2017 NEC Significant Code Changes Part 4

Four (4) Continuing Education Hours
Course Approval #EE1004

Approved Continuing Education for Professional Engineers

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LEARNING OBJECTIVES

Upon completion of this course the student will be able to:

1. Become familiar with some of the significant changes including additions, deletions, and modification to the 2017 Edition of NFPA 70: National Electrical Code (NEC) from the 2014 Edition.
2. Comprehend, after reviewing the significant changes and additions to the 2017 Edition of NFPA 70: National Electrical Code (NEC) the large scope of the changes to the code, thereby seeking additional and more thorough reviews of the entire code, following completion of this course.

INTRODUCTION

Every three years, the National Electrical Code® (NEC®) is revised and expanded. Initially the NFPA® received 4,012 public suggestions for changes, which resulted in 1,235 first revisions. There were 1,513 public comments submitted in response to these 1,235 first revisions, resulting in 559 second revisions. Changes included editorial clarification, expanded requirements, new requirements, deleted requirements, and the relocation of other requirements. Nine new articles were proposed, and five new articles were added to the 2017 NEC. With the fast pace of technology, it's more important than ever for anyone participating in the electrical industry to get up to speed with all the changes.

2017 National Electric Code (NEC)

- 5,525 Public Suggestions to 2014 NEC
- 1,794 Revisions Made
- Changes Included
  - Editorial Clarification,
  - Expanded Requirements,
  - New Requirements,
  - Deleted Requirements,
  - Relocation of Requirements
- Five New Articles Added

What to Expect

In this course the student will be presented an overview of the most significant changes found in the 2017 NEC.

This is part 2 of a series of courses covering the changes and will progress through each chapter and its articles presenting the many important changes.

The changes will be highlighted for easy recognition and a short synopsis of the reason for the change is presented as well.

DISCLAIMER:

Although every effort has been made to the accuracy of the material presented, by no means shall the student use or substitute this material for the official 2017 NEC. Additionally, Ezekiel Enterprises, LLC shall not be liable for any special, incidental, consequential or exemplary damages resulting, in whole or in part, from the reader's uses of or reliance upon this material.

2017 NEC Major Additions

- Large-Scale Photovoltaic (PV) Electric Power Production Facility (New Article 691) covers systems that produce at least 5 megawatts (MW) of power, or enough to power 800+ U.S. homes.
- Energy Storage Systems (New Article 706) governs ESS installation, disconnection, shutdown, and safety labeling.
- Stand-Alone Systems (New Article 710) covers power production sources that are not connected to the grid, including PV and wind-powered systems.
- Direct Current Microgrids (New Article 712) concerns independent energy distribution networks that allow the utilization of power from dc sources to direct-current loads. Microgrids are on the rise worldwide

CHAPTER 6 EQUIPMENT FOR GENERAL USE

ARTICLE 600
Electric Signs and Outline Lighting

600.4(B) Signs with a Retrofitted Illumination System

(B) Signs with a Retrofitted Illumination System.

(1) The retrofitted sign shall be marked that the illumination system has been replaced.

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

(3) Signs equipped with tubular light-emitting diode lamps powered by the existing sign sockets shall require an additional warning label 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.

■Reason for the Change

A new marking requirement was added to 600.4(B) to indicate that the illumination system has been replaced with a listed retrofit kit.

600.6(A)(1), Ex. No. 2 Disconnects. (Electric Signs and Outline Lighting)

600.6 Disconnects.

Each sign and outline lighting system, feeder ~~circuit~~ 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 ~~680.12~~ 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 complete and local control of the disconnecting means.

(A) Location.

(1) At Point of Entry to a Sign ~~Enclosure~~. 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(C)(3) ~~and~~. The disconnect shall ~~disconnect~~ open all ~~wiring~~ungr ounded 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 ~~circuits~~conductor(s) passing through the sign where 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 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.*

■Reason for the Change

A new exception was added to specifically address a sign enclosure or sign body that supplies an internal panelboard(s) in that same sign enclosure or sign body. A field-applied permanent warning label that is visible during servicing is required to be applied to the raceway containing these energized conductors at or near the point of entry into the sign enclosure or sign body complying with 110.21(B). The marking on the warning label must include the location of the disconnecting means for the energized conductor(s), with the disconnecting means being capable of being locked in the open position in accordance with 110.25.

600.33 Class 2 Sign Illumination Systems, Secondary Wiring.

600.33 ~~LED~~ Class 2 Sign Illumination Systems, Secondary Wiring.

The wiring methods and materials used shall be installed in accordance with the sign manufacturer's installation instructions using any applicable wiring methods from Chapter 3, Wiring Methods, and the requirements for Class 2 circuits contained in ~~Part III of Article 725, as applicable~~ 600.12(C), 600.24, and 600.33(A), (B), (C), and (D).

(A) Insulation and Sizing of Class 2 Conductors.

~~Listed~~ Class 2 cable listed for the applicationthat complies with Table ~~725.154~~ 600.33(A) (1) or Table 600.33(A)(2) 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 ~~22~~ 18 AWG.

Table 600.33(A)(1) Applications of Power Limited Cable in Signs and Outline Lighting

See Page 4 to view Table

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

See Page 4 to view Table

(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)(1) and (A)(2) shall be permitted to be used as follows:

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

(2) CL2R or CL3R — Vertical shafts and risers

(3) Substitutions from Table 600.33(A)(2)

(3) Wet Locations. Class 2 cable used in a wet location shall be listed and

Table 600.33(A)(1) Applications of Power Limited Cable in Signs and Outline Lighting

Location	CL2	CL3	CL2R	CL3R	CL2P	CL3P	PLTC
Non-concealed 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- or risers	N	N	N	N	Y	Y	N
Wet locations	N	N	N	N	N	N	Y

Y = Permitted. N = Not Permitted.

Reproduction of NEC Table 600.33(A)(1)

Table 600.33(A)(2) 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

Reproduction of NEC Table 600.33(A)(2)

marked ~~identified~~ suitable for use in a wet locations ~~or have a moisture-impervious metal sheath~~.

(4) Other Locations. ~~In other locations, any applicable cable permitted in Table 725.154 shall be permitted to be used~~ Class 2 cable exposed to sunlight shall be listed and marked sunlight resistant suitable for outdoor use.

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

(1) ~~Support~~ 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 be 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).

(2) 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. Where subject to physical damage, the conductors shall be protected and installed in accordance with 300.4.

(D) Grounding and Bonding. Grounding and bonding shall be in accordance with 600.7.

■**Reason for the Change**

The title of 600.33 was changed to "Class 2 Sign Illumination Systems, Secondary Wiring," and the section was expanded to cover all types of Class 2 lighting systems, not just LED lighting systems. Two new tables were added to 600.33(A). Table 600.33(A)(1) provides a list of acceptable Class 2 cables listed for the application in signs and outline lighting. Table 600.33(A)(2) provides a list of permitted cable substitutions in these sign applications.

600.34, 600.2 Photovoltaic (PV) Powered Sign

600.34 Photovoltaic (PV) Powered Sign. (Electric Signs and Outline Lighting)

600.2 Definitions.

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.

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:

(1) Listed, labeled, and suitable for photovoltaic applications

(2) Routed to closely follow the sign body or enclosure

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

(4) 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.

■**Reason for the Change**

Along with this new definition for a *Photovoltaic (PV Powered) Sign*, a new 600.34 titled "Photovoltaic (PV Powered) Sign," was added to Article 600 covering field wiring and installation of PV powered signs.

ARTICLE 605
Office Furnishings

605.9(C) Freestanding-Type Office Furnishings, Cord- and Plug-Connected

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.

(C) Receptacle ~~Outlets~~, Maximum. An individual office furnishing or groups of interconnected individual office furnishings shall not contain more than 13 15-ampere, 125-volt ~~receptacle outlets~~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.

■Reason for the Change

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

ARTICLE 610
Cranes and Hoists

610.42(B)(3) Branch-Circuit Short-Circuit and Ground-Fault Protection. (Cranes and Hoists)

610.42 Branch-Circuit Short-Circuit and Ground-Fault Protection. (Cranes and Hoists)

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

(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.

~~**(3) Brake Coils.** Taps without separate overcurrent protection shall be permitted to brake coils.~~

■Reason for the Change

Brake coil taps for cranes or hoists without separate overcurrent protection have been deleted.

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

620.16 Short-Circuit Current Rating. (Elevators, Etc.)

620.16 Short-Circuit Current Rating. (Elevators, Etc.)

(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:

(1) Short-circuit current rating of a listed assembly

(2) Short-circuit current rating established utilizing an approved method

Informational Note: UL 508A-2013, Supplement SB, is an example of an approved method.

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

■Reason for the Change

New short-circuit current rating marking requirements and installation restrictions for elevator control panels were added at 620.16.

ARTICLE 625
Electric vehicle Charging System

625.2 Definitions. (Electric Vehicle Charging System)

625.2 Definitions. (Electric Vehicle Charging 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.

■Reason for the Change

Two new definitions, *Wireless Power Transfer (WPT)* and *Wireless Power Transfer Equipment (WPTE)*, were added at 625.2 as well as a new Part IV of Article 625 entitled, "Wireless Power Transfer Equipment." Additionally, article 625 for Electric Vehicle Charging Systems was reformatted with provisions for wireless power transfer equipment being incorporated into the article.

625.10 Electric Vehicle Coupler

625.10 Electric Vehicle Coupler.

The electric vehicle coupler shall comply with 625.10(A) through ~~(F)~~(D).

~~**(A) Polarization.** The electric vehicle coupler shall be polarized.~~

~~**Exception:** A coupler that is part of a listed electric vehicle supply equipment.~~

~~**(B) Noninterchangeability.** The electric vehicle coupler shall have a configuration that is noninterchangeable with wiring devices in other electrical systems. Nongroundingtype electric vehicle couplers shall not be interchangeable with grounding-type electric vehicle couplers.~~

~~(C)~~(A) Construction and Installation. The electric vehicle coupler shall be constructed and installed so as to guard against inadvertent contact by persons with parts made live from the electric vehicle supply equipment or the electric vehicle battery.

~~(D)~~(B) Unintentional Disconnection. The electric vehicle coupler shall be provided with a positive means to prevent unintentional disconnection.

~~(E)~~(C) Grounding Pole. The electric vehicle coupler shall be provided with a grounding pole, unless provided as part of a listed isolated electric vehicle supply equipment system.

~~(F)~~(D) Grounding Pole Requirements. If a grounding pole is provided, the electric vehicle coupler shall be so designed that the grounding pole connection is the first to make and the last to break contact.

■Reason for the Change

The provisions for polarization and non-interchangeability of electric vehicle couplers were deleted for the 2017 *NEC* as this is a design issue addressed by the listing of the product.

Article 625, Part IV Wireless Power Transfer Equipment (Electric Vehicle Charging System)

625.101 Grounding.

The primary pas 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 Construction.

(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) Installation. 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:

(1) Pedestal

(2) Wall or pole

(3) Building or structure

(4) 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 included primary pas constructions with the charger power converter located in the primary pas enclosure.

(1) 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 above the surface.*

(2) 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 the 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.

■Reason for the Change

A new Part IV of Article 625 entitled, "Wireless Power Transfer Equipment" was added to Article 625, as well as two new definitions, *Wireless Power Transfer (WPT)* and *Wireless Power Transfer Equipment (WPTE)* were added at 625.2.

ARTICLE 645
Information Technology Equipment

645.3(B) Other Articles. (Information Technology Equipment)

645.3 Other Articles. (Information Technology Equipment)

Circuits and equipment shall comply with 645.3(A) through (G)(I), as applicable.

(B) Wiring and Cabling in Other Spaces Used for Environmental Air (Plenums). The following sections and tables shall apply to wiring and cabling in a plenum other spaces used for environmental air (plenums) above an information technology equipment room:

(1) Wiring methods: 300.22(C)(1)

(2) Class 2, Class 3, and PLTC cables: 725.135(C) and Table 725.154

(3) Fire alarm systems: 760.53(B)(2), 725.135(C) 760.135(C), and Table 760.154

(4) Optical fiber cables: 770.113(C), and Table 770.154(a)

(5) Communications circuits: 820.113(C) 800.113(C) and Table 800.154(a), (b), and (c)

(6) CATV and radio distribution systems: 820.113(C) and Table 820.154(a)

■**Reason for the Change**

The information about other articles and sections applying to wiring and cabling in plenums above an IT equipment room has been reformatted into a list format with appropriate titles added at each *Code* reference. The title of 645.3(B) was changed from "Plenums" to "Wiring and Cabling in Other Spaces Used for Environmental Air (Plenums)."

645.5(E) Supply Circuits and Interconnecting Cables. (Information Technology Equipment), Under Raised Floors

645.5 Supply Circuits and Interconnecting Cables. (Information Technology Equipment)

(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 (3)~~., provided the following conditions are met~~:

~~(1) The raised floor is of approved construction, and the area under the floor is accessible.~~

~~(2) The branch-circuit supply conductors to receptacles or field-wired equipment are in 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, liquid-tight flexible metal conduit, or liquidtight flexible nonmetallic conduit, Type MI cable, Type MC cable, or Type AC cable and associated metallic and nonmetallic boxes or enclosures. These supply conductors shall be installed in accordance with the requirements of 300.11.~~

(1) Installation Requirements for Branch Circuit Supply Conductors Under a Raised Floor.

(a) ~~These~~ 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:

(1) Rigid metal conduit

(2) Rigid nonmetallic conduit

(3) Intermediate metal conduit

(4) Electrical metallic tubing

(5) Electrical nonmetallic tubing

(6) Metal wireway

(7) Nonmetallic wireway

(8) Surface metal raceway with metal cover

(9) Surface nonmetallic raceway

(10) Flexible metal conduit

(11) Liquidtight flexible metal conduit

(12) Liquidtight flexible nonmetallic conduit

(13) Type MI cable

(14) Type MC cable

(15) Type AC cable

(16) Associated metallic and nonmetallic boxes or enclosures

(17) 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:

(1) Supply cords of listed information technology equipment in accordance with 645.5(B)

(2) Interconnecting cables enclosed in a raceway

(3) Equipment grounding conductors

(4) 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.

(5) 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 1685-2011, *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- ~~M-2001~~ 09, *Test Methods for Electrical Wires and Cables.*

~~(3) Supply cords of listed information technology equipment are in accordance with 645.5(B).~~

~~(4) Ventilation in the underfloor area is used for the information technology equipment room only, except as provided in 645.4(2).~~

~~(5) Openings in raised floors for cords and cables protect cords and cables against abrasion and minimize the entrance of debris beneath the floor.~~

~~(6) Cables, other than those covered in 645.5(E)(2) and (E)(3), are one of the following:~~

~~a. Listed Type DP cable having adequate fire-resistant characteristics suitable for use under raised floors of an information technology equipment room~~

~~b. Interconnecting cables enclosed in a raceway~~

~~c. Cable type designations shown in Table 645.5(E)(6)~~

~~d. Equipment grounding conductors~~

(3) Installation Requirements for Optical Fiber Cables Under a Raised Floor.

In addition to optical fiber cables installed in accordance with 770.113(C), Types OFNR, OFCR, OFN, and OFC shall be permitted under raised floors.

~~Table 645.5(E)(6) Cable Types Permitted Under Raised Floors~~

[Table 645.5(E)(6) has been deleted]

■Reason for the Change

First level subdivision 645.5(E) was revised and re-organized for usability and clarity. A list format was incorporated for usability as well. The previous Table 645.5(E)(6) was deleted as it is no longer needed.

645.18 Surge Protection for Critical Operations Data Systems. (Information Technology Equipment)

645.18 Surge Protection for Critical Operations Data Systems. (Information Technology Equipment)

Surge protection shall be provided for critical operations data systems.

■Reason for the Change

Surge protection is now required for critical operations data systems by the provisions of new 645.18.

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 sounding apparatus, typically organ pipes~~and keyboards~~.

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.

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.

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 sounding apparatus is also referred to as the "pipe organ chamber."

650.9 Protection from Accidental Contact. The wiring of the 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 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 millwork that permits the passage of sound.

■**Reason for the Change**

Article 650 was revised by adding 650.2 for definitions pertaining to this article. A new 650.9 was added pertaining to protection against accidental contact with the sounding apparatus.

ARTICLE 660
X-Ray Equipment

660.5 Disconnecting Means. (X-Ray Equipment)

660.5 Disconnecting Means. (X-Ray Equipment)

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

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 in accordance with 110.25:*

(1) 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

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

■**Reason for the Change**

The disconnecting means for X-ray equipment is now required to be located within sight from the X-ray control and readily accessible.

ARTICLE 670
Industrial Machinery

670.6 Surge Protection. (Industrial Machinery)

670.6 Surge Protection. (Industrial Machinery)

Industrial machinery with safety interlock circuits shall have surge protection installed.

■**Reason for the Change**

A new requirement was added at 670.6 requiring industrial machinery with safety interlock circuits to be provided with surge protection.

ARTICLE 680
Swimming Pools, Fountains, and Similar Installations

680.2 and Part VIII of Article 680 Definitions, Swimming Pools, Fountains, and Similar Installations

680.2 Definitions. (Swimming Pools, Fountains, and Similar Installations)

Electrically Powered Pool Lift. An electrically powered lift that provides accessibility to and from a pool or spa for people with disabilities.

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. They shall not be required to comply with other parts of this article.

680.81 Equipment Approval. Lifts shall be listed 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 -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.*

680.82 Protection. Pool lifts connected to premises wiring and operated above the low-voltage contact limit shall be provided with GFCI protection for personnel.

680.83 Bonding. Lifts shall be bonded in accordance with 680.26(B)(5) and (B)(7).

680.84 Switching Devices. Switches and switching devices that are operated above the low-voltage contact limit shall comply with 680.22(C).

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.*

■**Reason for the Change**

A new definition for *Electrically Powered Pool Lift* along with a new Part VIII entitled, "Electrically Powered Pool Lifts," were added to Article 680.

680.2 Definitions. (Swimming Pools, Fountains, and Similar Installations)

680.2 Definitions. (Swimming Pools, Fountains, and Similar Installations)

Storable Swimming, Wading, or Immersion Pools; or Storable/ Portable Spas and Hot Tubs. ~~Those~~ 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.

■Reason for the Change

Further clarification was instituted with the phrase "constructed on or above the ground" added before storable/portable "nonmetallic, polymeric or inflatable tubs, spas, or pools regardless of the dimension." This addition clarifies that a storable/portable pool, spa, or hot tub with nonmetallic, molded polymeric walls or inflatable fabric walls regardless of dimension is always installed "on or above the ground."

680.7 Grounding and Bonding Terminals. (Swimming Pools, Fountains, and Similar Installations)

680.7 Grounding and Bonding Terminals. (Swimming Pools, Fountains, and Similar Installations)

Grounding and bonding terminals shall be identified for use in wet and corrosive environments. Field-installed grounding and bonding connections in a damp, wet, or corrosive environment shall be composed of copper, copper alloy, or stainless steel. They shall be listed for direct burial use.

■Reason for the Change

A new grounding and bonding termination requirement was added at 680.7. This new requirement calls for grounding and bonding terminals to be identified for use in wet and corrosive environments and listed for direct burial applications as well.

Table 680.10 Underground Wiring Location. (Swimming Pools, Fountains, and Similar Installations)

680.~~10~~ 11 Underground Wiring Location. (Swimming Pools, Fountains, and Similar Installations)

Underground wiring shall ~~not be permitted under the pool or within the area extending 1.5 m (5 ft) horizontally from the inside wall of~~ be permitted where installed in rigid metal conduit, intermediate metal conduit, rigid polyvinyl chloride conduit, reinforced thermosetting resin conduit, or Type MC cable, suitable for the conditions subject to that location. Underground wiring shall not be permitted under the pool unless this wiring is necessary to supply pool equipment permitted by this article. ~~Where space limitations prevent wiring from being routed a distance 1.5 m (5 ft) or more from the pool, such wiring shall be permitted where installed in complete raceway systems of rigid metal conduit, intermediate metal conduit, or a nonmetallic raceway system. All metal conduit shall be corrosion resistant and suitable for the location. The Minimum cover depth shall be as given in~~ Table 680.10 Table 300.5.

(Table 680.10 Minimum Cover Depths has been deleted)

■Reason for the Change

Underground wiring is now permitted to be installed in close proximity to the pool, and no consideration needs to be given as to whether this wiring is "necessary to supply pool equipment." The wiring methods employed are to be rigid metal conduit, intermediate metal conduit, rigid polyvinyl chloride conduit, reinforced thermosetting resin conduit, or Type MC cable, suitable for the conditions subject to that location. Underground wiring shall not be permitted to be installed *under* the pool unless this wiring is necessary to supply pool equipment permitted by Article 680. The minimum burial depth cover requirements will now be facilitated by Table 300.5, and Table 680.10 for minimum cover depths around pools has been deleted.

680.12 and 680.14 Equipment Rooms and Pits. (Swimming Pools,

Fountains, and Similar Installations) and 680.14 Corrosive Environment

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.

680.14 Corrosive Environment.

(A) General. Areas where pool sanitation chemicals are stored, as well as areas with circulation pumps, automatic chlorinators, filters, open areas under decks adjacent to or abutting the pool structure, and similar locations shall be considered to be a corrosive environment. The air in such areas shall be considered to be laden with acid, chlorine, and bromine vapors, or any combination of acid, chlorine, or bromine vapors, and any liquids or condensation in those areas shall be considered to be laden with acids, chlorine, and bromine vapors, or any combination of acid, chlorine, or bromine vapors.

(B) Wiring Methods. Wiring methods in the areas described in 680.14(A) 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 specified in 680.14(A).

■Reason for the Change

In addition to proper drainage as required by previous 680.11, 680.12 now requires electrical equipment located in equipment rooms or pits to be suitable for the environment in accordance with 300.6, which calls for materials suitable for the environment in which they are to be installed. New requirements at 680.14 detail the corrosion resistance of wiring methods needed in swimming pool installations where chemicals are stored.

680.21(A) (Swimming Pools, Fountains, and Similar Installations)

680.21 Motors. (Swimming Pools, Fountains, and Similar Installations)

(A) Wiring Methods. The wiring to a pool motor shall comply with (A) (1) unless modified for specific circumstances by (A)(2), (A)(3), (A)(4), or (A)(5).

(1) General. ~~The branch circuits for pool-associated motors shall be installed in rigid metal conduit, intermediate metal conduit, rigid polyvinyl chloride conduit, reinforced thermosetting resin conduit,~~Wiring methods installed in the corrosive environment described in 680.14 shall comply with 680.14(B) or shall be Type MC cable listed for ~~the~~ that location. Other wiring methods and materials shall be permitted in specific locations or applications as covered in this section. ~~Any~~ Wiring methods installed in these locations ~~employed~~ shall contain an insulated copper equipment grounding conductor sized in accordance with 250.122 but not smaller Where installed in noncorrosive environments, branch circuits shall comply with the general requirements in Chapter 3.

~~(2) On or Within Buildings.~~ ~~Where installed on or within buildings, electrical metallic tubing shall be permitted.~~

~~(3)~~ (2) Flexible Connections. Where necessary to employ flexible connections at or adjacent to the motor, liquidtight flexible metal or liquid-tight flexible nonmetallic conduit with approved fittings shall be permitted.

~~(4) One-Family Dwellings.~~ ~~In the interior of dwelling units, or in the interior of accessory buildings associated with a dwelling unit, any of the wiring methods recognized in~~ Chapter 3 ~~of this Code that comply with the provisions of this section shall be permitted. Where run in a~~

~~cable assembly, the equipment grounding conductor shall be permitted to be uninsulated, but it shall be enclosed within the outer sheath of the cable assembly.~~

~~(5)~~ (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.

■Reason for the Change

The restricted wiring methods previously described in 680.21(A)(1) through (A)(5) will now only apply in areas where protection from physical damage is needed or where protection from environmental conditions associated with wet, damp, and corrosive conditions are present.

Where installed in noncorrosive environments (such as in the interior of a dwelling unit), branch circuits wiring methods for permanently installed swimming pool pump motors only need to comply with the general requirements of wiring methods mentioned in Chapter 3 of the *NEC*.

680.22(A)(2) Lighting, Receptacles, and Equipment. (Swimming Pools, Fountains, and Similar Installations)

680.22 Lighting, Receptacles, and Equipment. (Swimming Pools, Fountains, and Similar Installations)

(A) Receptacles.

(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 ~~3.0 m (10 ft)~~ 1.83 m (6 ft) from the inside walls of the pool~~, or not less than 1.83 m (6 ft) from the inside walls of the pool if they meet all of the following~~ conditions. These receptacles shall have GFCI protection and be of the grounding type.

~~(1) Consist of single receptacles~~

~~(2) Are of the grounding type~~

~~(3) Have GFCI protection~~

■Reason for the Change

Receptacles that supply power for pool pump motors or other loads directly related to the circulation and sanitation system can now be located not less than 1.83 m (6 ft) from the inside walls of the pool, provided the receptacle(s) are of the grounding type and equipped with GFCI protection.

680.22(B)(7) Low-Voltage Gas-Fired Luminaires, Decorative Fireplaces, Fire Pits, and Similar Equipment

680.22 Lighting, Receptacles, and Equipment. (Swimming Pools, Fountains, and Similar Installations)

(B) Luminaires, Lighting Outlets, and Ceiling-Suspended (Paddle) Fans.

(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).

■Reason for the Change

New provisions were added in 680.22(B)(7) to specifically address low-voltage gas-fired luminaires, decorative fireplaces, fire pits,

and similar equipment. With the inclusion of electronic ignitors for these devices, *NEC* regulations were needed for this type of low-voltage, gas-fired equipment.

680.25 Feeders. (Swimming Pools, Fountains, and Similar Installations)

680.25 Feeders. (Swimming Pools, Fountains, and Similar Installations)

These provisions shall apply to any feeder on the supply side of panel-boards 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) Wiring Methods.~~

~~(1)~~ (A) Feeders. ~~Feeders shall be installed in rigid metal conduit or intermediate metal conduit. The following wiring methods shall be permitted if not subject to physical damage~~: Where feeders are installed in corrosive environments as described in 680.14, the wiring method of that portion of the feeder shall be as required in 680.14(B) or shall be liquid-tight 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 Table 250.122, but not smaller than 12 AWG.

Where installed in noncorrosive environments, feeders shall comply with the general requirements in Chapter 3.

~~(1) Liquidtight flexible nonmetallic conduit~~

~~(2) Rigid polyvinyl chloride conduit~~

~~(3) Reinforced thermosetting resin conduit~~

~~(4) Electrical metallic tubing where installed on or within a building~~

~~(5) Electrical nonmetallic tubing where installed within a building~~

~~(6) Type MC cable where installed within a building and if not subject to corrosive environment~~

~~(2)~~ (B) Aluminum Conduit. Aluminum conduit shall not be permitted in the pool area where subject to corrosion.

~~(B) Grounding. An equipment grounding conductor shall be installed with the feeder conductors between the grounding terminal of the pool equipment panelboard and the grounding terminal of the applicable service equipment or source of a separately derived system. For other than feeders to separate buildings that do not utilize an insulated equipment grounding conductor in accordance with 680.25(B)(2), this equipment grounding conductor shall be insulated.~~

~~(1) Size. This conductor shall be sized in accordance with 250.122 but not smaller than 12 AWG. On separately derived systems, this conductor shall be sized in accordance with 250.30(A)(3) but not smaller than 8 AWG.~~

~~(2) Separate Buildings. A feeder to a separate building or structure shall be permitted to supply swimming pool equipment branch circuits, or feeders supplying swimming pool equipment branch circuits, if the grounding arrangements in the separate building meet the requirements in 250.32(B).~~

■Reason for the Change

The previous 680.25(B) for grounding of swimming pool panelboard feeders was deleted in its entirety as grounding provisions for swimming pool panelboard feeders have been incorporated into the revised text at 680.25(A). The revised text at 680.25(A) requires restricted wiring methods only in areas where harsh conditions (such as physical damage, environmental conditions, corrosive conditions, etc.) are present. Chapter 3 wiring methods are now otherwise permitted.

680.27(B)(1), Ex. and 680.27(B)(2), Ex. Specialized Pool Equipment. (Swimming Pools, Fountains, and Similar Installations)

680.27 Specialized Pool Equipment. (Swimming Pools, Fountains, and Similar Installations)

(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 operator has full view of the pool.

~~**Informational Note No. 1:** For cabinets installed in damp and wet locations, see 312.2.~~

~~**Informational Note No. 2:** For switches or circuit breakers installed in wet locations, see 404.4.~~

~~**Informational Note No. 3:** For protection against liquids, see 430.11.~~

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 by a ground-fault circuit interrupter.

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).*

■Reason for the Change

Two exceptions were added below the parent text of 680.27(B)(1) and 680.27(B)(2) recognizing pool cover motors that are part of a listed system with ratings not exceeding the low-voltage contact limits, allowing such a low-voltage type motor to be installed within 1.5 m (5 ft) of the inside walls of the pool, and the omission of GFCI protection for said motor.

680.28 Gas-Fired Water Heater. (Swimming Pools, Fountains, and Similar Installations)

680.28 Gas-Fired Water Heater. (Swimming Pools, Fountains, and Similar Installations)

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.

■Reason for the Change

New provisions were added requiring branch circuits serving gas-fired swimming pool and spa water heaters operating at voltages above the low-voltage contact limit to be provided with GFCI protection for personnel.

680.74 Bonding. (Hydromassage Bathtubs)

680.74 Bonding. (Hydromassage Bathtubs)

~~Both metal piping systems and grounded metal parts in contact with the circulating water shall be bonded together using a solid copper bonding jumper, insulated, covered, or bare, not smaller than 8 AWG. The bonding jumper shall be connected to the terminal on the circulating pump motor that is intended for this purpose. The bonding jumper shall not be required to be connected to a double insulated circulating pump motor. The 8 AWG or larger solid copper bonding jumper 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. The 8 AWG or larger solid copper bonding jumper shall be long enough to terminate on a replacement non-double-insulated pump motor and shall be terminated to the equipment grounding conductor of the branch circuit of the motor when a double-insulated circulating pump motor is used.~~

(A) General. The following parts shall be bonded together:

(1) All metal fittings within or attached to the tub structure that are in contact with the circulating water

(2) Metal parts of electrical equipment associated with the tub water circulating system, including pump and blower motors

(3) 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

(4) 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

(5) Electrical devices and controls that are not associated with the hydro-massage tubs and that are located 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) 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 panel-board, 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.

■Reason for the Change

The former requirements for equipotential bonding of a hydromassage bathtub were retained and placed into a list format. Section 680.74 now has two first level subdivisions, (A) and (B), with two exceptions for 680.74(A). A list of metallic items located "within 1.5 m (5 ft) of the inside walls of the tub" were added to the items required to be bonded. A new exception now exempts bonding of "small conductive surfaces."

ARTICLE 682
Natural and Artificially Made Bodies of Water

682.15 Ground-Fault Circuit-Interrupter (GFCI) Protection. (Natural and Artificially Made Bodies of Water)

682.15 Ground-Fault Circuit-Interrupter (GFCI) Protection. (Natural and Artificially Made Bodies of Water)

Fifteen- and 20-ampere single-phase, 125-volt through 250-volt receptacles installed outdoors and in or on floating buildings or structures within the electrical datum plane area ~~that are used for storage, maintenance, or repair where portable electric hand tools, electrical diagnostic equipment, or portable lighting equipment are to be used~~ shall be provided with GFCI protection for personnel. The GFCI protection device shall be located not less than 300 mm (12 in.) above the established electrical datum plane.

■Reason for the Change

GFCI protection for personnel is now required for all 15- and 20-ampere, single-phase, 125-volt through 250-volt receptacles installed outdoors and in or on floating buildings or structures within the electrical datum plane area, not just those receptacles in areas used for storage, maintenance, or repair where portable electric hand tools, electrical diagnostic equipment, or portable lighting equipment are to be used.

ARTICLE 690
Solar Photovoltaic (PV) Systems

690.2 Definitions. [Solar Photovoltaic (PV) Systems]

Functional Grounded PV System. A PV system that has an electrical reference to ground that is not solidly grounded.

Informational Note: A functional grounded PV system is often connected to ground through a fuse, circuit breaker, resistance device, non-isolated grounded ac circuit, or electronic means that is part of a listed ground-fault protection system. Conductors in these systems that are normally at ground potential may have voltage to ground during fault conditions.

■Reason for the Change

A new definition for *Functional Grounded PV System* was added at 690.2. This term is now used in six different locations throughout Article 690.

690.7 Maximum Voltage [Solar Photovoltaic (PV) Systems]

690.7 Maximum Voltage [Solar Photovoltaic (PV) Systems]

The maximum voltage of PV system dc circuits shall be the highest voltage between any two circuit conductors or any conductor and ground. PV system dc circuits on or in one- and two-family dwellings shall be permitted to have a maximum voltage of 600 volts or less. PV system dc circuits on or in other types of buildings shall be permitted to have a maximum voltage of 1000 volts or less. Where not located on or in buildings, listed dc PV equipment, rated at a maximum voltage of 1500 volts or less, shall not be required to comply with Parts II and III of Article 490.

(A) ~~Maximum~~ Photovoltaic ~~System Voltage~~ Source and Output Circuits.

Table 690.7(A) Voltage Correction Factors for Crystalline and Multi-Crystalline Silicon Modules

~~(B) Direct-Current Utilization Circuits.~~

(B) DC-to-DC Converter Source Output Circuits.

~~(C) Photovoltaic Source and Output Circuits.~~

~~(D) Circuits over 150 Volts to Ground.~~

(E) (C) Bipolar Source and Output Circuits.

■Reason for the Change

Section 690.7 went through an extensive revision this cycle to simplify these maximum voltage requirements. Three first level subdivisions remain, and Table 690.7 was changed to Table 690.7(A), as this is where the reference to this table exists.

690.8(A)(1) Circuit Sizing and Current. [Solar Photovoltaic (PV) Systems]

690.8 Circuit Sizing and Current. [Solar Photovoltaic (PV) Systems]

(A) Calculation of Maximum Circuit Current. The maximum current for the specific circuit shall be calculated in accordance with 690.8(A) (1) through (A)~~(5)~~ (6).

Informational Note: Where the requirements of 690.8(A)(1) and (B)(1) are both applied, the resulting multiplication factor is 156 percent.

(1)Photovoltaic Source Circuit Currents. The maximum current shall be ~~the sum of parallel module rated short-circuit currents multiplied by 125 percent.~~ calculated by one of the following methods:

(1) The sum of parallel-connected PV module-rated short-circuit currents multiplied by 125 percent

(2) For PV systems with a generating capacity of 100 kW or greater, a documented and stamped PV system design, using an industry standard method and provided by a licensed professional electrical engineer, shall be permitted. The calculated maximum current value shall be based on the highest 3-hour 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)(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.

■Reason for the Change

In addition to the 125 percent method permitted by previous editions of the *Code*, a second option was added for calculating the maximum current for a PV source circuit using an industry standard method provided by a licensed professional electrical engineer.

690.11, Exception Arc-Fault Circuit Protection (Direct Current). [Solar Photovoltaic (PV) Systems]

690.11 Arc-Fault Circuit Protection (Direct Current). [Solar Photovoltaic (PV) Systems]

Photovoltaic systems ~~with dc source circuits, dc output circuits, or both,~~ operating at ~~a PV system maximum system voltage of~~ 80 volts dc or greater, shall be protected by a listed ~~(dc)~~ PV arc-fault circuit interrupter, ~~PV type,~~ or other system components listed to provide equivalent protection. ~~The PV arc-fault protection means shall comply with the following requirements~~: 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 ~~dc~~ PV system ~~source and~~ dc ~~PV output~~ circuits.

~~(1) 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 dc PV source and dc PV output circuits.~~

~~(2) The system shall require that the disabled or disconnected equipment be manually restarted.~~

~~(3) The system shall have an annunciator that provides a visual indication that the circuit interrupter has operated. This indication shall not reset automatically.~~

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 direct buried, installed in metallic raceways, or installed in enclosed metallic cable trays are 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.*

■Reason for the Change

The requirement for PV AFCI protection at 690.11 was revised by removing the previous subsections 690.11(2) and (3). A new exception allows PV AFCI protection to be omitted for PV systems that are not installed on or in buildings where the output circuits and dc-to-dc converter output circuits are direct buried, installed in metallic raceways, or installed in enclosed metallic cable trays.

690.12 Rapid Shutdown of PV Systems on Buildings. [Solar Photovoltaic (PV) Systems]

690.12 Rapid Shutdown of PV Systems on Buildings. [Solar Photovoltaic (PV) Systems]

PV system circuits installed on or in buildings shall include a rapid shutdown function ~~that controls specific conductors~~ to reduce shock hazard for emergency responders in accordance with 690.12~~(1)~~ (A)through~~(5)~~(D) ~~as follows~~.

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.*

~~(1)~~ (A) Controlled Conductors. Requirements for controlled

conductors shall apply ~~only~~ to PV circuits supplied by the PV system ~~conductors of more than 1.5 m (5 ft) in length inside a building, or more than 3 m (10 ft) from a PV array.~~

(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).

~~(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 ~~and 240 volt amperes~~ within ~~10~~ 30 seconds of rapid shutdown initiation. ~~(3)~~ Voltage and ~~power~~ 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:

(1) The PV array shall be listed or field labeled as a rapid shutdown PV array. Such a PV array shall be installed and used in accordance with the instructions included with the rapid shutdown PV array listing or field labeling.

Informational Note: A listed or field labeled rapid shutdown PV array is evaluated as an assembly or system as defined in the installation instructions to reduce but not eliminate risk of electric shock hazard within a damaged PV array during fire-fighting procedures. These rapid shutdown PV arrays are designed to reduce shock hazards by methods such as limiting access to energized components, reducing the voltage difference between energized components, limiting the electric current that might flow in an electrical circuit involving personnel with increased resistance of the conductive circuit, or by a combination of such methods.

(2) Controlled conductors located inside the boundary or not more than 1 m (3 ft) from the point of penetration of the surface of the building 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.

(3) PV arrays with no exposed wiring methods, no exposed conductive parts, and installed more than 2.5 m (8 ft) from exposed grounded conductive parts or ground shall not be required to comply with 690.12(B)(2).

The requirement of 690.12(B)(2) shall become effective January 1, 2019.

(C) Initiation Device. The initiation device(s) shall initiate the rapid shutdown function of all the PV system. The device "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.

~~(4) The rapid shutdown initiation methods shall be labeled in accordance with 690.56(B).~~

The rapid shutdown initiation device(s) shall consist of at least one of the following:

(1) Service disconnecting means

(2) PV system disconnecting means

(3) Readily accessible switch that plainly indicates whether it is in the "off" or "on" position

Informational Note: One example of why an initiation device that complies with 690.12(C)(3) would be used is where a PV system is connected to an optional standby system that remains energized upon loss of utility voltage.

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. Where

auxiliary initiation devices are installed, these auxiliary devices shall control all PV systems with rapid shutdown functions on that service.

~~(5)~~(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 ~~and identified~~ for providing rapid shutdown protection.

Informational Note: Inverter input circuit conductors often remain energized for up to 5 minutes with inverters not listed for rapid shutdown.

■Reason for the Change

The rapid shutdown requirements of 690.12 were revised to emphasize the primary purpose of the rapid shutdown requirements, which is to reduce shock hazard for emergency responders, and to answer questions regarding the functionality of the PV rapid shutdown device itself. The structure of 690.12 is now subdivided into four separate subsections: (A) Controlled Conductors, (B) Controlled Limits, (C) Initiation Device, and (D) Equipment.

690.13 Photovoltaic System Disconnecting Means. [Solar Photovoltaic (PV) Systems]

690.13 ~~Building or Other Structure Supplied by a~~ Photovoltaic System Disconnecting Means. [Solar Photovoltaic (PV) Systems]

Means shall be provided to disconnect ~~all ungrounded dc conductors of a~~ the PV system from all ~~other conductors in a building or other structure~~ 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 l~~ocation either on the outside of a building or structure or inside nearest the point of entrance of the system conductors~~.

~~Exception:~~ *~~Installations that comply with 690.31(F) shall be permitted to have the disconnecting means located remote from the point of entry of the system conductors. The PV system disconnecting means shall not be installed in bathrooms.~~*

Informational Note: PV systems installed in accordance with 690.12 address the concerns related to energized conductors entering a building.

(B) Marking. 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 ~~to identify it as a PV system disconnect~~. 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).

(C) Suitable for Use. ~~Each~~ If the PV system is connected to the supply side of the service disconnecting means as permitted in 230.82(6), the PV system disconnecting means shall ~~not be required to~~ be listed as suitable for use as service equipment.

(D) Maximum Number of Disconnects. ~~The~~ 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(D)(1), is an example of a single PV system disconnecting means.

~~**(E) Grouping.** The PV system disconnecting means shall be grouped with other disconnecting means for the system in accordance with 690.13(D). A PV disconnecting means shall not be required at the PV module or array location.~~

(E) Ratings. The PV system disconnecting means shall have ratings sufficient for the maximum circuit current available short-circuit current, and voltage that is available at the terminals of the PV system disconnect.

(F) Type of Disconnect.

(1) Simultaneous Disconnection. The PV system disconnecting means shall simultaneously disconnect the PV system conductors of the circuit from all conductors of other wiring systems. The PV system disconnecting means shall be an externally operable general-use switch or circuit breaker, or other approved means. A dc PV system disconnecting means shall be marked for use in PV systems or be suitable for backfeed operation.

(2) Devices Marked "Line" and "Load." Devices marked with "line" and "load" shall not be permitted for backfeed or reverse current.

(3) DC-Rated Enclosed Switches, Open-Type Switches, and Low-Voltage Power Circuit Breakers. DC-rated, enclosed switches, open-type switches, and low-voltage power circuit breakers shall be permitted for backfeed operation.

■**Reason for the Change**

The requirements for PV disconnecting means at 690.13 received extensive revisions along with a few new provisions added. This section now has six first level subdivisions: (A) Location, (B) Marking, (C) Suitable for Use, (D) Maximum Number of Disconnects, (E) Rating, and (F) Type of Disconnect.

690.31(C)(1) 690.31 (Wiring) Methods Permitted. [Solar Photovoltaic (PV) Systems]

690.31 (Wiring) Methods Permitted. [Solar Photovoltaic (PV) Systems]

(C) Single-Conductor Cable.

(1) General. Single-conductor cable Type USE-2 and single-conductor cable listed and ~~labeled~~identified as photovoltaic (PV) wire shall be permitted in exposed outdoor locations in PV source circuits ~~for PV module interconnections~~ within the PV array. PV wire shall be installed in accordance with 338.10(B)(4)(b) and 334.30.

~~***Exception:** Raceways shall be used when required by 690.31(A).*~~

■**Reason for the Change**

The term *listed and labeled* was replaced with *listed and identified* when describing single-conductor PV wire. A new installation requirement and references to 338.10(B)(4)(b) and 334.30 have been added to 690.31(C) (1) for PV wiring in a PV array. The exception requiring a PV wire installed in a readily accessible location within a PV array be installed in a raceway was removed.

690.35 Ungrounded Photovoltaic Power Systems

~~**690.35 Ungrounded Photovoltaic Power Systems.**~~

~~Photovoltaic power systems shall be permitted to operate with ungrounded PV source and output circuits where the system complies with 690.35(A) through (G).~~

~~**(A) Disconnects.**~~

~~**(B) Overcurrent Protection.**~~

~~**(C) Ground-Fault Protection.**~~

~~**(D) Conductors.**~~

~~(E) Battery Systems.~~

~~(F) Marking.~~

~~(G) Equipment.~~

■Reason for the Change

The requirements for an ungrounded photovoltaic (PV) power system at 690.35 have been deleted. Ungrounded systems are now defined as a functional grounded PV system.

690.41 System Grounding. [Solar Photovoltaic (PV) Systems]

690.41 System Grounding. [Solar Photovoltaic (PV) Systems]

(A) PV System Grounding Configurations. One or more of the following system grounding configurations shall be employed:
~~Photovoltaic systems shall comply with one of the following~~:

(1) ~~Ungrounded systems shall comply with 690.35.~~ 2-wire PV arrays with one functional grounded conductor

(2) ~~Grounded two-wire systems shall have one conductor grounded or be impedance grounded, and the system shall comply with 690.5~~. Bipolar PV arrays according to 690.7(C) with a functional ground reference (center tap)

(3) ~~Grounded bipolar systems shall have the reference (center tap) conductor grounded or be impedance grounded, and the system shall comply with 690.5.~~ PV arrays not isolated from the grounded inverter output circuit

(4) ~~Other methods that accomplish equivalent system protection in accordance with 250.4(A) with equipment listed and identified for the use shall be permitted to be used.~~ Ungrounded PV arrays

(5) Solidly grounded PV arrays as permitted in 690.41(B) Exception

(6) 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. ~~Grounded~~ dc PV arrays shall be provided with dc ground-fault protection meeting the requirements of 690.41(B) (1) and (2) to reduce fire hazards. (was 690.5)

Exception: ~~*Ground-mounted or pole-mounted PV arrays with not more than two paralleled source circuits and with all dc source and dc output circuits isolated from buildings shall be permitted without ground-fault protection.*~~ *PV arrays with not more than two PV source circuits and with all PV system dc circuits not on or in buildings shall be permitted without ground-fault protection where solidly grounded. (was 690.5 Exception)*

(1) Ground-Fault Detection. The ground fault ~~protection~~ protective device or system shall ~~be capable of detecting a~~ detect ground fault(s) in the PV array dc current-carrying conductors and components, including any ~~intentionally~~ functional grounded conductors, and be listed for providing PV ground-fault protection. [was 690.5(A)(1) and (A)(4)]

(2) Isolating Faulted Circuits. The faulted circuits shall be isolated by one of the following methods:

(1) The ~~ungrounded~~ current-carrying conductors of the faulted circuit shall be automatically disconnected.

(2) The inverter or charge controller fed by the faulted circuit shall automatically cease to supply power to output circuits and isolate the PV system dc circuits from the ground reference in a functional grounded system. [was 690.5(B)(1) and (B)(2)]

■Reason for the Change

The provisions of 690.41 were revised to properly address the methods by which PV systems are grounded. Two new first level subdivisions were added to 690.41 — 690.41(A) addresses "PV System Grounding Configurations," while 690.41(B) covers "Ground-Fault Protection" for PV systems. To cap off this revision, the former text of 690.5 was relocated to 690.41(B) to concur

with the revised grounding requirements for PV systems.

690.47 Grounding Electrode System. [Solar Photovoltaic (PV) Systems]

690.47 Grounding Electrode System. [Solar Photovoltaic (PV) Systems]

~~**(A) Alternating-Current Systems.**~~

~~**(B) Direct-Current Systems.**~~

~~**(C) Systems with Alternating-Current and Direct-Current Grounding Requirements.**~~

(A) Buildings or Structures Supporting a PV Array. A building or structure supporting a PV array shall have a grounding electrode system installed in accordance with Part III of Article 250.

PV array equipment grounding conductors shall be connected to the grounding electrode system of the building or structure supporting the PV array 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 PV systems that are not solidly grounded, the equipment grounding conductor for the output of the PV system, connected to associated distribution equipment, shall be permitted to be the connection to ground for ground-fault protection and equipment grounding of the PV array.

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 installed in the past decade are functional grounded systems rather than solidly grounded systems as defined in this *Code*. For functional grounded PV systems with an interactive inverter output, the ac equipment grounding conductor is connected to associated grounded ac distribution equipment. This connection is often the connection to ground for ground-fault protection and equipment grounding of the PV array.

(B) ~~(D)~~ Additional Auxiliary Electrodes for Array Grounding. ~~A~~ Grounding electrodes shall be permitted to be installed in accordance with 250.52 and 250.54 at the location of all ground- and ~~pole-mounted PV arrays and as close as practicable to the location of~~ roof-mounted PV arrays. The electrodes shall be permitted to be connected directly to the array frame(s) or structure. The ~~dc~~ grounding electrode conductor shall be sized according to ~~250.166~~ 250.66. ~~Additional electrodes are not permitted to be used as a substitute for equipment bonding or equipment grounding conductor requirements.~~ The structure of a ground- ~~or pole-~~mounted PV array shall be permitted to be considered a grounding electrode if it meets the requirements of 250.52. Roof-mounted PV arrays shall be permitted to use the metal frame of a building or structure if the requirements of 250.52(A)(2) are met.

■Reason for the Change

For the 2017 *NEC*, the requirements for the installation of grounding electrodes and grounding electrode conductors have been greatly simplified, while maintaining the safety of PV systems. The provisions of former 690.47(A), (B), and (C) have been abridged and incorporated into the new 690.47(A). The provisions of former 690.47(D) [now 690.47(B)] pertaining to additional auxiliary electrodes for PV array grounding have been revised to clarify that these auxiliary electrodes are permitted but not required.

690.56(C) Identification of Power Sources

690.56 Identification of Power Sources.

(A) Facilities with Stand-Alone Systems. Any structure or building with a PV power system that is not connected to a utility

service source and is a stand-alone system shall have a permanent plaque or directory installed on the exterior of the building or structure at a readily visible location ~~acceptable to the authority having jurisdiction~~. The plaque or directory shall indicate the location of system disconnecting means and that the structure contains a stand-alone electrical power system. The marking shall be in accordance with 690.31(G).

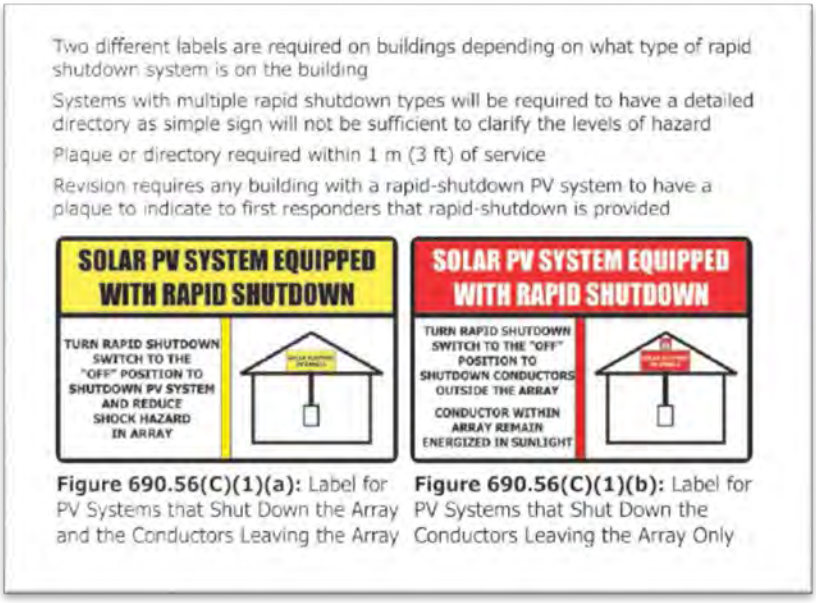

Figure 690.56(C)(1)(a): Label for PV Systems that Shut Down the Array and the Conductors Leaving the Array

Figure 690.56(C)(1)(b): Label for PV Systems that Shut Down the Conductors Leaving the Array Only

(B) Facilities with Utility Services and PV Systems.

~~Buildings or structures with both utility service and a PV system shall have a permanent plaque or directory providing the location of the service disconnecting means and the PV system disconnecting means if not located at the same location. The warning sign(s) or label(s) shall comply with 110.21(B).~~

Plaques or directories shall be installed in accordance with 705.10.

(C) ~~Facilities~~ Buildings with Rapid Shutdown.

~~Buildings or structures with both utility service and a PV system, complying with 690.12, shall have a permanent plaque or directory including the following wording:~~

~~PHOTOVOLTAIC SYSTEM EQUIPPED WITH RAPID SHUTDOWN~~

~~The plaque or directory shall be reflective, with all letters capitalized and having a minimum height of 9.5 mm (3/8 in.), in white on red background.~~

Buildings with PV systems shall have permanent plaques or directories as described in 690.56(C)(1) through (C)(3).

(1) Rapid Shutdown Type. The type of PV system rapid shutdown shall be labeled as described in 690.56(C)(1)(a) or (1)(b):

(a)For PV systems that shut down the array and conductors leaving the array:

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 SHUT DOWN" 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. [See Figure 690.56(C)(1)(a).]

(b) For PV systems that only shut down conductors leaving the array:

SOLAR PV SYSTEM IS EQUIPPED WITH RAPID SHUTDOWN

TURN RAPID SHUTDOWN SWITCH TO THE "OFF" POSITION TO SHUT DOWN

CONDUCTORS OUTSIDE THE ARRAY. CONDUCTORS IN ARRAY REMAIN

ENERGIZED IN SUNLIGHT.

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 white on red background, and the remaining characters shall be capitalized with a minimum height of 4.8 mm (3/16 in.) in black on white background. [See Figure 690.56(C)(1)(b).]

Figure 690.56(C)(1)(a): Label for PV Systems that Shut Down the Array and the Conductors Leaving the Array.

Figure 690.56(C)(1)(b): Label for PV Systems that Shut Down the Conductors Leaving the Array Only.

The labels in 690.56(C)(1)(a) and (b) shall include a simple diagram of a building with a roof. The diagram shall have sections in red to signify sections of the PV system that are not shut down when the rapid shutdown switch is operated.

The rapid shutdown label in 690.56(C)(1) shall be located on or no more than 1 m (3 ft) from the service disconnecting means to which the PV systems are connected and shall indicate the location of all identified rapid shutdown switches if not at the same location.

(2) Buildings with More Than One Rapid Shutdown Type. For buildings that have PV systems with both rapid shutdown types or a PV system with a rapid shutdown type and a PV system with no rapid shutdown, a detailed plan view diagram of the roof shall be provided showing each different PV system and a dotted line around areas that remain energized after the rapid shutdown switch is operated.

(3) Rapid Shutdown Switch. A rapid shutdown switch shall have a ~~plaque or directory~~ label located on or no more than 1 m (3 ft) from the ~~service disconnecting means~~ switch that includes the following wording:

RAPID SHUTDOWN SWITCH FOR SOLAR PV SYSTEM

The ~~plaque or directory~~ 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.

■Reason for the Change

Through an extensive revision process, 690.56(C) was divided into three list items: (C)(1) addresses rapid shutdown types; (C)(2) deals with buildings with more than one rapid shutdown type; and (C)(3) makes provisions for the rapid shutdown switch or rapid shutdown initiator (RSI). Two new figures were added in 690.56(C)(1) to illustrate new labels that are now required for the two different types of rapid shutdown systems for a PV installation [see Figure 690.56(C)(1)(a) and Figure 690.56(C)(1)(b)]. A detailed plan view diagram of the roof is required in certain situations by 690.56(C)(2) to provide illustrated guidance showing each different PV system and should include a "dotted line" around areas that remain energized after the rapid shutdown initiation switch is activated. The requirements of 690.56(C)(3) necessitate a rapid shutdown switch to have a label located directly on the RSI or no more than 1 m (3 ft) from the rapid shutdown switch that includes the words, "RAPID SHUTDOWN SWITCH FOR SOLAR PV SYSTEM."

Article 690, Part VII

Part VII. Connection to Other Sources [Solar Photovoltaic (PV) Systems]

~~690.57 Load Disconnect.~~ ~~A load disconnect that has multiple sources of power shall disconnect all sources when in the off position.~~

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.

~~690.60 Identified Interactive Equipment.~~ ~~Only inverters and ac modules listed and identified as interactive shall be permitted in interactive systems.~~

~~690.61 Loss of Interactive System Power.~~ ~~An inverter or an ac module in an interactive solar PV system shall automatically de-energize its output to the connected electrical production and distribution network upon loss of voltage in that system and shall remain in that state until the electrical production and distribution network voltage has been restored. A normally interactive solar PV 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.~~

~~690.63 Unbalanced Interconnections.~~ ~~Unbalanced connections shall be in accordance with 705.100.~~

~~690.64 Point of Connection.~~ ~~Point of connection shall be in accordance with 705.12.~~

■Reason for the Change

Revisions to Part VII of Article 690 removed the majority of Part VII and replaced it with one reference to Article 705 where interconnection requirements are covered in detail. Part VII of Article 690 now contains one section, 690.59, Connection to Other Sources.

690.71 General. (Energy Storage Systems) [Solar Photovoltaic (PV) Systems]

690.71 ~~Installation~~ General. (Energy St orage ~~Batteries~~ Systems) [Solar Photovoltaic (PV) Systems]

An energy storage system connected to a PV system shall be installed in accordance with Article 706.

~~(A) General.~~ ~~Storage batteries in a solar photovoltaic system shall be installed in accordance with the provisions of Article 480. The interconnected battery cells shall be considered grounded where the photovoltaic power source is installed in accordance with 690.41.~~

~~(B) Dwellings.~~

~~(C) Current Limiting.~~

~~(D) Battery Nonconductive Cases and Conductive Racks.~~

~~(E) Disconnection of Series Battery Circuits.~~

~~(F) Battery Maintenance Disconnecting Means.~~

~~(G) Battery Systems of More Than 48 Volts.~~

~~(H) Disconnects and Overcurrent Protection.~~

■Reason for the Change

The former provisions of 690.71 for installation of PV storage battery systems have been relocated to Part III of Article 706, leaving one reference to new Article 706 at 690.71.

ARTICLE 691
Large-Scale Photovoltaic (PV) Electric Power Production Facility

Article 691 Large-Scale Photovoltaic (PV) Electric Power Production Facility

691.1 Scope. This article covers the installation of large-scale PV electric power production facilities with a 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 C2-2012, *National Electrical Safety Code*.

691.2 Definitions.

Electric Supply Stations. Locations containing the generating stations and substations, including their associated generator, storage battery, transformer, and switchgear areas.

Generating Capacity. The sum of parallel-connected inverter rated maximum continuous output power at 40°C in kilowatts (kW).

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:

(1) Electrical circuits and equipment shall be maintained and operated only by qualified personnel.

Informational Note: Refer to NFPA 70E-2015, Standard for Electrical Safety in the Workplace, for electrical safety requirements.

(2) Access to PV electric supply stations is 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).

(3) 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.

(4) The electrical loads within the supply station are only used to power auxiliary equipment for the generation of the PV power.

(5) Large-scale PV electric supply stations shall not be installed on buildings.

691.5 Equipment Approval.

All Electrical equipment shall be approved for installation by one of the following:

(1) Listing and labeling

(2) Field labeling

(3) Where products complying with 691.5(1) or (2) are not available, by engineering review validating that the electrical equipment is 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 report 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 Disconnection of Photovoltaic Equipment.

Isolating devices shall be permitted to be more than 1.8 m (6 ft) from the equipment where written safety procedures and conditions of maintenance and supervision ensure that only qualified persons service the equipment. Buildings whose sole purpose is to house and protect supply station equipment shall not be required to comply with 690.12.

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 Grounding.

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.

■Reason for the Change

A new Article 691 for "Large-Scale Photovoltaic (PV) Electric Power Production Facility" was added to the 2017 *NEC*. This article covers the installation of large-scale PV electric power production facilities operated for the sole purpose of providing electric supply to the utility transmission or distribution system with a generating capacity of no less than 5,000 kW.

ARTICLE 695
Fire Pumps

695.6(G) Power Wiring. (Fire Pumps)

695.6 Power Wiring. (Fire Pumps)

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.

(G) Ground-Fault Protection of Equipment. Ground-fault protection of equipment shall not be ~~permitted for fire pumps~~ installed in any fire pump power circuit. [**20:** 9.1.8.1]

■Reason for the Change

The text at 695.6(G) was changed to state that ground-fault protection of equipment "shall not be installed" in any fire pump power circuit.

695.15 Surge Protection. (Fire Pumps)

695.15 Surge Protection. (Fire Pumps)

A listed surge protection device shall be installed in or on the fire pump controller.

■Reason for the Change

A new requirement was added to 695.15 demanding a listed surge protection device (SPD) be installed in or on all fire pump controllers.

ACCESS THE CODE

The complete 2017 NEC can be accessed online for free at the following link. Be sure to select "Free access to the 2017 edition of NFPA 70"

http://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards?mode=code&code=70

Additional, the code can be purchased in both a book and pdf from the same link.

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Quiz Questions

The following twenty (20) question quiz will test the student's comprehension of the course. The student must past this online quiz with a score greater than 70%.

1. **Signs equipped with tubular light-emitting diode lamps powered by the existing sign sockets shall require what?**

- o A warning label not to install fluorescent lamps
- o A warning label that is visible during re-lamping
- o Any of these
- o A label alerting the service personnel the sign has been modified

2. True or False. A disconnect shall 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.

- o True
- o False

3. **What is the minimum size of Class 2 power source conductors used for sign illumination?**

- o 16 AWG
- o 12 AWG
- o 18 AWG
- o 22 AWG

4. **In reference to table 600.33(a)(1), what type of cable should be used for a wet location?**

- o Class 3R
- o PLTC
- o Class 2
- o Class 4T

5. **In reference to table 600.33(a)(2), which of the following can be used as substitutions for CL3R?**

- o CMP
- o CL3P
- o All of the above
- o CMR

6. **When securing class 2 cable, the cable shall be supported and secured at intervals not exceeding?**

- o 6 feet
- o 12 feet
- o 8 feet
- o 10 feet

7. **What does WPTE stand for?**

- o Wi-Fi Power Terminal Equipment
- o Wireless Power Transfer Equipment
- o Watts Per Transit Evolution
- o Windlass Power Transfer Equipment

8. **Regarding wireless power transfer, the charger power converter that is not integral to the primary pad for an indoor charging shall be mounted?**

- o Flush with the floor level
- o At least 600 mm above the floor level
- o At least 18 inches above the floor level
- o At least 24 inches above the floor level

9. **CATV wiring used for environmental air on IT equipment can be referenced in which 2017 NEC sections?**

- o 725.135 (C)
- o 770.113 (C)
- o 760.53 (C)
- o 820.113 (C)

10. **Disconnecting means of X-ray equipment shall be located within_____from the X- ray control.?**

- o 50 in.
- o 36 in.
- o Sight
- o 24 in.

11. **Field-installed grounding and bonding connections for a swimming pool that are installed in a damp, wet, or corrosive environment shall be composed of _____, _____ or_____.**

- o copper, copper alloy, stainless steel
- o galvanized steel, aluminum, steel
- o CL2, CL3, CMG
- o non-metallic conduit, rigid polyvinyl chloride conduit, aluminum conduit

12. **Where installed in noncorrosive environments (such as in the interior of a dwelling unit), branch circuits wiring methods for permanently installed swimming pool pump motors need to comply with the general requirements of wiring methods in _____?**

- o Chapter 6 of the NEC
- o Article 680
- o Section 680.21
- o Chapter 3 of the NEC

13. **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_____from the inside walls of the pool.**

- o 10 feet
- o 5 feet
- o 7 feet
- o 12 feet

14. **What is the maximum voltage of a solar photovoltaic system DC circuits for one/two family dwellings?**

- o Is not specified
- o 400 volts
- o 1000 volts
- o 600 volts

15. **For PV systems with a generating capacity of 100 kW or greater, a documented and stamped PV system design, using an industry standard method and provided by _____, shall be permitted?**

- o a licensed professional architect
- o a licensed professional electrical engineer
- o a licensed master electrician
- o any licensed person

16. **To reduce shock hazards for emergency responders, what must also be installed for PV system circuits in buildings.**

- o Rapid Shutdown Function
- o AFCI equipment
- o Fire protection equipment
- o GFCI equipment

17. **Each PV system disconnecting means shall plainly indicate whether in the open (off) or closed (on) position and be permanently marked "_____" or equivalent.**

- o PV SYSTEM DISCONNECT
- o ELECTRICAL HAZARD
- o REFER TO OPERATIONS MANUAL
- o RAPID SHUTDOWN

18. **Single-conductor cable _____ and single-conductor cable listed and identified as photovoltaic (PV) wire shall be permitted in exposed outdoor locations in PV source circuits within the PV array.**

- o Type DOG
- o Type CMG
- o Type USE-2
- o Type UV2

19. **Most PV systems installed in the past decade are _____ grounded systems rather than _____ grounded systems as defined in this Code.**

- o isolated, not-isolated
- o solidly, functional
- o not-isolated, isolated
- o functional, solidly

20. **Which article should be reference for PV systems with generating outputs greater than 5000 kW?**

- o Article 695
- o Article 692
- o Article 691
- o Article 690