self-Contained Storable and Portable Immersion Pools

Self-contained storable and portable packaged immersion pools with identified integral permanently attached switches and/or controls, pumps, and/or heaters, including circulation heaters, rated 120 volts and 20 amperes or less, single phase, shall be permitted to be cord-and-plug-connected with a cord not shorter than 1.83 m (6 ft) and not longer than 4.6 m (15 ft), and shall be protected by a ground-fault circuit interrupter. The cord shall be minimum hard usage. If the ground-fault circuit interrupter is provided as an integral part of the cord assembly, it shall be located at the attachment plug or in the power supply cord within 300 mm (12 in.) of the attachment plug.

(B) Storable and Portable Pumps

A cord-connected storable or portable pump utilized with, but not built-in or permanently attached as an integral part of, a storable or portable immersion pool shall be listed, labeled, and identified for swimming pool and spa use, and shall meet the requirements of 680.31.

(C) Storable and Portable Heaters

A storable or portable heater, including circulation heaters, utilized with, but not built-in or permanently attached as an integral part of, a storable or portable immersion pool shall be rated 120 volts and 20 amperes or less or 250 volts and 30 amperes or less, single phase; shall be identified for swimming pool and spa use; shall be permitted to be cord-and-plug-connected with a cord not shorter than 1.83 m (6 ft) and not longer than 4.6 m (15 ft); and heaters supplied by branch circuits rated 150 volts or less to ground shall be provided with Class A ground-fault circuit-interrupter protection. The cord shall be minimum hard usage. If the ground-fault circuit interrupter is provided as an integral part of the cord assembly, it shall be located at the attachment plug or in the power supply cord within 300 mm (12 in.) of the attachment plug.

(D) Audio Equipment

Audio equipment shall not be installed in or on a self-contained storable or portable immersion pool. All audio equipment operating at greater than the low-voltage contact limit and located within 1.83 m (6 ft) from the inside walls of a storable or portable immersion pool shall be grounded and shall be protected by a ground-fault circuit interrupter.

(E) Location Proximate to Luminaires, Lighting Outlets, and Ceiling-Suspended (Paddle) Fans

The storable or portable immersion pool shall be installed at least 3 m (10 ft), measured diagonally from the nearest point on each luminaire, lighting outlet, and ceiling-suspended (paddle) fan operating at greater than the low-voltage contact limit, to the nearest point on the top rim of the immersion pool. Luminaires shall not be installed in or on a storable or portable immersion pool.

(F) Location Proximate to Switches

The storable or portable immersion pool shall be installed at least 1.5 m (5 ft), measured horizontally, from all switches operating above the low-voltage contact limit. Switches that are packaged with the immersion pool as an integral part of its internal electrical system, or that are integral to cord-and-plug-connected electrical equipment utilized in the pool's water circulation or drain system, including storable and portable pumps, heaters, and circulation heaters, shall be permitted to be located less than 1.5 m (5 ft) from the inside walls of the pool.

(G) Receptacles

All receptacles rated 250 volts, 50 amperes or less, located within 6.0 m (20 ft) of the inside walls of the installed storable or portable immersion pool and utilized for supplying power to heaters or other electrical equipment serving the immersion pool, shall meet the requirements of 680.32 and 680.34.

Part IV Spas, Hot Tubs, and Permanently Installed Immersion Pools

680.40 General

Electrical installations at spas and hot tubs shall comply with the provisions of Part I and Part IV of this article.

680.41 Emergency Switch for Spas and Hot Tubs

A clearly labeled emergency shutoff or control switch for the purpose of stopping the motor(s) that provides power to the recirculation system and jet system shall be installed at a point readily accessible to the users and not less than 1.5 m (5 ft) away, adjacent to, and within sight of the spa or hot tub. This requirement shall not apply to one-family dwellings.

680.42 Outdoor Installations

A spa or hot tub installed outdoors shall comply with the provisions of Parts I and II of this article, except as permitted in 680.42(A) and (B), that would otherwise apply to pools installed outdoors.

(A) Flexible Connections

Listed packaged spa or hot tub equipment assemblies or self-contained spas or hot tubs utilizing a factory-installed or assembled control panel or panelboard shall be permitted to use flexible connections as covered in 680.42(A)(1) and (A)(2).

(1) Flexible Conduit

liquidtight flexible metal conduit or liquidtight flexible nonmetallic conduit shall be permitted.

(2) Cord-and-Plug Connections

Cord-and-plug connections with a cord not longer than 4.6 m (15 ft) shall be permitted where protected by a ground-fault circuit interrupter.

(B) Bonding

Bonding by metal-to-metal mounting on a common frame or base shall be permitted. The metal bands or hoops used to secure wooden staves shall not be required to be bonded as required in 680.26.

Equipotential bonding of perimeter surfaces in accordance with 680.26(B)(2) shall not be required to be provided for spas and hot tubs where all of the following conditions apply:

The spa or hot tub shall be listed, labeled, and identified as a self-contained spa for aboveground use.

The spa or hot tub shall not be identified as suitable only for indoor use.

The installation shall be in accordance with the manufacturer's instructions and shall be located on or above grade.

The top rim of the spa or hot tub shall be at least 710 mm (28 in.) above all perimeter surfaces that are within 760 mm (30 in.), measured horizontally from the spa or hot tub. The height of nonconductive external steps for entry to or exit from the self-contained spa shall not be used to reduce or increase this rim height measurement.

Informational Note: For information regarding listing requirements for self-contained spas and hot tubs, see ANSI/UL 1563-2010, Standard for Electric Spas, Equipment Assemblies, and Associated Equipment.

(C) Interior Wiring to Outdoor Installations

In the interior of a dwelling unit or in the interior of another building or structure associated with a dwelling unit, any of the wiring methods recognized or permitted in Chapter 3 of this Code shall be permitted to be used for the connection to motor disconnecting means and the motor, heating, and control loads that are part of a self-contained spa or hot tub or a packaged spa or hot tub equipment assembly. Wiring to an underwater luminaire shall comply with 680.23 or 680.33.

Informational Note: See 680.25 for feeders.

680.43 Indoor Installations

A spa or hot tub installed indoors shall comply with the provisions of Parts I and II of this article except as modified by this section and shall be connected by the wiring methods of Chapter 3.

Exception No. 1: Listed spa and hot tub packaged units rated 20 amperes or less shall be permitted to be cord-and-plug-connected to facilitate the removal or disconnection of the unit for maintenance and repair.

Exception No. 2: The equipotential bonding requirements for perimeter surfaces in 680.26(B)(2) shall not apply to a listed self-contained spa or hot tub installed above a finished floor.

Exception No. 3: For a dwelling unit(s) only, where a listed spa or hot tub is installed indoors, the wiring method requirements of 680.42(C) shall also apply.

(A) Receptacles

At least one 125-volt, 15- or 20-ampere receptacle on a general-purpose branch circuit shall be located not less than 1.83 m (6 ft) from, and not exceeding 3.0 m (10 ft) from, the inside wall of the spa or hot tub.

(1) Location

Receptacles shall be located at least 1.83 m (6 ft) measured horizontally from the inside walls of the spa or hot tub.

(2) Protection, General

Receptacles rated 125 volts and 30 amperes or less and located within 3.0 m (10 ft) of the inside walls of a spa or hot tub shall be protected by a ground-fault circuit interrupter.

(3) Protection, Spa or Hot Tub Supply Receptacle

Receptacles that provide power for a spa or hot tub shall be ground-fault circuit-interrupter protected.

(4) Measurements

In determining the dimensions in this section addressing receptacle spacings, the distance to be measured shall be 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.

(B) Installation of Luminaires, Lighting Outlets, and Ceiling-Suspended (Paddle) Fans

(1) Elevation

Luminaires, except as covered in 680.43(B)(2), lighting outlets, and ceiling-suspended (paddle) fans located over the spa or hot tub or within 1.5 m (5 ft) from the inside walls of the spa or hot tub shall comply with the clearances specified in 680.43(B)(1)(a), (B)(1)(b), and (B)(1)(c) above the maximum water level.

(a) Without GFCI. Where no GFCI protection is provided, the mounting height shall be not less than 3.7 m (12 ft).

(b) With GFCI. Where GFCI protection is provided, the mounting height shall be permitted to be not less than 2.3 m (7 ft 6 in.).

(c) Below 2.3 m (7 ft 6 in.). Luminaires meeting the requirements of item (1) or (2) and protected by a ground-fault circuit interrupter shall be permitted to be installed less than 2.3 m (7 ft 6 in.) over a spa or hot tub:

Recessed luminaires with a glass or plastic lens, nonmetallic or electrically isolated metal trim, and suitable for use in damp locations

Surface-mounted luminaires with a glass or plastic globe, a nonmetallic body, or a metallic body isolated from contact, and suitable for use in damp locations

(2) Underwater Applications

Underwater luminaires shall comply with the provisions of 680.23 or 680.33.

(C) Switches

Switches shall be located at least 1.5 m (5 ft), measured horizontally, from the inside walls of the spa or hot tub.

(D) Bonding

The following parts shall be bonded together:

All metal fittings within or attached to the spa or hot tub structure

Metal parts of electrical equipment associated with the spa or hot tub water circulating system, including pump motors, unless part of a listed, labeled, and identified self-contained spa or hot tub

Metal raceway and metal piping that are within 1.5 m (5 ft) of the inside walls of the spa or hot tub and that are not separated from the spa or hot tub by a permanent barrier

All metal surfaces that are within 1.5 m (5 ft) of the inside walls of the spa or hot tub and that are not separated from the spa or hot tub area by a permanent barrier

Exception: Small conductive surfaces not likely to become energized, such as air and water jets and drain fittings, where not connected to metallic piping, towel bars, mirror frames, and similar nonelectrical equipment, shall not be required to be bonded.

Non-current-carrying metal parts of electrical devices and controls that are not associated with the spas or hot tubs and that are located within 1.5 m (5 ft) of such units

(E) Methods of Bonding

All metal parts associated with the spa or hot tub shall be bonded by any of the following methods:

The interconnection of threaded metal piping and fittings

Metal-to-metal mounting on a common frame or base

The provisions of a solid copper bonding jumper, insulated, covered, or bare, not smaller than 8 AWG

(F) Grounding

The following equipment shall be connected to the equipment grounding conductor:

All electrical equipment located within 1.5 m (5 ft) of the inside wall of the spa or hot tub

All electrical equipment associated with the circulating system of the spa or hot tub

Exception to (1) and (2): Electrical equipment listed for operation at the low-voltage contact limit or less and supplied by a transformer or power supply that complies with 680.23(A)(2) shall not be required to be connected to the equipment grounding conductor.

(G) Underwater Audio Equipment

Underwater audio equipment shall comply with the provisions of Part II of this article.

680.44 Protection

Except as otherwise provided in this section, the outlet(s) that supplies a self-contained spa or hot tub, a packaged spa or hot tub equipment assembly, or a field-assembled spa or hot tub shall be protected by a ground-fault circuit interrupter.

(A) Listed Units

If so marked, a listed, labeled, and identified self-contained unit or a listed, labeled, and identified packaged equipment assembly that includes integral ground-fault circuit-interrupter protection for all electrical parts within the unit or assembly (pumps, air blowers, heaters, lights, controls, sanitizer generators, wiring, and so forth) shall be permitted without additional GFCI protection.

(B) Other Units

A field-assembled spa or hot tub rated 3 phase or rated over 250 volts or with a heater load of more than 50 amperes shall not require the supply to be protected by a ground-fault circuit interrupter.

Informational Note: See 680.2 for definitions of self-contained spa or hot tub and for packaged spa or hot tub equipment assembly.

680.45 Permanently Installed Immersion Pools

Electrical installations at permanently installed immersion pools, whether installed indoors or outdoors, shall comply with the provisions of Part I, Part II, and Part IV of this article except as modified by this section and shall be connected by the wiring methods of Chapter 3. With regard to provisions in Part IV of this article, an immersion pool shall be considered to be a spa or hot tub.

Exception No. 1: The equipotential bonding requirements in 680.26(B) shall not apply to immersion pools that incorporate no permanently installed or permanently connected electrical equipment, and that are installed with all portions located on or above a finished floor.

Exception No. 2: The equipotential bonding requirements for perimeter surfaces in 680.26(B)(2) shall not apply to nonconductive perimeter surfaces, such as steps, treads, and walking surfaces made of fiberglass composite.

(A) Cord-and-Plug Connections

To facilitate the removal or disconnection of the unit(s) for maintenance, storage, and repair, self-contained portable packaged immersion pools with integral pumps and/or heaters, including circulation heaters, rated 120 volts and 20 amperes or less shall be permitted to be cord-and-plug-connected with a cord not shorter than 1.83 m (6 ft) and not longer than 4.6 m (15 ft) and shall be protected by a ground-fault circuit interrupter. The cord shall ground all non-current-carrying metal parts of the electrical equipment. The means for grounding shall be an equipment grounding conductor run with the power-supply conductors in the flexible cord that is properly terminated in a grounding-type attachment plug having a fixed grounding contact member. If the ground-fault circuit interrupter is provided as an integral part of the cord assembly, it shall be located at the attachment plug or in the power-supply cord within 300 mm (12 in.) of the attachment plug.

(B) Storable and Portable Pumps

A cord-connected storable or portable pump utilized with, but not built-in or permanently attached as an integral part of, a permanently installed immersion pool shall be identified for swimming pool and spa use. It shall incorporate an approved system of double insulation or its equivalent and shall be provided with means for grounding only the internal and nonaccessible non-current-carrying metal parts of the appliance. The means for grounding shall be an equipment grounding conductor run with the power-supply conductors in the flexible cord that is properly terminated in a grounding-type attachment plug having a fixed grounding contact member. Cord-connected pool filter pumps shall be provided with a ground-fault circuit interrupter that is an integral part of the attachment plug or located in the power-supply cord within 300 mm (12 in.) of the attachment plug.

(C) Heaters

Heaters used with permanently installed immersion pools shall comply with either 680.45(C)(1) or (C)(2).

(1) Permanently Installed Heaters

A permanently installed heater, including immersion heaters, circulation heaters, and combination pump-heater units, built-in or permanently attached as an integral part of a permanently installed immersion pool, rated 120 volts or 250 volts, shall be identified for swimming pool and spa use; shall be grounded and bonded; and heaters supplied by branch circuits rated 150 volts or less to ground shall be provided with Class A ground-fault circuit-interrupter protection. Permanently installed immersion heaters, rated 120 volts and 20 amperes or less or 250 volts and 30 amperes or less, single phase, are permitted to be cord-and-plug-connected with a cord not shorter than 1.83 m (6 ft) and not longer than 4.6 m (15 ft), shall be protected by a ground-fault circuit interrupter, and shall be provided with means for grounding all non-current-carrying metal parts of the appliance. The means for grounding shall be an equipment grounding conductor run with the power-supply conductors in the flexible cord that is properly terminated in a grounding-type attachment plug having a fixed grounding contact member. If the ground-fault circuit interrupter is provided as an integral part of the cord assembly, it shall be located at the attachment plug or in the power-supply cord within 300 mm (12 in.) of the attachment plug.

(2) Storable and Portable Heaters

A cord-connected storable or portable heater, including immersion heaters, circulation heaters, and combination pump-heater units, utilized with, but not permanently installed or attached as an integral part of a permanently installed immersion pool, rated 120 volts and 20 amperes or less or 250 volts and 30 amperes or less, single phase, shall be identified for swimming pool and spa use; shall cord-and-plug-connected with a cord not shorter than 1.83 m (6 ft) and not longer than 4.6 m (15 ft), heaters supplied by branch circuits rated 150 volts or less to ground shall be provided with Class A ground-fault circuit-interrupter protection, and shall be provided with means for grounding all non-current-carrying metal parts of the appliance. The means for grounding shall be an equipment grounding conductor run with the power-supply conductors in the flexible cord that is properly terminated in a grounding-type attachment plug having a fixed grounding contact member. If the ground-fault circuit interrupter is provided as an integral part of the cord assembly, it shall be located at the attachment plug or in the power-supply cord within 300 mm (12 in.) of the attachment plug.

(D) Audio Equipment

Audio equipment shall not be installed in or on a permanently installed immersion pool. All audio equipment operating at greater than the low-voltage contact limit and located within 1.83 m (6 ft) from the inside walls of a permanently installed immersion pool shall be connected to the equipment grounding conductor and protected by a ground-fault circuit interrupter.

Part V Fountains

680.50 General

Part I and Part V of this article shall apply to all permanently installed fountains as defined in 680.2. Fountains that have water common to a pool and fountains intended for recreational use by pedestrians, including splash pads, shall additionally comply with the requirements in Part II of this article. Part V does not cover self-contained, portable fountains. Portable fountains shall comply with Parts II and III of Article 422.

680.51 Luminaires, Submersible Pumps, and Other Submersible Equipment

(A) Ground-Fault Circuit Interrupter

Diagram

Luminaires, submersible pumps, and other submersible equipment, unless listed for operation at low voltage contact limit or less and supplied by a transformer or power supply that complies with 680.23(A)(2), shall be protected by a ground-fault circuit interrupter.

UpCodes Diagrams

P

Sump Design

(B) Operating Voltage

No luminaires shall be installed for operation on supply circuits over 150 volts between conductors. Submersible pumps and other submersible equipment shall operate at 300 volts or less between conductors.

(C) Luminaire Lenses

Luminaires shall be installed with the top of the luminaire lens below the normal water level of the fountain unless listed for above-water locations. A luminaire facing upward shall comply with either (1) or (2):

Have the lens guarded to prevent contact by any person

Be listed for use without a guard

(D) Overheating Protection

Electrical equipment that depends on submersion for safe operation shall be protected against overheating by a low-water cutoff or other approved means when not submerged.

(E) Wiring

Equipment shall be equipped with provisions for threaded conduit entries or be provided with a suitable flexible cord. The maximum length of each exposed cord in the fountain shall be limited to 3.0 m (10 ft). Cords extending beyond the fountain perimeter shall be enclosed in approved wiring enclosures. Metal parts of equipment in contact with water shall be of brass or other approved corrosion-resistant metal.

(F) Servicing

All equipment shall be removable from the water for relamping or normal maintenance. Luminaires shall not be permanently embedded into the fountain structure such that the water level must be reduced or the fountain drained for relamping, maintenance, or inspection.

(G) Stability

Equipment shall be inherently stable or be securely fastened in place.

680.52 Junction Boxes and Other Enclosures

(A) General

Junction boxes and other enclosures used for other than underwater installation shall comply with 680.24.

(B) Underwater Junction Boxes and Other Underwater Enclosures

Junction boxes and other underwater enclosures shall meet the requirements of 680.52(B)(1) and (B)(2).

(1) Construction

(a) Underwater enclosures shall be equipped with provisions for threaded conduit entries or compression glands or seals for cord entry.

(b) Underwater enclosures shall be listed and rated for prolonged submersion and made of copper, brass, or other corrosion-resistant material.

(2) Installation

Underwater enclosure installations shall comply with 680.52(B)(2)(a) and (B)(2)(b).

(a) Underwater enclosures shall be filled with a listed potting compound to prevent the entry of moisture.

(b) Underwater enclosures shall be firmly attached to the supports or directly to the fountain surface and bonded as required. Where the junction box is supported only by conduits in accordance with 314.23(E) and (F), the conduits shall be of copper, brass, stainless steel, or other corrosion-resistant metal. Where the box is fed by nonmetallic conduit, it shall have additional supports and fasteners of copper, brass, or other corrosion-resistant material.

680.54 Grounding and Bonding

(A) Grounding

The following equipment shall be connected to the equipment grounding conductor:

Other than listed low-voltage luminaires not requiring grounding, all electrical equipment located within the fountain or within 1.5 m (5 ft) of the inside wall of the fountain

All electrical equipment associated with the recirculating system of the fountain

Panelboards that are not part of the service equipment and that supply any electrical equipment associated with the fountain

Informational Note: See 250.122 for sizing of these conductors.

(B) Bonding

The following parts shall be bonded together and connected to an equipment grounding conductor on a branch circuit supplying the fountain:

All metal piping systems associated with the fountain

All metal fittings within or attached to the fountain

Metal parts of electrical equipment associated with the fountain water-circulating system, including pump motors

Metal raceways that are within 1.5 m (5 ft) of the inside wall or perimeter of the fountain and that are not separated from the fountain by a permanent barrier

All metal surfaces that are within 1.5 m (5 ft) of the inside wall or perimeter of the fountain and that are not separated from the fountain by a permanent barrier

Electrical devices and controls that are not associated with the fountain and are located less than 1.5 m (5 ft) of the inside wall or perimeter of the fountain

680.55 Methods of Grounding

(A) Applied Provisions

The provisions of 680.21(A), 680.23(B)(3), 680.23(F)(1) and (F)(2), 680.24(F), and 680.25 shall apply.

(B) Supplied by a Flexible Cord

Electrical equipment that is supplied by a flexible cord shall have all exposed non—current-carrying metal parts grounded by an insulated copper equipment grounding conductor that is an integral part of this cord. The equipment grounding conductor shall be connected to an equipment grounding terminal in the supply junction box, transformer enclosure, power supply enclosure, or other enclosure.

680.56 Cord-and-Plug-Connected Equipment

(A) Ground-Fault Circuit Interrupter

All electrical equipment, including power-supply cords, shall be protected by ground-fault circuit interrupters.

(B) Cord Type

Flexible cord immersed in or exposed to water shall be of a type for extra-hard usage, as designated in Table 400.4, and shall be a listed type with a "W" suffix.

(C) Sealing

The end of the flexible cord jacket and the flexible cord conductor termination within equipment shall be covered with, or encapsulated in, a suitable potting compound to prevent the entry of water into the equipment through the cord or its conductors. In addition, the ground connection within equipment shall be similarly treated to protect such connections from the deteriorating effect of water that may enter into the equipment.

(D) Terminations

Connections with flexible cord shall be permanent, except that grounding-type attachment plugs and receptacles shall be permitted to facilitate removal or disconnection for maintenance, repair, or storage of fixed or stationary equipment not located in any water-containing part of a fountain.

680.57 Signs

(A) General

This section covers electric signs installed within a fountain or within 3.0 m (10 ft) of the fountain edge.

(B) Ground-Fault Circuit-Interrupter Protection for Personnel

Branch circuits or feeders supplying the sign shall have ground-fault circuit-interrupter protection for personnel.

(C) Location

(1) Fixed or Stationary

A fixed or stationary electric sign installed within a fountain shall be not less than 1.5 m (5 ft) inside the fountain measured from the outside edges of the fountain.

(2) Portable

A portable electric sign shall not be placed within a pool or fountain or within 1.5 m (5 ft) measured horizontally from the inside walls of the fountain.

(D) Disconnect

A sign shall have a local disconnecting means in accordance with 600.6 and 680.13.

(E) Bonding and Grounding

A sign shall be grounded and bonded in accordance with 600.7.

680.58 GFCI Protection for Adjacent Receptacle Outlets

All 15- or 20-ampere, single-phase 125-volt through 250-volt receptacles located within 6.0 m (20 ft) of a fountain edge shall be provided with GFCI protection.

680.59 GFCI Protection for Permanently Installed Nonsubmersible Pumps

Outlets supplying all permanently installed nonsubmersible pump motors rated 250 volts or less and 60 amperes or less, single-or 3-phase, shall be provided with ground-fault circuit-interrupter protection.

Part VI Pools and Tubs for Therapeutic Use

680.60 General

The provisions of Part I and Part VI of this article shall apply to pools and tubs for therapeutic use in health care facilities, gymnasiums, athletic training rooms, and similar areas. Portable therapeutic appliances shall comply with Parts II and III of Article 422.

Informational Note: See 517.2 for definition of health care facilities.

680.61 Permanently Installed Therapeutic Pools

Therapeutic pools that are constructed in the ground, on the ground, or in a building in such a manner that the pool cannot be readily disassembled shall comply with Parts I and II of this article.

Exception: The limitations of 680.22(B)(1) through (B)(4) shall not apply where all luminaires are of the totally enclosed type.

680.62 Therapeutic Tubs (Hydrotherapeutic Tanks)

Therapeutic tubs, used for the submersion and treatment of patients, that are not easily moved from one place to another in normal use or that are fastened or otherwise secured at a specific location, including associated piping systems, shall comply with Part VI.

(A) Protection

Except as otherwise provided in this section, the outlet(s) that supplies a self-contained therapeutic tub or hydrotherapeutic tank, a packaged therapeutic tub or hydrotherapeutic tank, or a field-assembled therapeutic tub or hydrotherapeutic tank shall be protected by a ground-fault circuit interrupter.

(1) Listed Units

If so marked, a listed, labeled, and identified self-contained unit or a listed, labeled, and identified packaged equipment assembly that includes integral ground-fault circuit-interrupter protection for all electrical parts within the unit or assembly (pumps, air blowers, heaters, lights, controls, sanitizer generators, wiring, and so forth) shall be permitted without additional GFCI protection.

(2) Other Units

A therapeutic tub or hydrotherapeutic tank rated 3 phase or rated over 250 volts or with a heater load of more than 50 amperes shall not require the supply to be protected by a ground-fault circuit interrupter.

(B) Bonding

The following parts shall be bonded together:

All metal fittings within or attached to the tub structure

Metal parts of electrical equipment associated with the tub water circulating system, including pump motors

Metal-sheathed cables and raceways and metal piping that are within 1.5 m (5 ft) of the inside walls of the tub and not separated from the tub by a permanent barrier

All metal surfaces that are within 1.5 m (5 ft) of the inside walls of the tub and not separated from the tub area by a permanent barrier

Electrical devices and controls that are not associated with the therapeutic tubs and located within 1.5 m (5 ft) from such units.

Exception: Small conductive surfaces not likely to become energized, such as air and water jets and drain fittings not connected to metallic piping, and towel bars, mirror frames, and similar nonelectrical equipment not connected to metal framing, shall not be required to be bonded.

(C) Methods of Bonding

All metal parts required to be bonded by this section shall be bonded by any of the following methods:

The interconnection of threaded metal piping and fittings

Metal-to-metal mounting on a common frame or base

Connections by suitable metal clamps

By the provisions of a solid copper bonding jumper, insulated, covered, or bare, not smaller than 8 AWG

(D) Grounding

(1) Fixed or Stationary Equipment

The equipment specified in 680.51(D)(1)(a) and (D)(1)(b) shall be connected to the equipment grounding conductor.

(a) Location. All electrical equipment located within 1.5 m (5 ft) of the inside wall of the tub shall be connected to the equipment grounding conductor.

(b) Circulation System. All electrical equipment associated with the circulating system of the tub shall be connected to the equipment grounding conductor.

(2) Portable Equipment

Portable therapeutic appliances shall meet the grounding requirements in 250.114.

(E) Receptacles

All receptacles within 1.83 m (6 ft) of a therapeutic tub shall be protected by a ground-fault circuit interrupter.

(F) Luminaires

All luminaires used in therapeutic tub areas shall be of the totally enclosed type.

Part VII Hydromassage Bathtubs

680.70 General

Hydromassage bathtubs as defined in 680.2 shall comply with Part VII of this article. They shall not be required to comply with other parts of this article.

680.71 Protection

Hydromassage bathtubs and their associated electrical components shall be on an individual branch circuit(s) and protected by a readily accessible ground-fault circuit interrupter. All 125-volt, single-phase receptacles not exceeding 30 amperes and located within 1.83 m (6 ft) measured horizontally of the inside walls of a hydromassage tub shall be protected by a ground-fault circuit interrupter.

680.72 Other Electrical Equipment

Luminaires, switches, receptacles, and other electrical equipment located in the same room, and not directly associated with a hydromassage bathtub, shall be installed in accordance with the requirements of Chapters 1 through 4 in this Code covering the installation of that equipment in bathrooms.

680.73 Accessibility

Hydromassage bathtub electrical equipment shall be accessible without damaging the building structure or building finish. Where the hydromassage bathtub is cord-and plug-connected with the supply receptacle accessible only through a service access opening, the receptacle shall be installed so that its face is within direct view and not more than 300 mm (1 ft) of the opening.

680.74 Bonding

(A) General

The following parts shall be bonded together:

All metal fittings within or attached to the tub structure that are in contact with the circulating water

Metal parts of electrical equipment associated with the tub water circulating system, including pump and blower motors

Metal-sheathed cables, metal raceways, and metal piping within 1.5 m (5 ft) of the inside walls of the tub and not separated from the tub by a permanent barrier

All exposed metal surfaces that are within 1.5 m (5 ft) of the inside walls of the tub and not separated from the tub area by a permanent barrier

Non—current-carrying metal parts of electrical devices and controls that are not associated with the hydromassage tubs within 1.5 m (5 ft) from such units

Exception No. 1: Small conductive surfaces not likely to become energized, such as air and water jets, supply valve assemblies, and drain fittings not connected to metallic piping, and towel bars, mirror frames, and similar nonelectrical equipment not connected to metal framing shall not be required to be bonded.

Exception No. 2: Double-insulated motors and blowers shall not be bonded.

(B) Bonding Conductor

All metal parts required to be bonded by this section shall be bonded together using a solid copper bonding jumper, insulated, covered, or bare, not smaller than 8 AWG. The bonding jumper(s) shall be required for equipotential bonding in the area of the hydromassage bathtub and shall not be required to be extended or attached to any remote panelboard, service equipment, or any electrode. In all installations a bonding jumper long enough to terminate on a replacement non-double-insulated pump or blower motor shall be provided and shall be terminated to the equipment grounding conductor of the branch circuit of the motor when a double-insulated circulating pump or blower motor is used.

Part VIII Electrically Powered Pool Lifts

680.80 General

Electrically powered pool lifts as defined in 680.2 shall comply with Part VIII of this article. Part VIII shall not be subject to the requirements of other parts of this article except where the requirements are specifically referenced.

680.81 Equipment Approval

Lifts shall be listed, labeled, and identified for swimming pool and spa use.

Exception No. 1: Lifts where the battery is removed for charging at another location and the battery is rated less than or equal to the low-voltage contact limit shall not be required to be listed or labeled.

Exception No. 2: Solar-operated or solar-recharged lifts where the solar panel is attached to the lift and the battery is rated less than or equal to 24 volts shall not be required to be listed or labeled.

Exception No. 3: Lifts that are supplied from a source not exceeding the low-voltage contact limit and supplied by listed transformers or power supplies that comply with 680.23(A)(2) shall not be required to be listed or labeled.

680.82 Protection

Pool lifts connected to premises wiring and operated above the low-voltage contact limit shall be provided with GFCI protection and comply with 680.5.

680.83 Bonding

Lifts shall be bonded in accordance with 680.26(B)(5) and (B)(7).

680.84 Switching Devices and Receptacles

Switches and switching devices that are operated above the low-voltage contact limit shall comply with 680.22(C). Receptacles for electrically powered pool lifts that are operated above the low-voltage contact limit shall comply with 680.22(A)(3) and (A)(4).

680.85 Nameplate Marking

Electrically powered pool lifts shall be provided with a nameplate giving the identifying name and model and rating in volts and amperes, or in volts and watts. If the lift is to be used on a specific frequency or frequencies, it shall be so marked. Battery-powered pool lifts shall indicate the type reference of the battery or battery pack to be used. Batteries and battery packs shall be provided with a battery type reference and voltage rating.

Exception: Nameplate ratings for battery-powered pool lifts shall only need to provide a rating in volts in addition to the identifying name and model.

Article 682 Natural and Artificially Made Bodies of Water

Part I General

682.1 Scope

This article applies to the installation of electrical wiring for, and equipment in and adjacent to, natural or artificially made bodies of water not covered by other articles in this Code, such as, but not limited to, aeration ponds, fish farm ponds, storm retention basins, treatment ponds, and irrigation (channels) facilities.

682.2 Definitions

The definitions in this section shall apply only within this article.

Artificially Made Bodies of Water. Bodies of water that have been constructed or modified to fit some decorative or commercial purpose such as, but not limited to, aeration ponds, fish farm ponds, storm retention basins, treatment ponds, and irrigation (channel) facilities. Water depths may vary seasonally or be controlled.

Natural Bodies of Water. Bodies of water such as lakes, streams, ponds, rivers, and other naturally occurring bodies of water, which may vary in depth throughout the year.

Shoreline. The farthest extent of standing water under the applicable conditions that determine the electrical datum plane for the specified body of water.

682.3 Other Articles

If the water is subject to boat traffic, the wiring shall comply with 555.34(B).

682.4 Industrial Application

This article shall not apply in industrial applications where there is alarm indication of equipment faults and the following conditions are in place:

Conditions of maintenance and supervision ensure that only qualified persons service and operate the installed systems.

Continued circuit operation is necessary for safe operation of equipment or processes.

682.5 Electrical Datum Plane Distances

The electrical datum plane shall consist of one of the following:

In land areas subject to tidal fluctuation, the electrical datum plane shall be a horizontal plane 600 mm (2 ft) above the highest tide level for the area occurring under normal circumstances, that is, highest high tide.

In land areas not subject to tidal fluctuation, the electrical datum plane shall be a horizontal plane 600 mm (2 ft) above the highest water level for the area occurring under normal circumstances.

In land areas subject to flooding, the electrical datum plane based on (1) or (2) above shall be a horizontal plane 600 mm (2 ft) above the point identified as the prevailing high water mark or an equivalent benchmark based on seasonal or storm-driven flooding from the authority having jurisdiction.

The electrical datum plane for floating structures and landing stages that are (a) installed to permit rise and fall response to water level, without lateral movement, and (b) that are so equipped that they can rise to the datum plane established for (1) or (2) above, shall be a horizontal plane 750 mm (30 in.) above the water level at the floating structure or landing stage and a minimum of 300 mm (12 in.) above the level of the deck.

Part II Installation

682.10 Electrical Equipment and Transformers

Electrical equipment and transformers, including their enclosures, shall be specifically approved for the intended location. No portion of an enclosure for electrical equipment not identified for operation while submerged shall be located below the electrical datum plane.

682.11 Location of Service Equipment

On land, the service equipment for floating structures and submersible electrical equipment shall be located no closer than 1.5 m (5 ft) horizontally from the shoreline and live parts shall be elevated a minimum of 300 mm (12 in.) above the electrical datum plane. Service equipment shall disconnect when the water level reaches the height of the established electrical datum plane.

682.12 Electrical Connections

All electrical connections not intended for operation while submerged shall be located at least 300 mm (12 in.) above the deck of a floating or fixed structure, but not below the electrical datum plane.

682.13 Wiring Methods and Installation

Liquidtight flexible metal conduit or liquidtight flexible nonmetallic conduit with approved fittings shall be permitted for feeders and where flexible connections are required for services. Extra-hard usage portable power cable listed for both wet locations and sunlight resistance shall be permitted for a feeder or a branch circuit where flexibility is required. Other wiring methods suitable for the location shall be permitted to be installed where flexibility is not required. Temporary wiring in accordance with 590.4 shall be permitted.

682.14 Submersible or Floating Equipment Power Connection(s)

Submersible or floating equipment shall be cord-and plug-connected, using extra-hard usage cord, as designated in Table 400.4, and listed with a "W" suffix. The plug and receptacle combination shall be arranged to be suitable for the location while in use. Disconnecting means shall be provided to isolate each submersible or floating electrical equipment from its supply connection(s) without requiring the plug to be removed from the receptacle.

Exception: Equipment listed for direct connection and equipment anchored in place and incapable of routine movement caused by water currents or wind shall be permitted to be connected using wiring methods covered in 682.13.

(A) Type and Marking

The disconnecting means shall consist of a circuit breaker, a switch, or both, or a molded case switch, and shall be specifically marked to designate which receptacle or other outlet it controls.

(B) Location

The disconnecting means shall be readily accessible on land, located not more than 750 mm (30 in.) from the receptacle it controls, and shall be located in the supply circuit ahead of the receptacle. The disconnecting means shall be located within sight of but not closer than 1.5 m (5 ft) from the shoreline and shall be elevated not less than 300 mm (12 in.) above the datum plane.

682.15 Ground-Fault Protection

The GFCI requirements in this article, unless otherwise noted, shall be in addition to the requirements in 210.8. Ground-fault protection shall be provided in accordance with 682.15(A) and (B). The protection device shall be located not less than 300 mm (12 in.) above the established electrical datum plane.

(A) Outlets

Outlets supplied by branch circuits not exceeding 150 volts to ground and 60 amperes, single-phase, shall be provided with ground-fault circuit-interrupter protection for personnel.

(B) Feeder and Branch Circuits on Piers

Feeder and branch-circuit conductors that are installed on piers shall be provided with ground-fault protection not exceeding 30 mA. Coordination with downstream ground-fault protection shall be permitted at the feeder overcurrent protective device.

Exception No. 1: Transformer secondary conductors of a separately derived ac system, operating at voltages exceeding 15 volts ac, that do not exceed 3 m (10 ft) and are installed in a raceway shall be permitted to be installed without ground-fault protection. This exception shall also apply to the supply terminals of the equipment supplied by the transformer secondary conductors.

Exception No. 2: Low-voltage circuits not requiring grounding, not exceeding the low-voltage contact limit as defined in 680.2, and supplied by listed transformers or power supplies that comply with 680.23(A)(2) shall be permitted to be installed without ground-fault protection.

Part III Grounding and Bonding

682.30 Grounding

Wiring and equipment within the scope of this article shall be grounded as specified in Part III of 553, 555.37, and with the requirements in Part III of this article.

682.31 Equipment Grounding Conductors

(A) Type

Equipment grounding conductors shall be insulated copper conductors sized in accordance with 250.122 but not smaller than 12 AWG.

(B) Feeders

Where a feeder supplies a remote panelboard or other distribution equipment, an insulated equipment grounding conductor shall extend from a grounding terminal in the service to a grounding terminal and busbar in the remote panelboard or other distribution equipment.

(C) Branch Circuits

The insulated equipment grounding conductor for branch circuits shall terminate at a grounding terminal in a remote panelboard or other distribution equipment or the grounding terminal in the main service equipment.

(D) Cord-and-Plug-Connected Appliances

Where grounded, cord-and-plug-connected appliances shall be grounded by means of an equipment grounding conductor in the cord and a grounding-type attachment plug.

682.32 Bonding of Non—Current-Carrying Metal Parts

All metal parts in contact with the water, all metal piping, tanks, and all non—current-carrying metal parts that are likely to become energized shall be bonded to the grounding terminal in the distribution equipment.

682.33 Equipotential Planes and Bonding of Equipotential Planes

An equipotential plane shall be installed where required in this section to mitigate step and touch voltages at electrical equipment.

(A) Areas Requiring Equipotential Planes

Equipotential planes shall be installed adjacent to all outdoor service equipment or disconnecting means that control equipment in or on water, that have a metallic enclosure and controls accessible to personnel, and that are likely to become energized. The equipotential plane shall encompass the area around the equipment and shall extend from the area directly below the equipment out not less than 900 mm (36 in.) in all directions from which a person would be able to stand and come in contact with the equipment.

(B) Areas Not Requiring Equipotential Planes

Equipotential planes shall not be required for the controlled equipment supplied by the service equipment or disconnecting means.

(C) Bonding

(1) Bonded Parts

The parts specified in 682.33(C)(1) through (C)(3) shall be bonded together and to the electrical grounding system. Bonding conductors shall be solid copper, insulated, covered or bare, and not smaller than 8 AWG. Connections shall be made by exothermic welding or by listed pressure connectors or clamps that are labeled as being suitable for the purpose and are of stainless steel, brass, copper, or copper alloy.

(2) Outdoor Service Equipment and Disconnects

Outdoor service equipment or disconnecting means that control equipment in or on water, that have a metallic enclosure and controls accessible to personnel, and that are likely to become energized shall be bonded to the equipotential plane.

(3) Walking Surfaces

Surfaces directly below the equipment specified in 682.33(C)(2) but not less than 900 mm (36 in.) in all directions from the equipment from which a person would be able to stand and come in contact with the equipment shall be bonded to the equipotential plane. Bonding to this surface shall be wire mesh or other conductive elements on, embedded in, or placed under the walk surface within 75 mm (3 in.).

Article 685 Integrated Electrical Systems

Part I General

685.1 Scope

This article covers 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 article is a unitized segment of an industrial wiring system where all of the following conditions are met:

An orderly shutdown is required to minimize personnel hazard and equipment damage.

The conditions of maintenance and supervision ensure that qualified persons service the system. The name(s) of the qualified person(s) shall be kept in a permanent record at the office of the establishment in charge of the completed installation.

A person designated as a qualified person shall possess the skills and knowledge related to the construction and operation of the electrical equipment and installation and shall have received documented safety training on the hazards involved. Documentation of their qualifications shall be on file with the office of the establishment in charge of the completed installation.

Effective safeguards approved by the authority having jurisdiction are established and maintained.

685.3 Application of Other Articles

The articles/sections in Table 685.3 apply to particular cases of installation of conductors and equipment, where there are orderly shutdown requirements that are in addition to those of this article or are modifications of them.

Table 685.3 Application of Other Articles

Conductor/Equipment Section

More than one building or other structure 225, Part II

Ground-fault protection of equipment 230.95, Exception

Protection of conductors 240.4

Electrical system coordination 240.12

Ground-fault protection of equipment 240.13(1)

Grounding ac systems of 50 volts to less than 1000 volts 250.21

Equipment protection 427.22

Orderly shutdown 430.44

Disconnection 430.75, Exception Nos. 1 and 2

Disconnecting means in sight from controller 430.102(A), Exception No. 2

Energy from more than one source 430.113, Exception Nos. 1 and 2

Disconnecting means 645.10, Exception

Uninterruptible power supplies (UPS) 645.11(1)

Point of connection 705.12

Part II Orderly Shutdown

685.10 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 unqualified personnel.

685.12 Direct-Current System Grounding

Two-wire dc circuits shall be permitted to be ungrounded.

685.14 Ungrounded Control Circuits

Where operational continuity is required, control circuits of 150 volts or less from separately derived systems shall be permitted to be ungrounded.

Article 690 Solar Photovoltaic (PV) Systems

Upcodes Diagrams

Part I General

690.1 Scope

This article applies to solar PV systems, other than those covered by Article 691, including the array circuit(s), inverter(s), and controller(s) for such systems. The systems covered by this article include those interactive with other electric power production sources or stand-alone, or both. These PV systems may have ac or dc output for utilization.

Informational Note No. 1: See Informational Note Figure 690.1(a) and Informational Note Figure 690.1(b).

Informational Note No. 2: Article 691 covers the installation of large-scale PV electric supply stations.

Note:

(1) These diagrams are intended to be a means of identification for PV power source components, circuits, and connections that make up the PV power source.

(2) Custom PV power source designs occur, and some components are optional.

Informational Note Figure 690.1(a) Identification of PV Power Source Components.

Note:

(1) These diagrams are intended to be a means of identification for PV system components, circuits, and connections.

(2) The PV system disconnect in these diagrams separates the PV system from all other systems.

(3) Not all disconnecting means required by Article 690, Part III are shown.

(4) System grounding and equipment grounding are not shown. See Article 690, Part V.

(5) Custom designs occur in each configuration, and some components are optional.

Informational Note Figure 690.1(b) Identification of PV System Components in Common Configurations.

690.2 Definitions

The definitions in this section shall apply only within this article.

AC Module System. An assembly of ac modules, wiring methods, materials, and subassemblies that are evaluated, identified, and defined as a system.

Alternating-Current (ac) Module (Alternating-Current Photovoltaic Module). A complete, environmentally protected unit consisting of solar cells, inverter, and other components, designed to produce ac power.

Array. A mechanically and electrically integrated grouping of modules with support structure, including any attached system components such as inverter(s) or dc-to-dc converter(s) and attached associated wiring.

Bipolar Circuit. A dc circuit that is comprised of two monopole circuits, each having an opposite polarity connected to a common reference point.

DC-to-DC Converter Output Circuit. The dc circuit conductors connected to the output of a dc combiner for dc-to-dc converter source circuits.

DC-to-DC Converter Source Circuit. Circuits between dc-to-dc converters and from dc-to-dc converters to the common connection point(s) of the dc system.

Direct-Current (dc) Combiner. An enclosure that includes devices used to connect two or more PV system dc circuits in parallel.

Electronic Power Converter. A device that uses power electronics to convert one form of electrical power into another form of electrical power.

Informational Note: Examples of electronic power converters include, but are not limited to, inverters, dc-to-dc converters, and electronic charge controllers. These devices have limited current capabilities based on the device ratings at continuous rated power.

Grounded, Functionally. A system that has an electrical ground reference for operational purposes that is not solidly grounded.

Informational Note: A functionally grounded system is often connected to ground through an electronic means internal to an inverter or charge controller that provides ground-fault protection. Examples of operational purposes for functionally grounded systems include ground-fault detection and performance-related issues for some power sources.

Module. A complete, environmentally protected unit consisting of solar cells and other components designed to produce dc power.

Monopole Circuit. An electrical subset of a PV system that has two conductors in the output circuit, one positive (+) and one negative (—).

PV Output Circuit. The dc circuit conductors from two or more connected PV source circuits to their point of termination.

PV Source Circuit. The dc circuit conductors between modules and from modules to dc combiners, electronic power converters, or a dc PV system disconnecting means.

PV System DC Circuit. Any dc conductor in PV source circuits, PV output circuits, dc-to-dc converter source circuits, and dc-to-dc converter output circuits.

Solar Cell. The basic PV device that generates electricity when exposed to light.

690.4 General Requirements

(A) Photovoltaic Systems

Photovoltaic systems shall be permitted to supply a building or other structure in addition to any other electrical supply system(s).

(B) Equipment

Inverters, motor generators, PV modules, ac modules and ac module systems, dc combiners, dc-to-dc converters, rapid shutdown equipment, dc circuit controllers, and charge controllers intended for use in PV systems shall be listed or be evaluated for the application and have a field label applied.

(C) Qualified Personnel

The installation of equipment and all associated wiring and interconnections shall be performed only by qualified persons.

Informational Note: See Article 100 for the definition of qualified person.

(D) Multiple PV Systems

Diagram

Multiple PV systems shall be permitted to be installed in or on a single building or structure. Where the PV systems are remotely located from each other, a directory in accordance with 705.10 shall be provided at each PV system disconnecting means.

Upcodes Diagrams

(E) Locations Not Permitted

PV system equipment and disconnecting means shall not be installed in bathrooms.

(F) Electronic Power Converters Mounted in Not Readily Accessible Locations

Electronic power converters and their associated devices shall be permitted to be mounted on roofs or other exterior areas that are not readily accessible. Disconnecting means shall be installed in accordance with 690.15.

690.6 Alternating-Current (AC) Modules and Systems

(A) Photovoltaic Source Circuits

The requirements of Article 690 pertaining to PV source circuits shall not apply to ac modules or ac module systems. The PV source circuit, conductors, and inverters shall be considered as internal components of an ac module or ac module system.

(B) Output Circuit

The output of an ac module or ac module system shall be considered an inverter output circuit.

Part II Circuit Requirements

690.7 Maximum Voltage

The maximum voltage of PV system dc circuits shall be the highest voltage between any two conductors of a circuit or any conductor and ground. The maximum voltage shall be used to determine the voltage and voltage to ground of circuits in the application of this Code. Maximum voltage shall be used for conductors, cables, equipment, working space, and other applications where voltage limits and ratings are used.

PV system dc circuits on or in buildings shall be permitted to have a maximum voltage no greater than 1000 volts. PV system dc circuits on or in one- and two-family dwellings shall be permitted to have a maximum voltage no greater than 600 volts. Where not located on or in buildings, listed dc PV equipment, rated at a maximum voltage no greater than 1500 volts, shall not be required to comply with Parts II and III of Article 490.

(A) Photovoltaic Source and Output Circuits

In a dc PV source circuit or output circuit, the maximum PV system voltage for that circuit shall be calculated in accordance with one of the following methods:

The sum of the PV module-rated open-circuit voltage of the series-connected modules corrected for the lowest expected ambient temperature using the open-circuit voltage temperature coefficients in accordance with the instructions included in the listing or labeling of the module

For crystalline and multicrystalline silicon modules, the sum of the PV module-rated open-circuit voltage of the series-connected modules corrected for the lowest expected ambient temperature using the correction factors provided in Table 690.7(A)

For PV systems with an inverter generating capacity of 100 kW or greater, a documented and stamped PV system design, using an industry standard method maximum voltage calculation provided by a licensed professional electrical engineer

Informational Note No. 1: One source for lowest-expected, ambient temperature design data for various locations is the chapter titled "Extreme Annual Mean Minimum Design Dry Bulb Temperature" found in the ASHRAE Handbook — Fundamentals, 2017. These temperature data can be used to calculate maximum voltage.

Informational Note No. 2: One industry standard method for calculating maximum voltage of a PV system is published by Sandia National Laboratories, reference SAND 2004-3535, Photovoltaic Array Performance Model.

Table 690.7(A) Voltage Correction Factors for Crystalline and Multicrystalline Silicon Modules

Correction Factors for Ambient Temperatures Below 25°C (77°F). (Multiply the rated open-circuit voltage by the appropriate correction factor shown below.)

Ambient Temperature (°C) Factor Ambient Temperature (°F)

24 to 20 1.02 76 to 68

19 to 15 1.04 67 to 59

14 to 10 1.06 58 to 50

9 to 5 1.08 49 to 41

4 to 0 1.10 40 to 32

—1 to —5 1.12 31 to 23

—6 to—10 1.14 22 to 14

—11 to —15 1.16 13 to 5

—16 to—20 1.18 4 to —4

—21 to —25 1.20 —5 to—13

—26 to —30 1.21 —14 to—22

—31 to —35 1.23 —23 to —31

—36 to —40 1.25 —32 to —40

(B) DC-to-DC Converter Source and Output Circuits

In a dc-to-dc converter source and output circuit, the maximum voltage shall be calculated in accordance with 690.7(B)(1) or (B)(2).

(1) Single DC-to-DC Converter

For circuits connected to the output of a single dc-to-dc converter, the maximum voltage shall be determined in accordance with the instructions included in the listing or labeling of the dc-to-dc converter. If the instructions do not provide a method to determine the maximum voltage, the maximum voltage shall be the maximum rated voltage output of the dc-to-dc converter.

(2) Two or More Series-Connected DC-to-DC Converters

For circuits connected to the output of two or more series-connected dc-to-dc converters, the maximum voltage shall be determined in accordance with the instructions included in the listing or labeling of the dc-to-dc converter. If the instructions do not provide a method to determine the maximum voltage, the maximum voltage shall be the sum of the maximum rated voltage output of the dc-to-dc converters in series.

(C) Bipolar Source and Output Circuits

For monopole subarrays in bipolar systems, the maximum voltage shall be the highest voltage between the monopole subarray circuit conductors where one conductor of the monopole subarray circuit is connected to the functionally grounded reference. To prevent overvoltage in the event of a ground fault or arc fault, the monopole subarray circuits shall be isolated from ground.

690.8 Circuit Sizing and Current

(A) Calculation of Maximum Circuit Current

The maximum current for the specific circuit shall be calculated in accordance with one of the methods in 690.8(A)(1) or (A)(2).

(1) PV System Circuits

The maximum current shall be calculated in accordance with 690.8(A)(1)(a) through (A)(1)(e).

(a) Photovoltaic Source Circuit Currents. The maximum current shall be as calculated in either of the following:

The maximum current shall be the sum of the short-circuit current ratings of the PV modules connected in parallel multiplied by 125 percent.

For PV systems with an inverter generating capacity of 100 kW or greater, a documented and stamped PV system design, using an industry standard method maximum current calculation provided by a licensed professional electrical engineer, shall be permitted. The calculated maximum current value shall be based on the highest 3hour current average resulting from the simulated local irradiance on the PV array accounting for elevation and orientation. The current value used by this method shall not be less than 70 percent of the value calculated using 690.8(A)(1)(a)(1).

Informational Note: One industry standard method for calculating maximum current of a PV system is available from Sandia National Laboratories, reference SAND 2004-3535, Photovoltaic Array Performance Model. This model is used by the System Advisor Model simulation program provided by the National Renewable Energy Laboratory.

(b) Photovoltaic Output Circuit Currents. The maximum current shall be the sum of parallel source circuit maximum currents as calculated in 690.8(A)(1)(a).

(c) DC-to-DC Converter Source Circuit Current. The maximum current shall be the dc-to-dc converter continuous output current rating.

(d) DC-to-DC Converter Output Circuit Current. The maximum current shall be the sum of parallel connected dc-to-dc converter source circuit currents as calculated in 690.8(A)(1)(c).

(e) Inverter Output Circuit Current. The maximum current shall be the inverter continuous output current rating.

(2) Circuits Connected to the Input of Electronic Power Converters

Where a circuit is protected with an overcurrent device not exceeding the conductor ampacity, the maximum current shall be permitted to be the rated input current of the electronic power converter input to which it is connected.

(B) Conductor Ampacity

Circuit conductors shall be sized to carry not less than the larger ampacity calculated in accordance with 690.8(B)(1) or (B)(2).

(1) Without Adjustment and Correction Factors

The maximum currents calculated in 690.8(A) multiplied by 125 percent without adjustment or correction factors.

Exception: Circuits containing an assembly, together with its overcurrent device(s), that is listed for continuous operation at 100 percent of its rating shall be permitted to be used at 100 percent of its rating.

(2) With Adjustment and Correction Factors

The maximum currents calculated in 690.8(A) with adjustment and correction factors.

(C) Systems With Multiple Direct-Current Voltages

For a PV power source that has multiple output circuit voltages and employs a common-return conductor, the ampacity of the common-return conductor shall not be less than the sum of the ampere ratings of the overcurrent devices of the individual output circuits.

(D) Sizing of Module Interconnection Conductors

Where a single overcurrent device is used to protect a set of two or more parallel-connected module circuits, the ampacity of each of the module interconnection conductors shall not be less than the sum of the rating of the single overcurrent device plus 125 percent of the short-circuit current from the other parallel-connected modules.

690.9 Overcurrent Protection

(A) Circuits and Equipment

PV system dc circuit and inverter output conductors and equipment shall be protected against overcurrent. Circuits sized in accordance with 690.8(A)(2) are required to be protected against overcurrent with overcurrent protective devices. Each circuit shall be protected from overcurrent in accordance with 690.9(A)(1), (A)(2), or (A)(3).

(1) Circuits Where Overcurrent Protection Not Required

Overcurrent protective devices shall not be required where both of the following conditions are met:

The conductors have sufficient ampacity for the maximum circuit current.

The currents from all sources do not exceed the maximum overcurrent protective device rating specified for the PV module or electronic power converter.

(2) Circuits Where Overcurrent Protection Is Required on One End

A circuit conductor connected at one end to a current-limited supply, where the conductor is rated for the maximum circuit current from that supply, and also connected to sources having an available maximum circuit current greater than the ampacity of the conductor, shall be protected from overcurrent at the point of connection to the higher current source.

Informational Note: Photovoltaic system dc circuits and electronic power converter outputs powered by these circuits are current-limited and in some cases do not need overcurrent protection. Where these circuits are connected to higher current sources, such as parallel-connected PV system dc circuits, energy storage systems, or a utility service, the overcurrent device is often installed at the higher current source end of the circuit conductor.

(3) Other Circuits

Circuits that do not comply with 690.9(A)(1) or (A)(2) shall be protected with one of the following methods:

Conductors not greater than 3 m (10 ft) in length and not in buildings, protected from overcurrent on one end

Conductors not greater than 3m (10 ft) in length and in buildings, protected from overcurrent on one end and in a raceway or metal clad cable

Conductors protected from overcurrent on both ends

Conductors not installed on or in buildings are permitted to be protected from overcurrent on one end of the circuit where the circuit complies with all of the following conditions:

The conductors are installed in metal raceways or metal-clad cables, or installed in enclosed metal cable trays, or underground, or where directly entering pad-mounted enclosures.

The conductors for each circuit terminate on one end at a single circuit breaker or a single set of fuses that limit the current to the ampacity of the conductors.

The overcurrent device for the conductors is an integral part of a disconnecting means or shall be located within 3 m (10 ft) of conductor length of the disconnecting means.

The disconnecting means for the conductors is installed outside of a building, or at a readily accessible location nearest the point of entrance of the conductors inside of a building, including installations complying with 230.6.

(B) Device Ratings

Overcurrent devices used in PV system dc circuits shall be listed for use in PV systems. Electronic devices that are listed to prevent backfeed current in PV system dc circuits shall be permitted to prevent overcurrent of conductors on the PV array side of the device. Overcurrent devices, where required, shall be rated in accordance with one of the following and permitted to be rounded up to the next higher standard size in accordance with 240.4(B):

Not less than 125 percent of the maximum currents calculated in 690.8(A).

An assembly, together with its overcurrent device(s), that is listed for continuous operation at 100 percent of its rating shall be permitted to be used at 100 percent of its rating.

Informational Note: Some electronic devices prevent backfeed current, which in some cases is the only source of overcurrent in PV system dc circuits.

(C) Source and Output Circuits

A single overcurrent protective device, where required, shall be permitted to protect the PV modules, dc-to-dc converters, and conductors of each source circuit or the conductors of each output circuit. Where single overcurrent protection devices are used to protect source or output circuits, all overcurrent devices shall be placed in the same polarity for all circuits within a PV system. The overcurrent devices shall be accessible but shall not be required to be readily accessible.

Informational Note: Due to improved ground-fault protection required in PV systems by 690.41(B), a single overcurrent protective device in either the positive or negative conductors of a PV system in combination with this ground-fault protection provides adequate overcurrent protection.

(D) Power Transformers

Overcurrent protection for a transformer with a source(s) on each side shall be provided in accordance with 450.3 by considering first one side of the transformer, then the other side of the transformer, as the primary.

Exception: A power transformer with a current rating on the side connected toward the interactive inverter output, not less than the rated continuous output current of the inverter, shall be permitted without overcurrent protection from the inverter.

690.10 Stand-Alone Systems

The wiring system connected to a stand-alone system shall be installed in accordance with 710.15.

690.11 Arc-Fault Circuit Protection (Direct Current)

Photovoltaic systems with PV system dc circuits operating at 80 volts dc or greater between any two conductors shall be protected by a listed PV arc-fault circuit interrupter or other system components listed to provide equivalent protection. The system shall detect and interrupt arcing faults resulting from a failure in the intended continuity of a conductor, connection, module, or other system component in the PV system dc circuits.

Informational Note: Annex A includes the reference for the Photovoltaic DC Arc-Fault Circuit Protection product standard.

Exception: For PV systems not installed on or in buildings, PV output circuits and dc-to-dc converter output circuits that are installed in metallic raceways or metal-clad cables, or installed in enclosed metallic cable trays, or are underground shall be permitted without arc-fault circuit protection. Detached structures whose sole purpose is to house PV system equipment shall not be considered buildings according to this exception.

690.12 Rapid Shutdown of PV Systems on Buildings

PV system circuits installed on or in buildings shall include a rapid shutdown function to reduce shock hazard for firefighters in accordance with 690.12(A) through (D).

Exception: Ground-mounted PV system circuits that enter buildings, of which the sole purpose is to house PV system equipment, shall not be required to comply with 690.12.

(A) Controlled Conductors

Requirements for controlled conductors shall apply to the following:

PV system dc circuits

Inverter output circuits originating from inverters located within the array boundary

Informational Note: The rapid shutdown function reduces the risk of electrical shock that dc circuits in a PV system could pose for firefighters. The ac output conductors from PV systems that include inverters will either be de-energized after shutdown initiation or will remain energized by other sources such as a utility service. To prevent PV arrays with attached inverters from having energized ac conductors within the PV array(s), those circuits are also specifically controlled after shutdown initiation.

(B) Controlled Limits

The use of the term array boundary in this section is defined as 305 mm (1 ft) from the array in all directions. Controlled conductors outside the array boundary shall comply with 690.12(B)(1) and inside the array boundary shall comply with 690.12(B)(2).

(1) Outside the Array Boundary

Controlled conductors located outside the boundary or more than 1 m (3 ft) from the point of entry inside a building shall be limited to not more than 30 volts within 30 seconds of rapid shutdown initiation. Voltage shall be measured between any two conductors and between any conductor and ground.

(2) Inside the Array Boundary

The PV system shall comply with one of the following:

A PV hazard control system listed for the purpose shall be installed in accordance with the instructions included with the listing or field labeling. Where a hazard control system requires initiation to transition to a controlled state, the rapid shutdown initiation device required in 690.12(C) shall perform this initiation.

Informational Note: A listed or field-labeled hazard PV control system is comprised of either an individual piece of equipment that fulfills the necessary functions or multiple pieces of equipment coordinated to perform the functions as described in the installation instructions to reduce the risk of electric shock hazard within a damaged PV array for fire fighters. See UL 3741, Photovoltaic Hazard Control.

Controlled conductors located inside the boundary shall be limited to not more than 80 volts within 30 seconds of rapid shutdown initiation. Voltage shall be measured between any two conductors and between any conductor and ground.

PV arrays shall have no exposed wiring methods or conductive parts and be installed more than 2.5 m (8 ft) from exposed grounded conductive parts or ground.

(C) Initiation Device

The initiation device(s) shall initiate the rapid shutdown function of the PV system. The device's "off" position shall indicate that the rapid shutdown function has been initiated for all PV systems connected to that device. For one-family and two-family dwellings an initiation device(s) shall be located at a readily accessible location outside the building.

For a single PV system, the rapid shutdown initiation shall occur by the operation of any single initiationdevice. Devices shall consist of at least one or more of the following:

Service disconnecting means

PV system disconnecting means

Readily accessible switch that plainly indicates whether it is in the "off" or "on" position

Informational Note: Examples of where an initiation device that complies with 690.12(C)(3) would be used is where a PV system is connected to an optional standby or stand-alone system.

Where multiple PV systems are installed with rapid shutdown functions on a single service, the initiation device(s) shall consist of not more than six switches or six sets of circuit breakers, or a combination of not more than six switches and sets of circuit breakers, mounted in a single enclosure, or in a group of separate enclosures. These initiation device(s) shall initiate the rapid shutdown of all PV systems with rapid shutdown functions on that service.

(D) Equipment

Equipment that performs the rapid shutdown functions, other than initiation devices such as listed disconnect switches, circuit breakers, or control switches, shall be listed for providing rapid shutdown protection.

Part III Disconnecting Means

690.13 Photovoltaic System Disconnecting Means

Means shall be provided to disconnect the PV system from all wiring systems including power systems, energy storage systems, and utilization equipment and its associated premises wiring.

(A) Location

The PV system disconnecting means shall be installed at a readily accessible location. Where disconnecting means of systems above 30 V are readily accessible to unqualified persons, any enclosure door or hinged cover that exposes live parts when open shall be locked or require a tool to open.

Informational Note: PV systems installed in accordance with 690.12 address the concerns related to energized conductors entering a building.

(B) Marking

Diagram

Each PV system disconnecting means shall plainly indicate whether in the open (off) or closed (on) position and be permanently marked "PV SYSTEM DISCONNECT" or equivalent. Additional markings shall be permitted based upon the specific system configuration. For PV system disconnecting means where the line and load terminals may be energized in the open position, the device shall be marked with the following words or equivalent:

WARNING

ELECTRIC SHOCK HAZARD TERMINALS ON THE LINE AND LOAD

SIDES MAY BE ENERGIZED IN THE OPEN POSITION

The warning sign(s) or label(s) shall comply with 110.21(B).

UpCodes Diagrams

P

Solar Labeling Requirements

(C) Maximum Number of Disconnects

Each PV system disconnecting means shall consist of not more than six switches or six sets of circuit breakers, or a combination of not more than six switches and sets of circuit breakers, mounted in a single enclosure, or in a group of separate enclosures. A single PV system disconnecting means shall be permitted for the combined ac output of one or more inverters or ac modules in an interactive system.

Informational Note: This requirement does not limit the number of PV systems connected to a service as permitted in 690.4(D). This requirement allows up to six disconnecting means to disconnect a single PV system. For PV systems where all power is converted through interactive inverters, a dedicated circuit breaker, in 705.12(B)(1), is an example of a single PV system disconnecting means.

(D) Ratings

The PV system disconnecting means shall have ratings sufficient for the maximum circuit current, available fault current, and voltage that is available at the terminals of the PV system disconnect.

(E) Type of Disconnect

The PV system disconnecting means shall simultaneously disconnect the PV system conductors that are not solidly grounded from all conductors of other wiring systems. The PV system disconnecting means or its remote operating device or the enclosure providing access to the disconnecting means shall be capable of being locked in accordance with 110.25. The PV system disconnecting means shall be one of the following:

A manually operable switch or circuit breaker

A connector meeting the requirements of 690.33(D)(1) or (D)(3)

A pull-out switch with the required interrupting rating

A remote-controlled switch or circuit breaker that is operable locally and opens automatically when control power is interrupted

A device listed or approved for the intended application

Informational Note: Circuit breakers marked "line" and "load" may not be suitable for backfeed or reverse current.

690.15 Disconnecting Means for Isolating Photovoltaic Equipment

Diagram

Disconnecting means of the type required in 690.15(D) shall be provided to disconnect ac PV modules, fuses, dc-to-dc converters, inverters, and charge controllers from all conductors that are not solidly grounded.

UpCodes Diagrams

P

Solar Labeling Requirements

(A) Location

Isolating devices or equipment disconnecting means shall be installed in circuits connected to equipment at a location within the equipment, or within sight and within 3 m (10 ft) of the equipment. An equipment disconnecting means shall be permitted to be remote from the equipment where the equipment disconnecting means can be remotely operated from within 3 m (10 ft) of the equipment. Where disconnecting means of equipment operating above 30 volts are readily accessible to unqualified persons, any enclosure door or hinged cover that exposes live parts when open shall be locked or require a tool to open.

(B) Isolating Device

An isolating device shall not be required to have an interrupting rating. Where an isolating device is not rated for interrupting the circuit current, it shall be marked "Do Not Disconnect Under Load" or "Not for Current Interrupting." An isolating device shall not be required to simultaneously disconnect all current-carrying conductors of a circuit. The isolating device shall be one of the following:

A mating connector meeting the requirements of 690.33 and listed and identified for use with specific equipment

A finger-safe fuse holder

An isolating device that requires a tool to place the device in the open (off) position

An isolating device listed for the intended application

(C) Equipment Disconnecting Means

Diagram

Equipment disconnecting means shall have ratings sufficient for the maximum circuit current, available fault current, and voltage that is available at the terminals. Equipment disconnecting means shall simultaneously disconnect all current-carrying conductors that are not solidly grounded to the circuit to which it is connected. Equipment disconnecting means shall be externally operable without exposing the operator to contact with energized parts and shall indicate whether in the open (off) or closed (on) position. Where not within sight or not within 3 m (10 ft) of the equipment, the disconnecting means or its remote operating device or the enclosure providing access to the disconnecting means shall be capable of being locked in accordance with 110.25. Equipment disconnecting means, where used, shall be one of the types in 690.13(E)(1) through (E)(5).

Equipment disconnecting means, other than those complying with 690.33, shall be marked in accordance with the warning in 690.13(B) if the line and load terminals can be energized in the open position.

Informational Note: A common installation practice is to terminate PV source-side dc conductors in the same manner that utility source-side ac conductors are generally connected on the line side of a disconnecting means. This practice is more likely to de-energize load-side terminals, blades, and fuses when the disconnect is in the open position and no energized sources are connected to the load side of the disconnect.

UpCodes Diagrams

P

Solar Labeling Requirements

(D) Type of Disconnecting Means

Where disconnects are required to isolate equipment, the disconnecting means shall be one of the following applicable types:

An equipment disconnecting means in accordance with 690.15(C) shall be required to isolate dc circuits with a maximum circuit current over 30 amperes.

An isolating device in accordance with 690.15(B) shall be permitted for circuits other than those covered by 690.15(D)(1).

Part IV Wiring Methods and Materials

690.31 Wiring Methods

(A) Wiring Systems

All raceway and cable wiring methods included in this Code, other wiring systems and fittings specifically listed for use in PV arrays, and wiring as part of a listed system shall be permitted. Where wiring devices with integral enclosures are used, sufficient length of cable shall be provided to facilitate replacement.

Where PV source and output circuits operating at voltages greater than 30 volts are installed in readily accessible locations, circuit conductors shall be guarded or installed in Type MC cable or in raceway. The ampacity of 105°C (221°F) and 125°C (257°F) conductors shall be permitted to be determined by Table 690.31(A)(b). For ambient temperatures greater than 30°C (86°F), the ampacities of these conductors shall be corrected in accordance with Table 690.31(A)(a).

Informational Note: See 110.14(C) for conductor temperature limitations due to termination provisions.

Table 690.31(A)(a) Correction Factors

Ambient Temperature (°C) Temperature Rating of Conductor

105°C (221°F) 125°C (257°F) Ambient Temperature (°F)

30 1 1 86

31—35 0.97 0.97 87—95

36—40 0.93 0.95 96—104

41—45 0.89 0.92 105—113

46—50 0.86 0.89 114—122

51—55 0.82 0.86 123—131

56—60 0.77 0.83 132—140

61—65 0.73 0.79 141—149

66—70 0.68 0.76 150—158

71—75 0.63 0.73 159—167

76—80 0.58 0.69 168—176

81—85 0.52 0.65 177—185

86—90 0.45 0.61 186—194

91—95 0.37 0.56 195—203

96—100 0.26 0.51 204—212

101—105 — 0.46 213—221

106—110 — 0.4 222—230

111—115 — 0.32 231—239

116—120 — 0.23 240—248

Table 690.31(A)(b) Ampacities of Insulated Conductors Rated Up To and Including 2000 Volts, 105°C Through 125°C (221°F Through 257°F), Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried), Based on Ambient Temperature of 30°C (86°F)

AWG Types

PVC, CPE, XLPE 105°C XLPE, EPDM 125°C

18 15 16

16 19 20

14 29 31

12 36 39

10 46 50

8 64 69

6 81 87

4 109 118

3 129 139

2 143 154

1 168 181

1/0 193 208

2/0 229 247

3/0 263 284

4/0 301 325

(B) Identification and Grouping

PV system dc circuits and Class 1 remote control, signaling, and power-limited circuits of a PV system shall be permitted to occupy the same equipment wiring enclosure, cable, or raceway. PV system dc circuits shall not occupy the same equipment wiring enclosure, cable, or raceway, as other non-PV systems, or inverter output circuits, unless the PV system dc circuits are separated from other circuits by a barrier or partition. PV system circuit conductors shall be identified and grouped as required by 690.31(B)(1) and (B)(2).

Exception: PV system dc circuits utilizing multiconductor jacketed cable or metal-clad cable assemblies or listed wiring harnesses identified for the application shall be permitted to occupy the same wiring method as inverter output circuits and other non-PV systems. All conductors, harnesses, or assemblies shall have an insulation rating equal to at least the maximum circuit voltage applied to any conductor within the enclosure, cable, or raceway.

(1) Identification

PV system dc circuit conductors shall be identified at all termination, connection, and splice points by color coding, marking tape, tagging, or other approved means. Conductors relying on other than color coding for polarity identification shall be identified by an approved permanent marking means such as labeling, sleeving, or shrink-tubing that is suitable for the conductor size. The permanent marking means for nonsolidly grounded positive conductors shall include imprinted plus signs (+) or the word POSITIVE or POS durably marked on insulation of a color other than green, white, or gray. The permanent marking means for nonsolidly grounded negative conductors shall include imprinted negative signs (—) or the word NEGATIVE or NEG durably marked on insulation of a color other than green, white, gray, or red. Only solidly grounded PV system dc circuit conductors shall be marked in accordance with 200.6.

Exception: Where the identification of the conductors is evident by spacing or arrangement, further identification shall not be required.

(2) Grouping

Where the conductors of more than one PV system occupy the same junction box or raceway with a removable cover(s), the PV system conductors of each system shall be grouped separately by cable ties or similar means at least once and shall then be grouped at intervals not to exceed 1.8 m (6ft).

Exception: The requirement for grouping shall not apply if the circuit enters from a cable or raceway unique to the circuit that makes the grouping obvious.

(C) Cables

Type PV wire or cable and Type distributed generation (DG) cable shall be listed.

Informational Note: See UL 4703, Standard for Photovoltaic Wire, for PV wire and UL 3003, Distributed Generation Cables, for DG cable.

(1) Single-Conductor Cable

Single-conductor cable in exposed outdoor locations in PV system dc circuits within the PV array shall be permitted to be one of the following:

PV wire or cable

Single-conductor cable marked sunlight resistant and Type USE-2 and Type RHW-2

Exposed cables shall be supported and secured at intervals not to exceed 600 mm (24 in.) by cable ties, straps, hangers, or similar fittings listed and identified for securement and support in outdoor locations. PV wire or cable shall be permitted in all locations where RHW-2 is permitted.

Exception: PV systems meeting the requirements of 691.4 shall be permitted to have support and securement intervals as defined in the engineered design.

(2) Cable Tray

Single-conductor PV wire or cable of all sizes or distributed generation (DG) cable of all sizes, with or without a cable tray rating, shall be permitted in cable trays installed in outdoor locations, provided that the cables are supported at intervals not to exceed 300 mm (12 in.) and secured at intervals not to exceed 1.4 m (41/2 ft).

Informational Note: PV wire and cable and DG cable have a nonstandard outer diameter. Table 1 of Chapter 9 contains the allowable percent of cross section of conduit and tubing for conductors and cables.

(3) Multiconductor Jacketed Cables

Where part of a listed PV assembly, multiconductor jacketed cables shall be installed in accordance with the included instructions. Where not part of a listed assembly, or where not otherwise covered in this Code, multiconductor jacketed cables, including DG cable, shall be installed in accordance with the product listing and shall be permitted in PV systems. These cables shall be installed in accordance with the following:

In raceways, where on or in buildings other than rooftops

Where not in raceways, in accordance with the following:

Marked sunlight resistant in exposed outdoor locations

Protected or guarded, where subject to physical damage

Closely follow the surface of support structures

Secured at intervals not exceeding 1.8 m (6 ft)

Secured within 600 mm (24 in.) of mating connectors or entering enclosures

Marked direct burial, where buried in the earth

(4) Flexible Cords and Cables Connected to Tracking PV Arrays

Flexible cords and flexible cables, where connected to moving parts of tracking PV arrays, shall comply with Article 400 and shall be of a type identified as a hard service cord or portable power cable; they shall be suitable for extra-hard usage, listed for outdoor use, water resistant, and sunlight resistant. Allowable ampacities shall be in accordance with 400.5. Stranded copper PV wire shall be permitted to be connected to moving parts of tracking PV arrays in accordance with the minimum number of strands specified in Table 690.31(C)(4).

Table 690.31(C)(4) Minimum PV Wire Strands

PV Wire AWG Minimum Strands

18 17

16—10 19

8—4 49

2 130

1 AWG—1000 MCM 259

(5) Flexible, Fine-Stranded Cables

Flexible, fine-stranded cables shall be terminated only with terminals, lugs, devices, or connectors in accordance with 110.14.

(6) Small-Conductor Cables

Single-conductor cables listed for outdoor use that are sunlight resistant and moisture resistant in sizes 16 AWG and 18 AWG shall be permitted for module interconnections where such cables meet the ampacity requirements of 400.5. Section 310.14 shall be used to determine the cable ampacity adjustment and correction factors.

(D) Direct-Current Circuits on or in Buildings

Where inside buildings, PV system dc circuits that exceed 30 volts or 8 amperes shall be contained in metal raceways, in Type MC metal-clad cable that complies with 250.118(10), or in metal enclosures.

Exception: PV hazard control systems installed in accordance with 690.12(B)(2)(1) shall be permitted to be provided with or listed for use with nonmetallic enclosure(s), nonmetallic raceway(s), and cables other than Type MC metal-clad cable(s), at the point of penetration of the surface of the building to the PV hazard control actuator.

Wiring methods on or in buildings shall comply with the additional installation requirements in 690.31(D)(1) and (D)(2).

(1) Flexible Wiring Methods

Where flexible metal conduit (FMC) smaller than metric designator 21 (trade size 3/4) or Type MC cable smaller than 25 mm (1 in.) in diameter containing PV power circuit conductors is installed across ceilings or floor joists, the raceway or cable shall be protected by substantial guard strips that are at least as high as the raceway or cable. Where run exposed, other than within 1.8 m (6 ft) of their connection to equipment, these wiring methods shall closely follow the building surface or be protected from physical damage by an approved means.

(2) Marking and Labeling Required

Diagram

Unless located and arranged so the purpose is evident, the following wiring methods and enclosures that contain PV system dc circuit conductors shall be marked with the wording PHOTOVOLTAIC POWER SOURCE or SOLAR PV DC CIRCUIT by means of permanently affixed labels or other approved permanent marking:

Exposed raceways, cable trays, and other wiring methods

Covers or enclosures of pull boxes and junction boxes

Conduit bodies in which any of the available conduit openings are unused

The labels or markings shall be visible after installation. All letters shall be capitalized and shall be a minimum height of 9.5 mm (3/8 in.) in white on a red background. Labels shall appear on every section of the wiring system that is separated by enclosures, walls, partitions, ceilings, or floors. Spacing between labels or markings, or between a label and a marking, shall not be more than 3 m (10 ft). Labels required by this section shall be suitable for the environment where they are installed.

Upcodes Diagrams

(E) Bipolar Photovoltaic Systems

Where the sum, without consideration of polarity, of the voltages of the two monopole circuits exceeds the rating of the conductors and connected equipment, monopole circuits in a bipolar PV system shall be physically separated, and the electrical output circuits from each monopole circuit shall be installed in separate raceways until connected to the inverter. The disconnecting means and overcurrent protective devices for each monopole circuit output shall be in separate enclosures. All conductors from each separate monopole circuit shall be routed in the same raceway. Solidly grounded bipolar PV systems shall be clearly marked with a permanent, legible warning notice indicating that the disconnection of the grounded conductor(s) may result in overvoltage on the equipment.

Exception: Listed switchgear rated for the maximum voltage between circuits and containing a physical barrier separating the disconnecting means for each monopole circuit shall be permitted to be used instead of disconnecting means in separate enclosures.

(F) Wiring Methods and Mounting Systems

Roof-mounted PV array mounting systems shall be permitted to be held in place with an approved means other than those required by 110.13 and shall utilize wiring methods that allow any expected movement of the array.

Informational Note: Expected movement of unattached PV arrays is often included in structural calculations.

690.32 Component Interconnections

Fittings and connectors that are intended to be concealed at the time of on-site assembly, where listed for such use, shall be permitted for on-site interconnection of modules or other array components. Such fittings and connectors shall be equal to the wiring method employed in insulation, temperature rise, and short-circuit current rating, and shall be capable of resisting the effects of the environment in which they are used.

690.33 Mating Connectors

Mating connectors, other than connectors covered by 690.32, shall comply with 690.33(A) through (D).

(A) Configuration

The mating connectors shall be polarized and shall have a configuration that is noninterchangeable with receptacles in other electrical systems on the premises.

(B) Guarding

The mating connectors shall be constructed and installed so as to guard against inadvertent contact with live parts by persons.

(C) Type

The mating connectors shall be of the latching or locking type. Mating connectors that are readily accessible and that are used in circuits operating at over 30 volts dc or 15 volts ac shall require a tool for opening. Where mating connectors are not of the identical type and brand, they shall be listed and identified for intermatability, as described in the manufacturer's instructions.

(D) Interruption of Circuit

Mating connectors shall be one of the following:

Rated for interrupting current without hazard to the operator

A type that requires the use of a tool to open and marked "Do Not Disconnect Under Load" or "Not for Current Interrupting"

Supplied as part of listed equipment and used in accordance with instructions provided with the listed connected equipment

Informational Note: Some listed equipment, such as microinverters, are evaluated to make use of mating connectors as disconnect devices even though the mating connectors are marked as "Do Not Disconnect Under Load" or "Not for Current Interrupting."

690.34 Access to Boxes

Junction, pull, and outlet boxes located behind modules or panels shall be so installed that the wiring contained in them can be rendered accessible directly or by displacement of a module(s) or panel(s) secured by removable fasteners and connected by a flexible wiring system.

Part V Grounding and Bonding

690.41 System Grounding

(A) PV System Grounding Configurations

One or more of the following system configurations shall be employed:

2-wire PV arrays with one functionally grounded conductor

Bipolar PV arrays according to 690.7(C) with a functional ground reference (center tap)

PV arrays not isolated from the grounded inverter output circuit

Ungrounded PV arrays

Solidly grounded PV arrays as permitted in 690.41(B)

PV systems that use other methods that accomplish equivalent system protection in accordance with 250.4(A) with equipment listed and identified for the use

(B) Ground-Fault Protection

PV system dc circuits that exceed 30 volts or 8 amperes shall be provided with dc ground-fault protection meeting the requirements of 690.41(B)(1) and (B)(2) to reduce fire hazards.

Solidly grounded PV source circuits with not more than two modules in parallel and not on or in buildings shall be permitted without ground-fault protection.

Informational Note: Not all inverters, charge controllers, or dc-to-dc converters include ground-fault protection. Equipment that does not have ground-fault protection often includes the following statement in the manual: "Warning: This unit is not provided with a GFDI device."

(1) Ground-Fault Detection

The ground-fault protection device or system shall detect ground fault(s) in the PV system dc circuit conductors, including any functional grounded conductors, and be listed for providing PV ground-fault protection. For dc-to-dc converters not listed as providing ground-fault protection, where required, listed ground fault protection equipment identified for the combination of the dc-to-dc converter and ground-fault protection device shall be installed to protect the circuit.

Informational Note: Some dc-to-dc converters without integral ground-fault protection on their input (source) side can prevent other ground-fault protection equipment from properly functioning on portions of PV system dc circuits.

(2) Faulted Circuits

The faulted circuits shall be controlled by one of the following methods:

The current-carrying conductors of the faulted circuit shall be automatically disconnected.

The device providing ground-fault protection fed by the faulted circuit shall automatically cease to supply power to output circuits and interrupt the faulted PV system dc circuits from the ground reference in a functionally grounded system.

(3) Indication of Faults

Ground-fault protection equipment shall provide indication of ground faults at a readily accessible location.

Informational Note: Examples of indication include, but are not limited to, the following: remote indicator light, display, monitor, signal to a monitored alarm system, or receipt of notification by web-based services.

690.42 Point of System Grounding Connection

Systems with a ground-fault protective device in accordance with 690.41(B) shall have any current-carrying conductor-to-ground connection made by the ground-fault protective device. For solidly grounded PV systems, the dc circuit grounding connection shall be made at any single point on the PV output circuit.

690.43 Equipment Grounding and Bonding

Exposed non-current-carrying metal parts of PV module frames, electrical equipment, and conductor enclosures of PV systems shall be connected to an equipment grounding conductor in accordance with 250.134 or 250.136, regardless of voltage. Equipment grounding conductors and devices shall comply with 690.43(A) through (D).

(A) Photovoltaic Module Mounting Systems and Devices

Devices and systems used for mounting PV modules that are also used for bonding module frames shall be listed, labeled, and identified for bonding PV modules. Devices that mount adjacent PV modules shall be permitted to bond adjacent PV modules.

(B) Equipment Secured to Grounded Metal Supports

Devices listed, labeled, and identified for bonding and grounding the metal parts of PV systems shall be permitted to bond the equipment to grounded metal supports. Metallic support structures shall have identified bonding jumpers connected between separate metallic sections or shall be identified for equipment bonding and shall be connected to the equipment grounding conductor.

(C) With Circuit Conductors

Equipment grounding conductors for the PV array and support structure where installed shall be contained within the same raceway or cable or otherwise run with the PV system conductors where those circuit conductors leave the vicinity of the PV array.

(D) Bonding for Over 250 Volts

The bonding requirements contained in 250.97 shall apply only to solidly grounded PV system circuits operating over 250 volts to ground.

690.45 Size of Equipment Grounding Conductors

Equipment grounding conductors for PV system circuits shall be sized in accordance with 250.122. Where no overcurrent protective device is used in the circuit, an assumed overcurrent device rated in accordance with 690.9(B) shall be used when applying Table 250.122.

Increases in equipment grounding conductor size to address voltage drop considerations shall not be required.

690.47 Grounding Electrode System

(A) Buildings or Structures Supporting a PV System

A building or structure(s) supporting a PV system shall utilize a grounding electrode system installed in accordance with Part III of Article 250.

PV array equipment grounding conductors shall be connected to a grounding electrode system in accordance with Part VII of Article 250. This connection shall be in addition to any other equipment grounding conductor requirements in 690.43(C). The PV array equipment grounding conductors shall be sized in accordance with 690.45. For specific PV system grounding configurations permitted in 690.41(A), one of the following conditions shall apply:

For PV systems that are not solidly grounded, the equipment grounding conductor for the output of the PV system, where connected to associated distribution equipment connected to a grounding electrode system, shall be permitted to be the only connection to ground for the system.

For solidly grounded PV systems, as permitted in 690.41(A)(5), the grounded conductor shall be connected to a grounding electrode system by means of a grounding electrode conductor sized in accordance with 250.166.

Informational Note: Most PV systems are functionally grounded systems rather than solidly grounded systems as defined in this Code. For functionally grounded PV systems with an interactive inverter output, the ac equipment grounding conductor is connected to associated grounded ac distribution equipment. This connection is most often the connection to ground for ground-fault protection and equipment grounding of the PV array.

(B) Grounding Electrodes and Grounding Electrode Conductors

Additional grounding electrodes shall be permitted to be installed in accordance with 250.52 and 250.54. Grounding electrodes shall be permitted to be connected directly to the PV module frame(s) or support structure. A grounding electrode conductor shall be sized according to 250.66. A support structure for a ground-mounted PV array shall be permitted to be considered a grounding electrode if it meets the requirements of 250.52. PV arrays mounted to buildings shall be permitted to use the metal structural frame of the building if the requirements of 250.68(C)(2) are met.

Part VI Marking

690.51 Modules and AC Modules

Modules and ac modules shall be marked in accordance with their listing.

690.53 DC PV Circuits

Diagram

A permanent readily visible label indicating the highest maximum dc voltage in a PV system, calculated in accordance with 690.7, shall be provided by the installer at one of the following locations:

DC PV system disconnecting means

PV system electronic power conversion equipment

Distribution equipment associated with the PV system

UpCodes Diagrams

P

Solar Labeling Requirements

690.54 Interactive System Point of Interconnection

Diagram

All interactive system(s) points of interconnection with other sources shall be marked at an accessible location at the disconnecting means as a power source and with the rated ac output current and the nominal operating ac voltage.

Upcodes Diagrams

690.55 Photovoltaic Systems Connected to Energy Storage Systems

The PV system output circuit conductors shall be marked to indicate the polarity where connected to energy storage systems.

690.56 Identification of Power Sources

(A) Facilities With Stand-Alone Systems

Plaques or directories shall be installed in accordance with 710.10.

(B) Facilities With Utility Services and Photovoltaic Systems

Diagram

Plaques or directories shall be installed in accordance with 705.10 and 712.10, as required.

UpCodes Diagrams

P

Solar Labeling Requirements

(C) Buildings With Rapid Shutdown

Diagram

Buildings with PV systems shall have a permanent label located at each service equipment location to which the PV systems are connected or at an approved readily visible location and shall indicate the location of rapid shutdown initiation devices. The label shall include a simple diagram of a building with a roof and shall include the following words:

SOLAR PV SYSTEM IS EQUIPPED WITH RAPID SHUTDOWN.

TURN RAPID SHUTDOWN SWITCH TO THE "OFF" POSITION TO SHUT DOWN

PV SYSTEM AND REDUCE SHOCK HAZARD IN ARRAY.

The title "SOLAR PV SYSTEM IS EQUIPPED WITH RAPID SHUTDOWN" shall utilize capitalized characters with a minimum height of 9.5 mm (3/8 in.) in black on yellow background, and the remaining characters shall be capitalized with a minimum height of 4.8 mm (3/16 in.) in black on white background.

Informational Note: See Informational Note Figure 690.56(C).

Informational Note Figure 690.56(C) Label for Roof-Mounted PV Systems with Rapid Shutdown.

Upcodes Diagrams

(1) Buildings With More Than One Rapid Shutdown Type

For buildings that have PV systems with more than one rapid shutdown type or PV systems with no rapid shutdown, a detailed plan view diagram of the roof shall be provided showing each different PV system with a dotted line around areas that remain energized after rapid shutdown is initiated.

(2) Rapid Shutdown Switch

A rapid shutdown switch shall have a label that includes the following wording located on or no more than 1 m (3 ft) from the switch:

RAPID SHUTDOWN SWITCH FOR SOLAR PV SYSTEM

The label shall be reflective, with all letters capitalized and having a minimum height of 9.5 mm (3/8 in.) in white on red background.

Part VII Connection to Other Sources

690.59 Connection to Other Sources

PV systems connected to other sources shall be installed in accordance with Parts I and II of Article 705 and Article 712.

Part VIII Energy Storage Systems

690.71 General

An energy storage system connected to a PV system shall be installed in accordance with Article 706.

690.72 Self-Regulated PV Charge Control

The PV source circuit shall be considered to comply with the requirements of 706.33 if:

The PV source circuit is matched to the voltage rating and charge current requirements of the interconnected battery cells and,

The maximum charging current multiplied by 1 hour is less than 3 percent of the rated battery capacity expressed in ampere-hours or as recommended by the battery manufacturer

Article 691 Large-Scale Photovoltaic (PV) Electric Supply Stations

691.1 Scope

This article covers the installation of large-scale PV electric supply stations with an inverter generating capacity of no less than 5000 kW, and not under exclusive utility control.

Informational Note No. 1: Facilities covered by this article have specific design and safety features unique to large-scale PV facilities and are operated for the sole purpose of providing electric supply to a system operated by a regulated utility for the transfer of electric energy.

Informational Note No. 2: Section 90.2(B)(5) includes information about utility-owned properties not covered under this Code. For additional information on electric supply stations, see ANSI/IEEE C2-2017, National Electrical Safety Code.

Informational Note No. 3: See Informational Note Figure 691.1.

Notes:

(1) Custom designs occur in each configuration, and some components are optional.

(2) The drawing is for informational purposes only and is not representative of all potential configurations.

Informational Note Figure 691.1 Identification of Large-Scale PV Electric Supply Station Components.

691.2 Definitions

The definitions in this section shall apply only within this article.

Electric Supply Stations. Locations containing the generating stations and substations, including their associated generator, storage battery, transformer, and switchgear areas.

Generating Station. A plant wherein electric energy is produced by conversion from some other form of energy (e.g., chemical, nuclear, solar, wind, mechanical, or hydraulic) by means of suitable apparatus.

691.4 Special Requirements for Large-Scale PV Electric Supply Stations

Large-scale PV electric supply stations shall be accessible only to authorized personnel and comply with the following:

Electrical circuits and equipment shall be maintained and operated only by qualified personnel.

Informational Note: Refer to NFPA 70E-2018, Standard for Electrical Safety in the Workplace, for electrical safety requirements.

Access to PV electric supply stations shall be restricted by fencing or other adequate means in accordance with 110.31. Field-applied hazard markings shall be applied in accordance with 110.21(B).

The connection between the PV electric supply station and the system operated by a utility for the transfer of electrical energy shall be through medium-or high-voltage switch gear, substation, switch yard, or similar methods whose sole purpose shall be to safely and effectively interconnect the two systems.

The electrical loads within the PV electric supply station shall only be used to power auxiliary equipment for the generation of the PV power.

Large-scale PV electric supply stations shall not be installed on buildings.

691.5 Equipment

All electrical equipment shall be approved for installation by one of the following:

Listing and labeling

Be evaluated for the application and have a field label applied

Where products complying with 691.5(1) or (2) are not available, by engineering review validating that the electrical equipment is evaluated and tested to relevant standards or industry practice

691.6 Engineered Design

Documentation of the electrical portion of the engineered design of the electric supply station shall be stamped and provided upon request of the AHJ. Additional stamped independent engineering reports detailing compliance of the design with applicable electrical standards and industry practice shall be provided upon request of the AHJ. The independent engineer shall be a licensed professional electrical engineer retained by the system owner or installer. This documentation shall include details of conformance of the design with Article 690, and any alternative methods to Article 690, or other articles of this Code.

691.7 Conformance of Construction to Engineered Design

Documentation that the construction of the electric supply station conforms to the electrical engineered design shall be provided upon request of the AHJ. Additional stamped independent engineering reports detailing the construction conforms with this Code, applicable standards and industry practice shall be provided upon request of the AHJ. The independent engineer shall be a licensed professional electrical engineer retained by the system owner or installer. This documentation, where requested, shall be available prior to commercial operation of the station.

691.8 Direct Current Operating Voltage

For large-scale PV electric supply stations, calculations shall be included in the documentation required in 691.6.

691.9 Disconnecting Means for Isolating Photovoltaic Equipment

Isolating devices shall not be required within sight of equipment and shall be permitted to be located remotely from equipment. The engineered design required by 691.6 shall document disconnection procedures and means of isolating equipment.

Informational Note: For information on electrical system maintenance, see NFPA 70B-2019, Recommended Practice for Electrical Equipment Maintenance. For information on written procedures and conditions of maintenance, including lockout/tagout procedures, see NFPA 70E-2018.

Buildings whose sole purpose is to house and protect supply station equipment shall not be required to comply with 690.12. Written standard operating procedures shall be available at the site detailing necessary shutdown procedures in the event of an emergency.

691.10 Arc-Fault Mitigation

PV systems that do not comply with the requirements of 690.11 shall include details of fire mitigation plans to address dc arc-faults in the documentation required in 691.6.

691.11 Fence Bonding and Grounding

Fence grounding requirements and details shall be included in the documentation required in 691.6.

Informational Note: See 250.194 for fence bonding and grounding requirements enclosing substation portions of an electric supply station. Grounding requirements for other portions of electric supply station fencing are assessed based on the presence of overhead conductors, proximity to generation and distribution equipment, and associated step and touch potential.

Article 692 Fuel Cell Systems

Part I General

692.1 Scope

This article applies to the installation of fuel cell systems.

Informational Note: Some fuel cell systems can be interactive with other electrical power production sources, are stand-alone, or both. Some fuel cell systems are connected to electric energy storage systems such as batteries. Fuel cell systems can have ac output(s), dc output(s), or both for utilization.

692.2 Definitions

The following definition(s) shall apply only within this article.

Fuel Cell Output Circuit. The conductors used to connect the fuel cell system to its electrical point of delivery.

Informational Note: In the case of sites that have series-or parallel-connected multiple units, the term output circuit also refers to the conductors used to electrically interconnect the fuel cell system(s).

692.4 Installation

(A) Fuel Cell System

A fuel cell system shall be permitted to supply a building or other structure in addition to any service(s) of another electricity supply system(s).

(B) Identification of Power Sources

Fuel cell systems shall be identified according to 692.4(B)(1) through (B)(3).

(1) Interconnected AC Systems

Plaques or directories shall be installed in accordance with 705.10.

(2) DC Microgrid Systems

Plaques or directories shall be installed in accordance with 712.10.

(3) Stand-Alone Systems

Plaques or directories shall be installed in accordance with 710.10.

(C) System Installation

Fuel cell systems including all associated wiring and interconnections shall be installed by only qualified persons.

Informational Note: See Article 100 for the definition of qualified person.

692.6 Listing Requirement

The fuel cell system shall be approved for the application in accordance with one of the following:

Be listed for the application

Be evaluated for the application and have a field label applied

Part II Circuit Requirements

692.8 Circuit Sizing and Current

(A) Nameplate Rated Circuit Current

The nameplate(s) rated circuit current shall be the rated current indicated on the fuel cell nameplate(s).

(B) Conductor Ampacity and Overcurrent Device Ratings

The ampacity of the feeder circuit conductors from the fuel cell system(s) to the premises wiring system shall not be less than the greater of (1) nameplate(s) rated circuit current or (2) the rating of the fuel cell system(s) overcurrent protective device(s).

(C) Ampacity of Grounded or Neutral Conductor

If an interactive single-phase, 2-wire fuel cell output(s) is connected to the grounded or neutral conductor and a single ungrounded conductor of a 3-wire system or of a 3-phase, 4-wire, wye-connected system, the maximum unbalanced neutral load current plus the fuel cell system(s) output rating shall not exceed the ampacity of the grounded or neutral conductor.

692.9 Overcurrent Protection

(A) Circuits and Equipment

If the fuel cell system is provided with overcurrent protection sufficient to protect the circuit conductors that supply the load, additional circuit overcurrent devices shall not be required. Equipment and conductors connected to more than one electrical source shall be protected.

(B) Accessibility

Overcurrent devices shall be readily accessible.

Part III Disconnecting Means

692.13 All Conductors

Means shall be provided to disconnect all current-carrying conductors of a fuel cell system power source from all other conductors in a building or other structure.

692.17 Switch or Circuit Breaker

The disconnecting means for ungrounded conductors shall consist of readily accessible, manually operable switch(es) or circuit breaker(s).

Where all terminals of the disconnecting means may be energized in the open position, a warning sign shall be mounted on or adjacent to the disconnecting means. The sign shall be clearly legible and shall have the following words or equivalent:

DANGER

ELECTRIC SHOCK HAZARD.

DO NOT TOUCH TERMINALS.

TERMINALS ON BOTH THE LINE AND LOAD SIDES MAY BE ENERGIZED IN THE OPEN POSITION.

The danger sign(s) or label(s) shall comply with 110.21(B).

Part IV Wiring Methods

692.31 Wiring Systems

All raceway and cable wiring methods included in Chapter 3 of this Code and other wiring systems and fittings specifically intended and identified for use with fuel cell systems shall be permitted. Where wiring devices with integral enclosures are used, sufficient length of cable shall be provided to facilitate replacement.

Part V Grounding

692.41 System Grounding

(A) AC Systems

Grounding of ac systems shall be in accordance with 250.20, and with 250.30 for stand-alone systems.

(B) DC Systems

Grounding of dc systems shall be in accordance with 250.160.

(C) Systems With Alternating-Current and Direct-Current Grounding Requirements

When fuel cell power systems have both alternating-current (ac) and direct-current (dc) grounding requirements, the dc grounding system shall be bonded to the ac grounding system. The bonding conductor shall be sized according to 692.45. A single common grounding electrode and grounding bar may be used for both systems, in which case the common grounding electrode conductor shall be sized to meet the requirements of both 250.66 (ac) and 250.166 (dc).

692.44 Equipment Grounding Conductor

A separate equipment grounding conductor shall be installed.

692.45 Size of Equipment Grounding Conductor

The equipment grounding conductor shall be sized in accordance with 250.122.

692.47 Grounding Electrode System

Any auxiliary grounding electrode(s) required by the manufacturer shall be connected to the equipment grounding conductor specified in 250.118.

Part VI Marking

692.53 Fuel Cell Power Sources

A marking specifying the fuel cell system, output voltage, output power rating, and continuous output current rating shall be provided at the disconnecting means for the fuel cell power source at an accessible location on the site.

692.54 Fuel Shut-Off

The location of the manual fuel shut-off valve shall be marked at the location of the primary disconnecting means of the building or circuits supplied.

692.56 Stored Energy

A fuel cell system that stores electrical energy shall require the following warning sign, or equivalent, at the location of the service disconnecting means of the premises:

WARNING

FUEL CELL POWER SYSTEM CONTAINS ELECTRICAL ENERGY STORAGE DEVICES.

The warning sign(s) or label(s) shall comply with 110.21(B).

Part VII Connection to Other Circuits

692.59 Transfer Switch

A transfer switch shall be required in non—grid-interactive systems that use utility grid backup. The transfer switch shall maintain isolation between the electrical production and distribution network and the fuel cell system. The transfer switch shall be permitted to be located externally or internally to the fuel cell system unit. Where the utility service conductors of the structure are connected to the transfer switch, the switch shall comply with Article 230, Part V.

692.60 Identified Interactive Equipment

Only fuel cell systems listed and marked as interactive shall be permitted in interactive systems.

692.61 Output Characteristics

Output characteristics shall be in accordance with 705.14.

692.62 Loss of Interactive System Power

The fuel cell system shall be provided with a means of detecting when the electrical production and distribution network has become de-energized and shall not feed the electrical production and distribution network side of the point of common coupling during this condition. The fuel cell system shall remain in that state until the electrical production and distribution network voltage has been restored.

A normally interactive fuel cell system shall be permitted to operate as a stand-alone system to supply loads that have been disconnected from electrical production and distribution network sources.

692.64 Unbalanced Interconnections

Unbalanced interconnections shall be in accordance with 705.45.

692.65 Utility-Interactive Point of Connection

Point of connection shall be in accordance with 705.12.

Article 694 Wind Electric Systems

Part I General

694.1 Scope

This article applies to wind (turbine) electric systems that consist of one or more wind electric generators and their related alternators, generators, inverters, controllers, and associated equipment.

Informational Note: Some wind electric systems are interactive with other electric power sources [see Figure 694.1(a)] and some are stand-alone systems [see Figure 694.1(b)]. Some systems have ac output and some have dc output. Some systems contain electrical energy storage, such as batteries.

FIGURE 694.1(a) Identification of Wind Electric System Components — Interactive System.

FIGURE 694.1(b) Identification of Wind Electric System Components — Stand-Alone System.

694.2 Definitions

The definitions in this section shall apply only within this article.

Diversion Charge Controller. Equipment that regulates the charging process of a battery or other energy storage device by diverting power from energy storage to dc or ac loads, or to an interconnected utility service.

Diversion Load. A load connected to a diversion charge controller or diversion load controller, also known as a dump load.

Diversion Load Controller. Equipment that regulates the output of a wind generator by diverting power from the generator to dc or ac loads or to an interconnected utility service.

Maximum Output Power. The maximum 1 minute average power output a wind turbine produces in normal steady-state operation (instantaneous power output can be higher).

Maximum Voltage. The maximum voltage the wind turbine produces in operation including open circuit conditions.

Nacelle. An enclosure housing the alternator and other parts of a wind turbine.

Rated Power. The output power of a wind turbine at its rated wind speed.

Informational Note: The method for measuring wind turbine power output is specified in IEC 61400-12-1, Power Performance Measurements of Electricity Producing Wind Turbines.

Tower (as applied to wind electric systems). A pole or other structure that supports a wind turbine.

Wind Turbine. A mechanical device that converts wind energy to electrical energy.

Wind Turbine Output Circuit. The circuit conductors between the internal components of a wind turbine (which might include an alternator, integrated rectifier, controller, and/or inverter) and other equipment.

Informational Note: See also definitions for interconnected systems in Article 705.

694.7 Installation

Systems covered by this article shall be installed only by qualified persons.

Informational Note: See Article 100 for the definition of Qualified Person.

Table 694.7 Working Spaces

Nominal Voltage to Ground Condition 1 Condition 2 Condition 3

0—150 900 mm (3 ft) 900 mm (3 ft) 900 mm (3 ft)

151—1000 900 mm (3 ft) 1.0 m (3 ft 6 in.) 1.2 m (4 ft)

(A) Wind Electric Systems

A wind electric system(s) shall be permitted to supply a building or other structure in addition to other sources of supply.

(B) Equipment

Wind electric systems shall be approved for the application in accordance with one of the following:

Be listed

Be evaluated for the application and have a field label applied

Wind electric systems undergoing evaluation for type certification and listing shall be permitted to be operated in a controlled location with access limited to qualified personnel.

Informational Note: Testing for certification and listing is typically performed under the supervision of a qualified electrical testing organization.

(C) Diversion Load Controllers

A wind electric system employing a diversion load controller as the primary means of regulating the speed of a wind turbine rotor shall be equipped with an additional, independent, reliable means to prevent over-speed operation. An interconnected utility service shall not be considered to be a reliable diversion load.

(D) Surge Protective Devices (SPD)

A surge protective device shall be installed between a wind electric system and any loads served by the premises electrical system. The surge protective device shall be permitted to be a Type 3 SPD on the circuit serving a wind electric system or a Type 2 SPD located anywhere on the load side of the service disconnect. Surge protective devices shall be installed in accordance with Part II of Article 242.

(E) Receptacles

A receptacle shall be permitted to be supplied by a wind electric system branch or feeder circuit for maintenance or data acquisition use. Receptacles shall be protected with an overcurrent device with a rating not to exceed the current rating of the receptacle. In addition to the requirements in 210.8, all 125-volt, single-phase, 15- and 20-ampere receptacles installed for maintenance of the wind turbine shall have ground-fault circuit-interrupter protection for personnel.

(F) Poles or Towers Supporting Wind Turbines Used as a Raceway

A pole or tower shall be permitted to be used as a raceway if approved in accordance with one of the following:

Be evaluated as part of the listing for the wind turbine

Be listed for the application

Be evaluated for the application and have a field label applied

(G) Working Clearances

Working space shall be provided for electrical cabinets and other electrical equipment in accordance with 110.26(A).

For large wind turbines where service personnel enter the equipment, where conditions of maintenance and supervision ensure that only qualified persons perform the work, working clearances shall be permitted to comply with Table 694.7 for systems up to 1000 V nominal.

Part II Circuit Requirements

694.10 Maximum Voltage

(A) Wind Turbine Output Circuits

Wind turbine output circuits on or in one-and two-family dwellings shall be permitted to have a maximum voltage up to 600 volts.

(B) Direct-Current Utilization Circuits

The voltage of dc utilization circuits shall comply with 210.6.

(C) Circuits Over 150 Volts to Ground

In one-and two-family dwellings, live parts in circuits over 150 volts to ground shall not be accessible to other than qualified persons while energized.

Informational Note: See 110.27 for guarding of live parts and 210.6 for branch circuit voltage limitations.

694.12 Circuit Sizing and Current

(A) Calculation of Maximum Circuit Current

The maximum current for a circuit shall be calculated in accordance with 694.12(A)(1) through (A)(3).

(1) Turbine Output Circuit Currents

The maximum current shall be based on the circuit current of the wind turbine operating at maximum output power.

(2) Inverter Output Circuit Current

The maximum output current shall be the inverter continuous output current rating.

(3) Stand-Alone Inverter Input Circuit Current

The maximum input current shall be the stand-alone continuous inverter input current rating of the inverter producing rated power at the lowest input voltage.

(B) Ampacity and Overcurrent Device Ratings

(1) Continuous Current

Wind turbine electric system currents shall be considered to be continuous.

(2) Sizing of Conductors and Overcurrent Devices

Circuit conductors and overcurrent devices shall be sized to carry not less than 125 percent of the maximum current as calculated in 694.12(A). The rating or setting of overcurrent devices shall be permitted in accordance with 240.4(B) and (C).

Exception: Circuits containing an assembly, together with its overcurrent devices, listed for continuous operation at 100 percent of its rating shall be permitted to be used at 100 percent of its rating.

694.15 Overcurrent Protection

(A) Circuits and Equipment

Turbine output circuits, inverter output circuits, and storage battery circuit conductors and equipment shall be protected in accordance with the requirements of Article 240. Circuits connected to more than one electrical source shall have overcurrent devices located so as to provide overcurrent protection from all sources.

Exception: An overcurrent device shall not be required for circuit conductors sized in accordance with 694.12(B) where the maximum current from all sources does not exceed the ampacity of the conductors.

Informational Note: Possible backfeed of current from any source of supply, including a supply through an inverter to the wind turbine output circuit, is a consideration in determining whether overcurrent protection from all sources is provided. Some wind electric systems rely on the turbine output circuit to regulate turbine speed. Inverters may also operate in reverse for turbine startup or speed control.

(B) Power Transformers

Overcurrent protection for a transformer with sources on each side shall be provided in accordance with 450.3 by considering first one side of the transformer, then the other side of the transformer, as the primary.

Exception: A power transformer with a current rating on the side connected to the inverter output, which is not less than the rated continuous output current rating of the inverter, shall not be required to have overcurrent protection at the inverter.

(C) Direct-Current Rating

Overcurrent devices, either fuses or circuit breakers, used in any dc portion of a wind electric system shall be listed for use in dc circuits and shall have appropriate voltage, current, and interrupting ratings.

Part III Disconnecting Means

694.20 All Conductors

Means shall be provided to disconnect all current-carrying conductors of a wind electric power source from all other conductors in a building or other structure. A switch, circuit breaker, or other device, either ac or dc, shall not be installed in a grounded conductor if operation of that switch, circuit breaker, or other device leaves the marked, grounded conductor in an ungrounded and energized state.

Exception: A wind turbine that uses the turbine output circuit for regulating turbine speed shall not require a turbine output circuit disconnecting means.

694.22 Additional Provisions

Disconnecting means shall comply with 694.22(A) through (D).

(A) Disconnecting Means

The disconnecting means shall not be required to be suitable for use as service equipment. The disconnecting means for ungrounded conductors shall consist of manually operable switches or circuit breakers complying with all of the following requirements:

They shall be located where readily accessible.

They shall be externally operable without exposing the operator to contact with live parts.

They shall plainly indicate whether in the open or closed position.

They shall have an interrupting rating sufficient for the nominal circuit voltage and the current that is available at the line terminals of the equipment.

Where all terminals of the disconnecting means are capable of being energized in the open position, a warning sign shall be mounted on or adjacent to the disconnecting means. The sign shall be clearly legible and shall have the following words or equivalent:

WARNING.

ELECTRIC SHOCK HAZARD.

DO NOT TOUCH TERMINALS.

TERMINALS ON BOTH THE LINE AND LOAD SIDES MAY BE ENERGIZED IN THE OPEN POSITION.

The warning sign(s) or label(s) shall comply with 110.21(B).

(B) Equipment

Equipment such as rectifiers, controllers, output circuit isolating and shorting switches, and over-current devices shall be permitted on the wind turbine side of the disconnecting means.

(C) Requirements for Disconnecting Means

(1) Location

The wind electric system disconnecting means shall be installed at a readily accessible location either on or adjacent to the turbine tower, on the outside of a building or structure, or inside at the point of entrance of the wind system conductors.

Exception: Installations that comply with 694.30(C) shall be permitted to have the disconnecting means located remotely from the point of entry of the wind system conductors.

A wind turbine disconnecting means shall not be required to be located at the nacelle or tower.

The disconnecting means shall not be installed in bathrooms.

For one-family and two-family dwellings, a disconnecting means or manual shutdown button or switch shall be located at a readily accessible location outside the building.

(2) Marking

Each turbine system disconnecting means shall be permanently marked to identify it as a wind electric system disconnect.

(3) Suitable for Use

Turbine system disconnecting means shall be suitable for the prevailing conditions.

(4) Maximum Number of Disconnects

The turbine disconnecting means shall consist of not more than six switches or six circuit breakers mounted in a single enclosure, in a group of separate enclosures, or in or on a switchgear.

(D) Equipment That Is Not Readily Accessible

Rectifiers, controllers, and inverters shall be permitted to be mounted in nacelles or other exterior areas that are not readily accessible.

694.23 Turbine Shutdown

(A) Manual Shutdown

Wind turbines shall be required to have a readily accessible manual shutdown button or switch. Operation of the button or switch shall result in a parked turbine state that shall either stop the turbine rotor or allow limited rotor speed combined with a means to de-energize the turbine output circuit.

Exception: Turbines with a swept area of less than 50 m2 (538 ft2) shall not be required to have a manual shutdown button or switch.

(B) Shutdown Procedure

The shutdown procedure for a wind turbine shall be defined and permanently posted at the location of a shutdown means and at the location of the turbine controller or disconnect, if the location is different.

694.24 Disconnection of Wind Electric System Equipment

Means shall be provided to disconnect equipment, such as inverters, batteries, and charge controllers, from all ungrounded conductors of all sources. If the equipment is energized from more than one source, the disconnecting means shall be grouped and identified.

A single disconnecting means in accordance with 694.22 shall be permitted for the combined ac output of one or more inverters in an interactive system.

A shorting switch or plug shall be permitted to be used as an alternative to a disconnect in systems that regulate turbine speed using the turbine output circuit.

Exception: Equipment housed in a turbine nacelle shall not be required to have a disconnecting means.

694.26 Fuses

Means shall be provided to disconnect a fuse from all sources of supply where the fuse is energized from both directions and is accessible to other than qualified persons. Switches, pullouts, or similar devices that are rated for the application shall be permitted to serve as a means to disconnect fuses from all sources of supply.

694.28 Installation and Service of a Wind Turbine

Open circuiting, short circuiting, or mechanical brakes shall be used to disable a turbine for installation and service.

Informational Note: Some wind turbines rely on the connection from the alternator to a remote controller for speed regulation. Opening turbine output circuit conductors may cause mechanical damage to a turbine and create excessive voltages that could damage equipment or expose persons to electric shock.

Part IV Wiring Methods

694.30 Permitted Methods

(A) Wiring Systems

All raceway and cable wiring methods included in this Code, and other wiring systems and fittings specifically intended for use on wind turbines, shall be permitted. In readily accessible locations, turbine output circuits that operate at voltages greater than 30 volts shall be installed in raceways.

(B) Flexible Cords and Cables

Flexible cords and cables, where used to connect the moving parts of turbines or where used for ready removal for maintenance and repair, shall comply with Article 400 and shall be of a type identified as hard service cord or portable power cable, shall be suitable for extra-hard usage, shall be listed for outdoor use, and shall be water resistant. Cables exposed to sunlight shall be sunlight resistant. Flexible, fine-stranded cables shall be terminated only with terminals, lugs, devices, or connectors in accordance with 110.14(A).

(C) Direct-Current Turbine Output Circuits Inside a Building

Direct-current turbine output circuits installed inside a building or structure shall be enclosed in metal raceways or installed in metal enclosures, or run in Type MC metal-clad cable that complies with 250.118(10), from the point of penetration of the surface of the building or structure to the first readily accessible disconnecting means.

Part V Grounding and Bonding

694.40 Equipment Grounding and Bonding

(A) General

Exposed non—current-carrying metal parts of towers, turbine nacelles, other equipment, and conductor enclosures shall be grounded and bonded to the premises grounding and bonding system. Attached metal parts, such as turbine blades and tails that are not likely to become energized, shall not be required to be grounded or bonded.

(B) Tower Grounding and Bonding

(1) Grounding Electrodes and Grounding Electrode Conductors

A wind turbine tower shall be connected to a grounding electrode system. Where installed in close proximity to galvanized foundation or tower anchor components, galvanized grounding electrodes shall be used.

Informational Note: Copper and copper-clad grounding electrodes, where used in highly conductive soils, can cause electrolytic corrosion of galvanized foundation and tower anchor components.

(2) Bonding Conductor

Equipment grounding conductors or supply-side bonding jumpers, as applicable, shall be required between turbines, towers, and the premises grounding system.

(3) Tower Connections

Equipment grounding, bonding, and grounding electrode conductors, where used, shall be connected to metallic towers using listed means. All mechanical elements used to terminate these conductors shall be accessible.

(4) Guy Wires

Guy wires used to support turbine towers shall not be required to be connected to an equipment grounding conductor or to comply with the requirements of 250.110.

Informational Note: Guy wires supporting grounded towers are unlikely to become energized under normal conditions, but partial lightning currents could flow through guy wires when exposed to a lightning environment. Grounding of metallic guy wires may be required by lightning standards. For information on lightning protection systems, see NFPA 780-2017, Standard for the Installation of Lightning Protection Systems.

Part VI Marking

694.50 Interactive System Point of Interconnection

All interactive system points of interconnection with other sources shall be marked at an accessible location at the disconnecting means and with the rated ac output current and the nominal operating ac voltage.

694.52 Power Systems Employing Energy Storage

Wind electric systems employing energy storage shall be marked with the maximum operating voltage, any equalization voltage, and the polarity of the grounded circuit conductor.

694.54 Identification of Power Sources

Wind turbine systems shall be identified according to 694.54(A) through (C).

(A) Interconnected AC Systems

Plaques or directories shall be installed in accordance with 705.10.

(B) DC Microgrid Systems

Plaques or directories shall be installed in accordance with 712.10.

(C) Stand-Alone Systems

Plaques or directories shall be installed in accordance with 710.10.

694.56 Instructions for Disabling Turbine

A plaque shall be installed at or adjacent to the turbine location providing basic instructions for disabling the turbine.

Part VII Connection to Other Sources

694.60 Identified Interactive Equipment

Only inverters that are listed, labeled, and identified as interactive shall be permitted in interactive systems.

694.62 Installation

Wind electric systems, where connected to utility electric sources, shall comply with the requirements of Article 705.

694.66 Operating Voltage Range

Wind electric systems connected to dedicated branch or feeder circuits shall be permitted to exceed normal voltage operating ranges on these circuits, provided that the voltage at any distribution equipment supplying other loads remains within normal ranges.

Informational Note: Wind turbines might use the electric grid to dump energy from short-term wind gusts. Normal operating voltages are defined in ANSI C84.1-2006, Voltage Ratings for Electric Power Systems and Equipment (60 Hz).

694.68 Point of Connection

Points of connection to interconnected electric power sources shall comply with 705.12.

Article 695 Fire Pumps

695.1 Scope

(A) Covered

This article covers the installation of the following:

Electric power sources and interconnecting circuits

Switching and control equipment dedicated to fire pump drivers

Informational Note: Text that is followed by a reference in brackets has been extracted from NFPA 20-2019, Standard for the Installation of Stationary Pumps for Fire Protection. Only editorial changes were made to the extracted text to make it consistent with this Code.

(B) Not Covered

This article does not cover the following:

The performance, maintenance, and acceptance testing of the fire pump system, and the internal wiring of the components of the system

The installation of pressure maintenance (jockey or makeup) pumps

Informational Note: For the installation of pressure maintenance (jockey or makeup) pumps supplied by the fire pump circuit or another source, see Article 430.

Transfer equipment upstream of the fire pump transfer switch (es)

Informational Note: See NFPA 20-2019, Standard for the Installation of Stationary Pumps for Fire Protection, for further information.

695.2 Definitions

The definitions in this section shall only apply within this article.

Fault-Tolerant External Control Circuits. Those control circuits either entering or leaving the fire pump controller enclosure, which if broken, disconnected, or shorted will not prevent the controller from starting the fire pump from all other internal or external means and may cause the controller to start the pump under these conditions.

On-Site Power Production Facility. The normal supply of electric power for the site that is expected to be constantly producing power.

On-Site Standby Generator. A facility producing electric power on site as the alternate supply of electric power. It differs from an on-site power production facility in that it is not constantly producing power.

695.3 Power Source(s) for Electric Motor-Driven Fire Pumps

Electric motor-driven fire pumps shall have a reliable source of power.

Informational Note: See Sections 9.3.2 and A.9.3.2 from NFPA 20-2019, Standard for the Installation of Stationary Pumps for Fire Protection, for guidance on the determination of power source reliability.

(A) Individual Sources

Where reliable, and where capable of carrying indefinitely the sum of the locked-rotor current of the fire pump motor(s) and the pressure maintenance pump motor(s) and the full-load current of the associated fire pump accessory equipment when connected to this power supply, the power source for an electric motor driven fire pump shall be one or more of the following.

(1) Electric Utility Service Connection

A fire pump shall be permitted to be supplied by a separate service, or from a connection located ahead of and not within the same cabinet, enclosure, vertical switchgear section, or vertical switchboard section as the service disconnecting means. The connection shall be located and arranged so as to minimize the possibility of damage by fire from within the premises and from exposing hazards. A tap ahead of the service disconnecting means shall comply with 230.82(5). The service equipment shall comply with the labeling requirements in 230.2 and the location requirements in 230.72(B). [20:9.2.2(1)]

(2) On-Site Power Production Facility

A fire pump shall be permitted to be supplied by an on-site power production facility. The source facility shall be located and protected to minimize the possibility of damage by fire. [20:9.2.2(3)]

(3) Dedicated Feeder

A dedicated feeder shall be permitted where it is derived from a service connection as described in 695.3(A)(1). [20:9.2.2(3)]

(B) Multiple Sources

If reliable power cannot be obtained from a source described in 695.3(A), power shall be supplied by one of the following: [20:9.3.2]

(1) Individual Sources

An approved combination of two or more of the sources from 695.3(A).

(2) Individual Source and On-Site Standby Generator

An approved combination of one or more of the sources in 695.3(A) and an on-site standby generator complying with 695.3(D). [20:9.3.4]

Exception to 695.3(B)(1) and (B)(2): An alternate source of power shall not be required where a back-up engine-driven fire pump, back-up steam turbine-driven fire pump, or back-up electric motor-driven fire pump with an independent power source in accordance with 695.3(A) or (C) is installed.

(C) Multibuilding Campus-Style Complexes

If the sources in 695.3(A) are not practicable and the installation is part of a multibuilding campus-style complex, feeder sources shall be permitted if approved by the authority having jurisdiction and installed in accordance with either 695.3(C)(1) and (C)(3) or (C)(2) and (C)(3).

(1) Feeder Sources

Two or more feeders shall be permitted as more than one power source if such feeders are connected to, or derived from, separate utility services. The connection(s), overcurrent protective device(s), and disconnecting means for such feeders shall meet the requirements of 695.4(B)(1)(b).

(2) Feeder and Alternate Source

A feeder shall be permitted as a normal source of power if an alternate source of power independent from the feeder is provided. The connection(s), overcurrent protective device(s), and disconnecting means for such feeders shall meet the requirements of 695.4(B)(1)(b).

(3) Selective Coordination

Overcurrent protective device(s) shall be selectively coordinated with all supply-side overcurrent protective device(s).

Selective coordination shall be selected by a licensed professional engineer or other qualified persons engaged primarily in the design, installation, or maintenance of electrical systems. The selection shall be documented and made available to those authorized to design, install, maintain, and operate the system.

Exception: Selective coordination shall not be required between two overcurrent devices located in series if no loads are connected in parallel with the downstream device.

(D) On-Site Standby Generator as Alternate Source

An on-site standby generator(s) used as an alternate source of power shall comply with 695.3(D)(1) through (D)(3). [20:9.6.2.1]

(1) Capacity

The generator shall have sufficient capacity to allow normal starting and running of the motor(s) driving the fire pump(s) while supplying all other simultaneously operated load(s). [20:9.6.1.1]

Automatic shedding of one or more optional standby loads in order to comply with this capacity requirement shall be permitted.

(2) Connection

A tap ahead of the generator disconnecting means shall not be required. [20:9.6.1.2]

(3) Adjacent Disconnects

The requirements of 430.113 shall not apply.

(E) Arrangement

All power supplies shall be located and arranged to protect against damage by fire from within the premises and exposing hazards. [20:9.1.4]

Multiple power sources shall be arranged so that a fire at one source does not cause an interruption at the other source.

(F) Transfer of Power

Transfer of power to the fire pump controller between the individual source and one alternate source shall take place within the pump room. [20:9.6.4]

(G) Power Source Selection

Selection of power source shall be performed by a transfer switch listed for fire pump service. [20:10.8.1.3.1]

(H) Overcurrent Device Selection

An instantaneous trip circuit breaker shall be permitted in lieu of the overcurrent devices specified in 695.4(B)(2)(a)(1), provided that it is part of a transfer switch assembly listed for fire pump service that complies with 695.4(B)(2)(a)(2).

(I) Phase Converters

Phase converters shall not be permitted to be used for fire pump service. [20:9.1.7]

695.4 Continuity of Power

Circuits that supply electric motor—driven fire pumps shall be supervised from inadvertent disconnection as covered in 695.4(A) or (B).

(A) Direct Connection

The supply conductors shall directly connect the power source to a listed fire pump controller, a listed combination fire pump controller and power transfer switch, or a listed fire pump power transfer switch.

(B) Connection Through Disconnecting Means and Overcurrent Device

(1) Number of Disconnecting Means

(a) General. A single disconnecting means and associated overcurrent protective device(s) shall be permitted to be installed between the fire pump power source(s) and one of the following: [20:9.1.2]

A listed fire pump controller

A listed fire pump power transfer switch

A listed combination fire pump controller and power transfer switch

(b) Feeder Sources. For systems installed under the provisions of 695.3(C) only, additional disconnecting means and the associated overcurrent protective device(s) shall be permitted.

(c) On-Site Standby Generator. Where an on-site standby generator is used to supply a fire pump, an additional disconnecting means and an associated overcurrent protective device(s) shall be permitted.

(2) Overcurrent Device Selection

Overcurrent devices shall comply with 695.4(B)(2)(a) or (B)(2)(b).

(a) Individual Sources. Overcurrent protection for individual sources shall comply with the following:

Overcurrent protective device(s) shall be rated to carry indefinitely the sum of the locked-rotor current of the largest fire pump motor and the full-load current of all of the other pump motors and accessory equipment. [20:9.2.3.4] Where the locked-rotor current value does not correspond to a standard overcurrent device size, the next standard overcurrent device size shall be used in accordance with 240.6. The requirement to carry the locked-rotor currents indefinitely shall not apply to conductors or devices other than overcurrent devices in the fire pump motor circuit(s).

Exception: The requirement to carry the locked-rotor currents indefinitely shall not apply to feeder overcurrent protective devices installed in accordance with 695.3(C).

Overcurrent protection shall be provided by an assembly listed for fire pump service and complying with the following:

The overcurrent protective device shall not open within 2 minutes at 600 percent of the full-load current of the fire pump motor(s).

The overcurrent protective device shall not open with a re-start transient of 24 times the full-load current of the fire pump motor(s).

The overcurrent protective device shall not open within 10 minutes at 300 percent of the full-load current of the fire pump motor(s).

The trip point for circuit breakers shall not be field adjustable. [20:9.2.3.4.1]

(b) On-Site Standby Generators. Overcurrent protective devices between an on-site standby generator and a fire pump controller shall be selected and sized to allow for instantaneous pickup of the full pump room load, but shall not be larger than the value selected to comply with 430.62 to provide short-circuit protection only. [20:9.6.1.1]

(3) Disconnecting Means

All disconnecting devices that are unique to the fire pump loads shall comply with items 695.4(B)(3)(a) through (B)(3)(e).

(a) Features and Location — Normal Power Source. The disconnecting means for the normal power source shall comply with all of the following: [20:9.2.3.1]

Be identified as suitable for use as service equipment.

Be lockable in the closed position. The provision for locking or adding a lock to the disconnecting means shall be installed on or at the switch or circuit breaker used as the disconnecting means and shall remain in place with or without the lock installed.

Not be located within the same enclosure, panelboard, switchboard, switchgear, or motor control center, with or without common bus, that supplies loads other than the fire pump.

Be located sufficiently remote from other building or other fire pump source disconnecting means such that inadvertent operation at the same time would be unlikely.

Exception to 695.4(B)(3)(a): For a multibuilding campus-style complex(s) installed under the provisions of 695.3(C), only the requirements in 695.4(B)(3)(a)(2) shall apply for normal power source disconnects.

(b) Features and Location — On-Site Standby Generator. The disconnecting means for an on-site standby generator(s) used as the alternate power source shall be installed in accordance with 700.10(B)(5) for emergency circuits and shall be lockable in the closed position. The provision for locking or adding a lock to the disconnecting means shall be installed on or at the switch or circuit breaker used as the disconnecting means and shall remain in place with or without the lock installed.

(c) Disconnect Marking. The disconnecting means shall be marked "Fire Pump Disconnecting Means." The letters shall be at least 25 mm (1 in.) in height, and they shall be visible without opening enclosure doors or covers. [20:9.2.3.1 (5)]

(d) Controller Marking. A placard shall be placed adjacent to the fire pump controller, stating the location of this disconnecting means and the location of the key (if the disconnecting means is locked). [20:9.2.3.2]

(e) Supervision. The disconnecting means shall be supervised in the closed position by one of the following methods:

Central station, proprietary, or remote station signal device

Local signaling service that causes the sounding of an audible signal at a constantly attended point

Locking the disconnecting means in the closed position

(f) Sealing of disconnecting means and approved weekly recorded inspections when the disconnecting means are located within fenced enclosures or in buildings under the control of the owner [20:9.2.3.3]

695.5 Transformers

Where the service or system voltage is different from the utilization voltage of the fire pump motor, transformer(s) protected by disconnecting means and overcurrent protective devices shall be permitted to be installed between the system supply and the fire pump controller in accordance with 695.5(A) and (B), or with (C). Only transformers covered in 695.5(C) shall be permitted to supply loads not directly associated with the fire pump system.

(A) Size

Where a transformer supplies an electric motor driven fire pump, it shall be rated at a minimum of 125 percent of the sum of the fire pump motor(s) and pressure maintenance pump(s) motor loads, and 100 percent of the associated fire pump accessory equipment supplied by the transformer.

(B) Overcurrent Protection

The primary overcurrent protective device(s) shall be selected or set to carry indefinitely the sum of the locked-rotor current of the fire pump motor(s) and the pressure maintenance pump motor(s) and the full-load current of the associated fire pump accessory equipment when connected to this power supply. Secondary overcurrent protection shall not be permitted. The requirement to carry the locked-rotor currents indefinitely shall not apply to conductors or devices other than overcurrent devices in the fire pump motor circuit(s).

(C) Feeder Source

Where a feeder source is provided in accordance with 695.3(C), transformers supplying the fire pump system shall be permitted to supply other loads. All other loads shall be calculated in accordance with Article 220, including demand factors as applicable.

(1) Size

Transformers shall be rated at a minimum of 125 percent of the sum of the fire pump motor(s) and pressure maintenance pump(s) motor loads, and 100 percent of the remaining load supplied by the transformer.

(2) Overcurrent Protection

The transformer size, the feeder size, and the overcurrent protective device(s) shall be coordinated such that overcurrent protection is provided for the transformer in accordance with 450.3 and for the feeder in accordance with 215.3, and such that the overcurrent protective device(s) is selected or set to carry indefinitely the sum of the locked-rotor current of the fire pump motor(s), the pressure maintenance pump motor(s), the full-load current of the associated fire pump accessory equipment, and 100 percent of the remaining loads supplied by the transformer. The requirement to carry the locked-rotor currents indefinitely shall not apply to conductors or devices other than overcurrent devices in the fire pump motor circuit(s).

695.6 Power Wiring

Power circuits and wiring methods shall comply with the requirements in 695.6(A) through (J), and as permitted in 230.90(A), Exception No. 4; 230.94, Exception No. 4; 240.13; 230.208; 240.4(A); and 430.31.

(A) Supply Conductors

(1) Services and On-Site Power Production Facilities

Service conductors and conductors supplied by on-site power production facilities shall be physically routed outside a building(s) and shall be installed as service-entrance conductors in accordance with 230.6, 230.9, and Parts III and IV of Article 230. Where supply conductors cannot be physically routed outside of buildings, the conductors shall be permitted to be routed through the building(s) where installed in accordance with 230.6(1) or (2).

Exception: The supply conductors within the fire pump room shall not be required to meet 230.6(1) or (2).

Informational Note: See 250.24(C) for routing the grounded conductor to the service equipment.

(2) Feeders

Fire pump supply conductors on the load side of the final disconnecting means and overcurrent device(s) permitted by 695.4(B), or conductors that connect directly to an on-site standby generator, shall comply with all of the following:

Independent Routing. The conductors shall be kept entirely independent of all other wiring.

Associated Fire Pump Loads. The conductors shall supply only loads that are directly associated with the fire pump system.

Protection from Potential Damage. The conductors shall be protected from potential damage by fire, structural failure, or operational accident.

Inside of a Building. Where routed through a building, the conductors shall be protected from fire for 2 hours using one of the following methods:

The cable or raceway is encased in a minimum 50 mm (2 in.) of concrete.

The cable or raceway is a listed fire-resistive cable system.

Informational Note No. 1: Fire-resistive cables are tested to ANSI/UL 2196-2017, Standard for Fire Test, for Circuit Integrity of Fire-Resistive Power, Instrumentation, Control and Data Cables.

Informational Note No. 2: The listing organization provides information for fire-resistive cable systems on proper installation requirements to maintain the fire rating.

The cable or raceway is a listed electrical circuit protective system.

Informational Note No. 1: Electrical circuit protective systems could include, but are not limited to, thermal barriers or a protective shaft and are tested in accordance with UL 1724, Fire Tests for Electrical Circuit Protection Systems.

Informational Note No. 2: The listing organization provides information for electrical circuit protective systems on proper installation requirements to maintain the fire rating.

Exception to 695.6(A)(2)(4): The supply conductors located in the electrical equipment room where they originate and in the fire pump room shall not be required to have the minimum 2-hour fire separation or fire-resistance rating unless otherwise required by 700.10(D) of this Code.

(B) Conductor Size

(1) Fire Pump Motors and Other Equipment

Conductors supplying a fire pump motor(s), pressure maintenance pumps, and associated fire pump accessory equipment shall have a rating not less than 125 percent of the sum of the fire pump motor(s) and pressure maintenance motor(s) full-load current(s), and 100 percent of the associated fire pump accessory equipment.

(2) Fire Pump Motors Only

Conductors supplying only a fire pump motor shall have a minimum ampacity in accordance with 430.22 and shall comply with the voltage drop requirements in 695.7.

(C) Overload Protection

Power circuits shall not have automatic protection against overloads. Except for protection of transformer primaries provided in 695.5(C)(2), branch-circuit and feeder conductors shall be protected against short circuit only. Where a tap is made to supply a fire pump, the wiring shall be treated as service conductors in accordance with 230.6. The applicable distance and size restrictions in 240.21 shall not apply.

Exception No. 1: Conductors between storage batteries and the engine shall not require overcurrent protection or disconnecting means.

Exception No. 2: For an on-site standby generator(s) rated to produce continuous current in excess of 225 percent of the full-load amperes of the fire pump motor, the conductors between the on-site generator(s) and the combination fire pump transfer switch controller or separately mounted transfer switch shall be installed in accordance with 695.6(A)(2).

The protection provided shall be in accordance with the short-circuit current rating of the combination fire pump transfer switch controller or separately mounted transfer switch.

(D) Pump Wiring

All wiring from the controllers to the pump motors shall be in rigid metal conduit, intermediate metal conduit, electrical metallic tubing, liquidtight flexible metal conduit, or liquidtight flexible nonmetallic conduit, listed Type MC cable with an impervious covering, or Type MI cable. Electrical connections at motor terminal boxes shall be made with a listed means of connection. Twist-on, insulation-piercing-type, and soldered wire connectors shall not be permitted to be used for this purpose.

(E) Loads Supplied by Controllers and Transfer Switches

A fire pump controller and fire pump power transfer switch, if provided, shall not serve any load other than the fire pump for which it is intended.

(F) Mechanical Protection

All wiring from engine controllers and batteries shall be protected against physical damage and shall be installed in accordance with the controller and engine manufacturer's instructions.

(G) Ground-Fault Protection of Equipment

Ground-fault protection of equipment shall not be installed in any fire pump power circuit. [20:9.1.8.1]

(H) Listed Electrical Circuit Protective System to Controller Wiring

Electrical circuit protective system installation shall comply with any restrictions provided in the listing of the electrical circuit protective system used, and the following also shall apply:

A junction box shall be installed ahead of the fire pump controller a minimum of 300 mm (12 in.) beyond the fire-rated wall or floor bounding the fire zone.

Where required by the manufacturer of a listed electrical circuit protective system or by the listing, or as required elsewhere in this Code, the raceway between a junction box and the fire pump controller shall be sealed at the junction box end as required and in accordance with the instructions of the manufacturer. [20:9.8.2]

Standard wiring between the junction box and the controller shall be permitted. [20:9.8.3]

(I) Junction Boxes

Where fire pump wiring to or from a fire pump controller is routed through a junction box, the following requirements shall be met:

The junction box shall be securely mounted. [20:9.7(1)]

Mounting and installing of a junction box shall not violate the enclosure type rating of the fire pump controller(s). [20:9.7(2)]

Mounting and installing of a junction box shall not violate the integrity of the fire pump controller(s) and shall not affect the short-circuit current rating of the controller(s).

As a minimum, a Type 2, drip-proof enclosure (junction box) shall be used where installed in the fire pump room. The enclosure shall be listed to match the fire pump controller enclosure type rating. [20:9.7(4)]

Terminals, junction blocks, wire connectors, and splices, where used, shall be listed. [20:9.7(5)]

A fire pump controller or fire pump power transfer switch, where provided, shall not be used as a junction box to supply other equipment, including a pressure maintenance (jockey) pump(s).

(J) Terminations

Where raceways or cable are terminated at a fire pump controller, the following requirements shall be met:

Raceway or cable fittings listed and identified for use in wet locations shall be used.

The type rating of the raceway or cable fittings shall be at least equal to that of the fire pump controller.

The installation instructions of the manufacturer of the fire pump controller shall be followed.

Alterations to the fire pump controller, other than raceway or cable terminations as allowed elsewhere in this Code, shall be approved by the authority having jurisdiction.

695.7 Voltage Drop

(A) Starting

The voltage at the fire pump controller line terminals shall not drop more than 15 percent below normal (controller-rated voltage) under motor starting conditions.

Exception: This limitation shall not apply for emergency run mechanical starting. [20:9.4.2]

(B) Running

The voltage at the load terminals of the fire pump controller shall not drop more than 5 percent below the voltage rating of the motor connected to those terminals when the motor is operating at 115 percent of the full-load current rating of the motor.

695.10 Listed Equipment

Diesel engine fire pump controllers, electric fire pump controllers, electric motors, fire pump power transfer switches, foam pump controllers, and limited service controllers shall be listed for fire pump service. [20:9.5.1.1, 10.1.2.1, 12.1.3.1]

Fire pump controllers and transfer switches shall not be permitted to be reconditioned.

695.12 Equipment Location

(A) Controllers and Transfer Switches

Electric motor-driven fire pump controllers and power transfer switches shall be located as close as practicable to, and within sight of, the motors that they control.

(B) Engine-Drive Controllers

Engine-drive fire pump controllers shall be located as close as is practical to, and within sight of, the engines that they control.

(C) Storage Batteries

Storage batteries for fire pump engine drives shall be supported above the floor, secured against displacement, and located where they are not subject to physical damage, flooding with water, excessive temperature, or excessive vibration.

(D) Energized Equipment

All energized equipment parts shall be located at least 300 mm (12 in.) above the floor level.

(E) Protection Against Pump Water

Fire pump controller and power transfer switches shall be located or protected so that they are not damaged by water escaping from pumps or pump connections.

(F) Mounting

All fire pump control equipment shall be mounted in a substantial manner on noncombustible supporting structures.

695.14 Control Wiring

(A) Control Circuit Failures

External control circuits that extend outside the fire pump room shall be arranged so that failure of any external circuit (open or short circuit) shall not prevent the operation of a pump(s) from all other internal or external means. Breakage, disconnecting, shorting of the wires, or loss of power to these circuits could cause continuous running of the fire pump but shall not prevent the controller(s) from starting the fire pump(s) due to causes other than these external control circuits. All control conductors within the fire pump room that are not fault tolerant shall be protected against physical damage. [20:10.5.2.6, 12.5.2.5]

(B) Sensor Functioning

No undervoltage, phase-loss, frequency-sensitive, or other sensor(s) shall be installed that automatically or manually prohibits actuation of the motor contactor. [20:10.4.5.6]

Exception: A phase-loss sensor(s) shall be permitted only as a part of a listed fire pump controller.

(C) Remote Device(s)

No remote device(s) shall be installed that will prevent automatic operation of the transfer switch. [20:10.8.1.3]

(D) Engine-Drive Control Wiring

All wiring between the controller and the diesel engine shall be stranded and sized to continuously carry the charging or control currents as required by the controller manufacturer. Such wiring shall be protected against physical damage. Controller manufacturer's specifications for distance and wire size shall be followed. [20:12.3.5.1]

(E) Electric Fire Pump Control Wiring Methods

All electric motor-driven fire pump control wiring shall be in rigid metal conduit, intermediate metal conduit, liquidtight flexible metal conduit, electrical metallic tubing, liquidtight flexible nonmetallic conduit, listed Type MC cable with an impervious covering, or Type MI cable.

(F) Generator Control Wiring Methods

Control conductors installed between the fire pump power transfer switch and the standby generator supplying the fire pump during normal power loss shall be kept entirely independent of all other wiring. The integrity of the generator remote start circuit shall be monitored for broken, disconnected, or shorted wires. Loss of integrity shall start the generator(s).

Informational Note: See NFPA 20-2019, Standard for the Installation of Stationary Pumps for Fire Protection, Section 3.3.7.2, for more information on fault-tolerant external control circuits.

The control conductors shall be protected to resist potential damage by fire or structural failure. Where routed through a building, the conductors shall be protected from fire for 2 hours using one of the following methods:

The cable or raceway is encased in a minimum 50 mm (2 in.) of concrete.

The cable or raceway is a listed fire-resistive cable system.

Informational Note No. 1: Fire-resistive cables are tested to ANSI/UL 2196-2017, Standard for Fire Test for Circuit Integrity of Fire-Resistive Power, Instrumentation, Control and Data Cables.

Informational Note No. 2: The listing organization provides information for fire-resistive cable systems on proper installation requirements to maintain the fire rating.

The cable or raceway is protected by a listed .

Informational Note No. 1: Electrical circuit protective systems could include, but are not limited to, thermal barriers or a protective shaft and are tested in accordance with UL 1724, Fire Tests for Electrical Circuit Protection Systems.

Informational Note No. 2: The listing organization provides information for electrical circuit protective systems on proper installation requirements to maintain the fire rating.

695.15 Surge Protection

A listed surge protection device shall be installed in or on the fire pump controller.























