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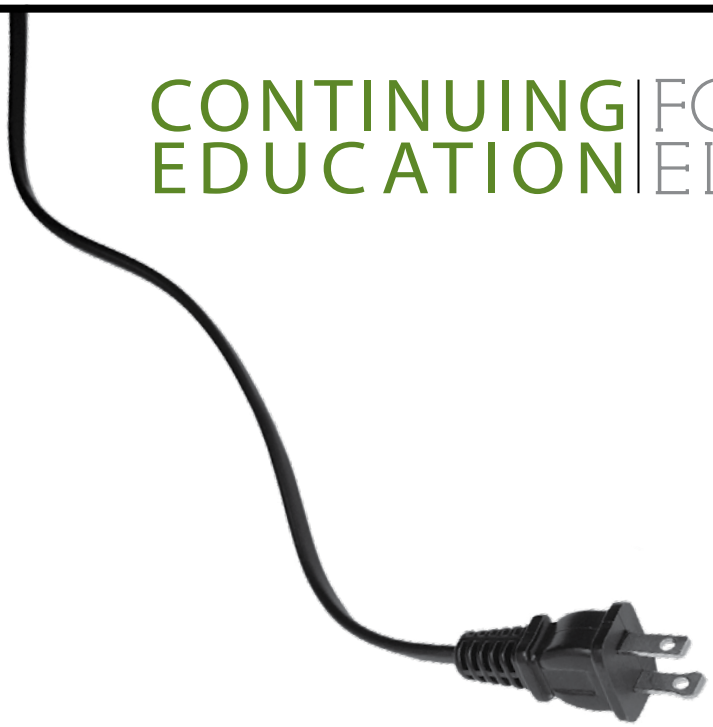

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2017 NEC Article 690

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N16 W23217 Stone Ridge Drive
Suite 290
Waukesha, WI 53188
262-409-4282
www.wcitraining.com

ARTICLE 690 SOLAR PHOTOVOLTAIC (PV) SYSTEMS

Article 690. Article 690 is organized into 9 different parts. The specific parts are as follows:

Part I General
Part II Circuit Requirements
Part III Disconnecting means
Part IV Wiring Methods
Part V Grounding
Part VI Marking
Part VII Connection to other Sources
Part VIII Storage batteries
Part IX Systems over 600 Volts

(Revised) 690.1 Scope. This article applies to solar PV systems, other than those covered by Article 691, including the array circuit(s), inverter(s), and controller(s) for such systems. [See Figure 690.1(a) and Figure 690.1(b).] The systems covered by this article may be interactive with other electrical power production sources or stand-alone or both, and may or may not be connected to energy storage systems such as batteries. These PV systems may have ac or dc output for utilization.

Informational Note: Article 691 covers the installation of largescale PV electric supply stations.

690.2 Definitions.

Module. A complete, environmentally protected unit consisting of solar cells, optics, and other components, exclusive of tracker, designed to generate dc power when exposed to sunlight.

Monopole Subarray. A PV subarray that has two conductors in the output circuit, one positive (+) and one negative(-). Two monopole PV subarrays are used to form a bipolar PV array.

Multimode Inverter. Equipment having the capabilities of both the interactive inverter and the stand-alone inverter.

Panel. A collection of modules mechanically fastened together, wired, and designed to provide a field-installable unit.

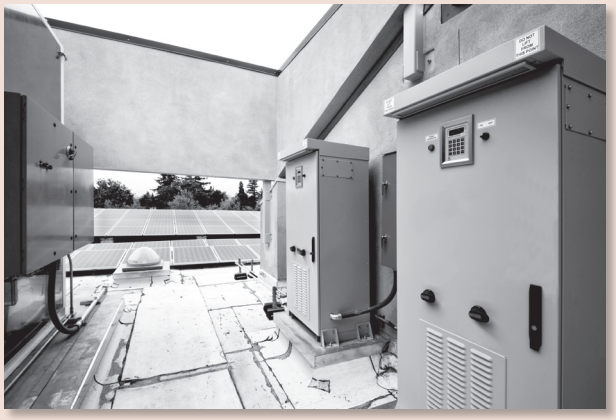
(Revised) 690.4 (D) Multiple PV Systems. Multiple PV systems shall be permitted to be installed in or on a single building or structure. Where the PV systems are remotely located from each other, a directory in accordance with 705.10 shall be provided at each PV system disconnecting means.

(NEW) 690.4 (E) Locations Not Permitted. PV system equipment and disconnecting means shall not be installed in bathrooms.

690.6 (A) Photovoltaic Source Circuits. The requirements of Article 690 pertaining to PV source circuits shall not apply to ac modules. The PV source circuit, conductors, and inverters shall be considered as internal wiring of an ac module.

690.6 (B) Inverter Output Circuit. The output of an ac module shall be considered an inverter output circuit.

(Revised) 690.7 Maximum Voltage. 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.

EXAM QUESTIONS

1. What is the maximum PV dc voltage permitted for an office building?

A. 600 volts
B. 480 volts
C. 1000 volts
D. 240 volts

2. What part of Article 690 covers the disconnects used with PV systems?

A. IV
B. III
C. I
D. VII

3. Article 690 applies to PV systems including controllers, array circuits, and _____.

A. Collectors
B. Balancers
C. Inverters
D. Inversion cells

4. What is the maximum PV dc voltage permitted for a single-family dwelling?

A. 240 volts
B. 480 volts
C. 1000 volts
D. 600 volts

5. Where are PV system equipment and disconnecting means NOT allowed to be installed?

A. Bathrooms
B. Office areas
C. Storage rooms
D. Crawl spaces

6. What part of Article 690 deals with systems over 600 volts?

A. 690
B. 516
C. 500
D. 505

7. What part of Article 690 deals specifically with grounding?

A. IV
B. VI
C. V
D. III

8. What best defines equipment having the capabilities of both the utility-interactive inverter and the stand-alone inverter?

A. Duel pole Inverter
B. Multimode Inverter
C. Standalone Inverter
D. Bipolar array

9. What part of Article 690 should be referenced to determine the systems required to be marked for a PV system?

A. IV
B. VI
C. V
D. IX

10. If multiple PV inverters are to be installed remotely from one another, a _____ must be installed at all ac and dc disconnecting means showing their locations.

A. Indicator arrows
B. Causeway
C. Phenolic labels
D. Directory

11. What is an AC modules output considered?

A. Source voltage
B. Source current
C. An inverter output circuit
D. Power factor correction

12. What part of Article 690 should be referenced to determine what voltage storage batteries can operate at in a residential application?

A. IV
B. VI
C. V
D. VIII

13. What are PV source circuit, conductors, and inverters considered with regards to an ac module?

A. Internal wiring
B. External wiring
C. Separately derived system
D. Service wiring

14. What part of Article 690 deals with Circuit Requirements?

A. V
B. II
C. VI
D. III

15. How many monopole PV subarrays are used to form a bipolar PV array?

A. 6
B. 3
C. 2
D. 5

(Revised) 690.7 (C) Bipolar Source and Output Circuits. For 2-wire dc circuits connected to bipolar PV arrays, the maximum voltage shall be the highest voltage between the 2-wire circuit conductors where one conductor of the 2-wire circuit is connected to the functional ground reference (center tap). To prevent overvoltage in the event of a ground-fault or arc-fault, the array shall be isolated from the ground reference and isolated into two 2-wire circuits.

690.8(A)(1) Photovoltaic Source Circuit Currents. The sum of parallel-connected PV module–rated short-circuit currents multiplied by 125 percent.

690.8(A)(3) Inverter Output Circuit Current. The maximum current shall be the inverter continuous output current rating.

690.8(A)(4) Stand-Alone Inverter Input Circuit Current. The maximum current shall be the stand-alone continuous inverter input current rating when the inverter is producing rated power at the lowest input voltage.

(Revised) 690.8 (B) Conductor Ampacity. PV system currents shall be considered to be continuous. Circuit conductors shall be sized to carry not less than the larger of 690.8(B)(1) or (B)(2) or where protected by a listed adjustable electronic overcurrent protective device in accordance 690.9(B)(3), not less than the current in 690.8(B)(3).

690.8 (C) Systems with Multiple Direct-Current Voltages. For a PV power source that has multiple output circuit voltages and employs a common- return conductor, the ampacity of the common-return conductor shall not be less than the sum of the ampere ratings of the overcurrent devices of the individual output circuits.

690.8 (D) Sizing of Module Interconnection Conductors. Where a single overcurrent device is used to protect a set of two or more parallel-connected module circuits, the ampacity of each of the module interconnection conductors shall not be less than the sum of the rating of the single overcurrent device plus 125 percent of the short-circuit current from the other parallel- connected modules.

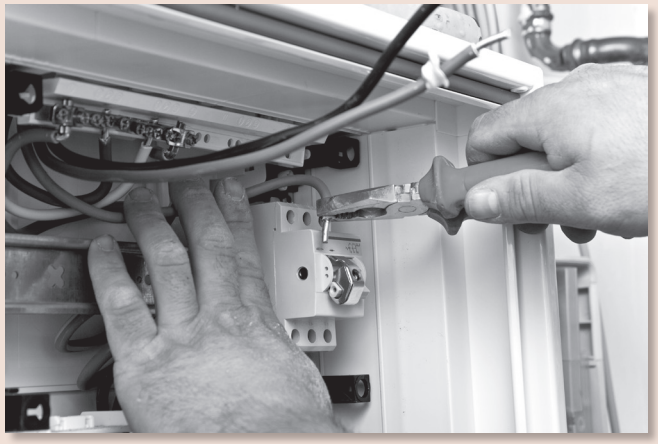
(Revised) 690.9 (A) Circuits and Equipment. PV system dc circuit and inverter output conductors and equipment shall be protected against overcurrent. Overcurrent protective devices shall not be required for circuits with sufficient ampacity for the highest available current. Circuits connected to current limited supplies (e.g., PV modules, dc-to-dc converters, interactive inverter output circuits) and also connected to sources having higher current availability (e.g., parallel strings of modules, utility power) shall be protected at the higher current source connection.

(Revised): 690.9 (B) Overcurrent Device Ratings. Overcurrent devices used in PV system dc circuits shall be listed for use in PV systems. Overcurrent devices, where required, shall be rated in accordance with one of the following:

(1) Not less than 125 percent of the maximum currents calculated in 690.8(A).

(2) An assembly, together with its overcurrent device(s), that is listed for continuous operation at 100 percent of its rating shall be permitted to be used at 100 percent of its rating.

(3) Adjustable electronic overcurrent protective devices rated or set in accordance with 240.6.



(Revised) 690.9 (C) Photovoltaic Source and Output Circuits. A single overcurrent protective device, where required, shall be permitted to protect the PV modules and conductors of each source circuit or the conductors of each output circuit. Where single overcurrent protection devices are used to protect PV source or output circuits, all overcurrent devices shall be placed in the same polarity for all circuits within a PV system. The overcurrent devices shall be accessible but shall not be required to be readily accessible.

EXAM QUESTIONS

16. How do you determine the ampacity of a PV power source common-return conductor that has multiple output circuit voltages?

A. You are not allowed to use a common-return conductor that has multiple output circuit voltages for PV systems
B. It's based on the sum of the voltage ratings of the overcurrent devices of the individual output circuits
C. It's based on the sum of the ampere ratings of the overcurrent devices of the individual input circuits
D. It's based on the sum of the ampere ratings of the overcurrent devices of the individual output circuits

17. How do you determine an inverter's maximum output current?

A. Based on the inverter's over current protection
B. Based on the inverter's continuous output current rating
C. Based on the inverters in rush current
D. Based on the stored potential of the battery storage system

18. The maximum PV circuit current is required to be the sum of the parallel module rated short circuit currents multiplied by what percentage?

A. 75
B. 100
C. 125
D. 50

19. What are PV system currents considered?

A. Stored
B. Intermittent
C. Continuous
D. Reusable

20. The input circuit current of a stand-alone inverter is required to be at its maximum when the inverter is producing rated power at what input voltage?

A. Maximum
B. Rated
C. Array
D. Lowest

21. How do you prevent overvoltage in the event of a ground-fault or arc-fault in a bipolar PV array?

A. The array shall be connected directly to the ground reference
B. The array shall be isolated from the ground reference and isolated into two 2-wire circuits
C. The array is required to have solder pot over current protection
D. The array is required to be isolated from the source reference and isolated into three 2-wire circuits

22. A PV system overcurrent device cannot be less than _____ of the maximum currents calculated in 690.8(A).

A. 150%
B. 100%
C. 125%
D. 225%

23. In what type of location are output PV circuit overcurrent devices required to be installed?

A. Accessible
B. Readily accessible
C. Guarded
D. Listed

24. What are PV system dc circuit inverter output conductors and equipment required to be protected against?

A. Overcurrent
B. Hysteresis
C. Eddy Currents
D. Copper loss

25. What are over current devices used in dc PV power systems required to be?

A. Instantaneous trip
B. Listed for PV systems
C. Intermittent duty
D. Fast acting

26. At what percentage would you size short-circuit current conductors that are used as a single overcurrent device protecting a set of two or more parallel-connected module circuits?

A. 150%
B. 100%
C. 125%
D. 225%

(Revised) 690.11 Arc-Fault Circuit Protection (Direct Current). Photovoltaic systems operating at 80 volts dc or greater between any two conductors shall be protected by a listed PV arc-fault circuit interrupter or other system components listed to provide equivalent protection. The system shall detect and interrupt arcing faults resulting from a failure in the intended continuity of a conductor, connection, module, or other system component in the PV system dc circuits.

Informational Note: Annex A includes the reference for the Photovoltaic DC Arc-Fault Circuit Protection product standard.

(Revised) 690.12 Rapid Shutdown of PV Systems on Buildings. PV system circuits installed on or in buildings shall include a rapid shutdown function to reduce shock hazard for emergency responders in accordance with 690.12(A) through (D).

(New) 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.

(New) 690.12 (A) Controlled Conductors. Requirements for controlled conductors shall apply to PV circuits supplied by the PV system.

(New) 690.12 (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).

(New) 690.12 (C) Initiation device. The initiation device(s) shall initiate the rapid shutdown function of 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.

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

(New) 690.12 (D) Equipment. Equipment that performs the rapid shutdown functions, other than initiation devices such as listed disconnect switches, circuit breakers, or control switches, shall be listed for providing rapid shutdown protection.

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

(Revised) 690.13 (A) Location. The PV system disconnecting means shall be installed at a readily accessible location.

(Revised) 690.13 (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. 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).

(Revised) 690.13 (D) Maximum Number of Disconnects. 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.

(Revised) 690.13 (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.

(Revised) 690.15 Disconnection of Photovoltaic Equipment. Isolating devices shall be provided to isolate PV modules, ac PV modules, fuses, dc-to-dc converters inverters, and charge controllers from all conductors that are not solidly grounded. An equipment disconnecting means or a PV system disconnecting means shall be permitted in place of an isolating device. Where the maximum circuit current is greater than 30 amperes for the output circuit of a dc combiner or the input circuit of a charge controller or inverter, an equipment disconnecting means shall be provided for isolation. Where a charge controller or inverter has multiple input circuits, a single equipment disconnecting means shall be permitted to isolate the equipment from the input circuits.

(Revised) 690.15(A) Location. Isolating devices or equipment disconnecting means shall be installed in circuits connected to equipment at a location within the equipment, or within sight and within 3 m (10 ft) of the equipment. An equipment disconnecting means shall be permitted to be remote from the equipment where the equipment disconnecting means can be remotely operated from within 3 m (10 ft) of the equipment.

EXAM QUESTIONS

27. Where is a PV initiation device required to be installed for a two-family dwelling?

A. Readily accessible location inside the building
B. Accessible location outside the building
C. Readily accessible location outside the building
D. Accessible location inside the building

28. What areas when installing a PV system do not require a PV rapid shutdown?

A. Installed on a building
B. Ground mounted systems
C. Installed inside a building
D. All PV systems require a rapid shutdown to be installed

29. What is the function of a PV system rapid shutdown?

A. Eliminate voltage spikes
B. Eliminate open grounds
C. Reduce the shock hazard for emergency responders
D. Isolate ground faults

30. What is a Photovoltaic system operating at 120 volts dc between any two conductors required to be protected by?

A. Listed for PV systems bi-metal circuit interrupter controller
B. Listed PV ground fault circuit interrupter
C. Rated for PV systems solder pot overloads
D. Listed PV arc-fault circuit interrupter

31. True or False? The requirements for controlled conductors shall not apply to PV circuits supplied by the PV system.

A. True
B. False

32. What annex includes the reference for photovoltaic DC arc-fault circuit protection product standards?

A. A
B. B
C. E
D. F

33. What area does an array boundary encompass?

A. 1 ft from the array in all directions
B. 5 ft from the array in all directions
C. 1 ft from the array controller in all directions
D. 3 ft from the array module in all directions

34. How long can the input circuit conductors supplying inverters not listed for rapid shutdown remain energized after they are turned off?

A. Up to 5 minutes
B. Up to 10 minutes
C. Up to 15 minutes
D. Up to 8 minutes

35. What section are controlled conductors inside the array boundary required to comply with?

A. 690.12 (D)(3)
B. 690.12(B)(1)
C. 690.12 (D)
D. 690.12(B)(2)

36. What section requires PV equipment that performs the rapid shutdown functions to be listed?

A. 690.12(B)(1)
B. 690.12(D)
C. 690.12 (B)(2)
D. 690.12 (D)(3)

37. What is a PV initiation device required to do?

A. Initiate the open function of the PV system
B. Initiate the on function of the PV system
C. Initiate the rapid shutdown function of the PV system
D. All listed answers

38. What is a PV system disconnecting means required to be rated for?

A. The voltage that is available at the terminals
B. The short-circuit current
C. The maximum circuit current available
D. All listed answers

39. How is a photovoltaic disconnect required to be permanently marked?

A. PV Back fed SYSTEM DISCONNECT
B. DC SYSTEM DISCONNECT
C. PV SYSTEM DISCONNECT
D. No special requirement for marking

40. What can be installed to replace a PV system isolating device?

A. A resistor bank
B. A PV system disconnect
C. A capacitor bank
D. All listed answers

41. If the line and load terminals of a PV system may be energized in the open position, what section are the warning labels required to comply with?

A. 110.21(B)
B. 690.2
C. 310.15(B)
D. 690.12(D)

42. Within how many feet of PV system equipment is a PV system disconnect required to be mounted?

A. 8 ft.
B. 5 ft.
C. 10 ft.
D. 20 ft.

43. What is the maximum number of PV disconnects allowed in a single enclosure?

A. 7
B. 8
C. 6
D. No limit

44. What type of location is a photovoltaic disconnect required to be installed?

A. Accessible
B. Readily accessible
C. Marked
D. Fenced

(New) 690.15 (B) Interrupting Rating. An equipment disconnecting means shall have an interrupting rating sufficient for the maximum short-circuit current and voltage that is available at the terminals of the equipment. An isolating device shall not be required to have an interrupting rating.

(New) 690.15 (C) Isolating Device. An isolating device shall not be required to simultaneously disconnect all current-carrying conductors of a circuit. The isolating device shall be one of the following:

(1) A connector meeting the requirements of 690.33 and listed and identified for use with specific equipment
(2) A finger safe fuse holder
(3) An isolating switch that requires a tool to open
(4) An isolating device listed for the intended application An isolating device shall be rated to open the maximum circuit current under load or be marked "Do Not Disconnect Under Load" or "Not for Current Interrupting."

(New) 690.15 (D) Equipment Disconnecting Means. An equipment disconnecting means shall simultaneously disconnect all current carrying

conductors that are not solidly grounded of the circuit to which it is connected. An equipment disconnecting means shall be externally operable without exposing the operator to contact with energized parts, shall indicate whether in the open (off) or closed (on) position, and shall be lockable in accordance with 110.25. An equipment disconnecting means shall be one of the following devices:

(1) A manually operable switch or circuit breaker

(2) A connector meeting the requirements of 690.33(E)(1)

(3) A load break fused pull out switch

(4) A remote-controlled circuit breaker that is operable locally and opens automatically when control power is interrupted

For equipment disconnecting means, other than those complying with 690.33, where the line and load terminals can be energized in the open position, the device shall be marked in accordance with the warning in 690.13(B).

(Revised) 690.31 (B) Identification and Grouping. PV source circuits and PV output circuits shall not be contained in the same raceway, cable tray, cable, outlet box, junction box, or similar fitting as conductors, feeders, branch circuits of other non-PV systems, or inverter output circuits, unless the conductors of the different systems are separated by a partition. PV system circuit conductors shall be identified and grouped as required by 690.31(B)(1) through (2). The means of identification shall be permitted by separate color coding, marking tape, tagging, or other approved means.

(Revised) 690.31 (B)(1) Identification. PV system circuit conductors shall be identified at all accessible points of termination, connection, and splices.

The means of identification shall be permitted by separate color coding, marking tape, tagging, or other approved means. Only solidly grounded PV system circuit conductors, in accordance with 690.41(A)(5), shall be marked in accordance with 200.6.

(Revised): 690.31 Methods Permitted. (C)(2) Cable Tray. PV source circuits and PV output circuits using single-conductor cable listed and identified as photovoltaic (PV) wire of all sizes, with or without a cable tray marking/rating, shall be permitted in cable trays installed in outdoor locations, provided that the cables are supported at intervals not to exceed 300 mm (12 in.) and secured at intervals not to exceed 1.4 m (4 1/2 ft).

Informational Note: Photovoltaic wire and PV cable have a nonstandard outer diameter. Table 1 of Chapter 9 contains the allowable percent of cross section of conduit and tubing for conductors and cables.

EXAM QUESTIONS

45. What is a finger safe fuse holder considered with regards to a PV system?

A. A required device used on the negative terminal of the array

B. A banned device for use with a PV system

C. An isolating device

D. A required device used on the positive terminal of the charging system

46. At what interval is single-conductor cable listed and identified as photovoltaic (PV) wire installed in a cable tray required to be supported?

A. 12 inches

B. 14 inches

C. 24 inches

D. 26 inches

47. What type of PV disconnect does section 690.33(E)(1) reference?

A. A manually operable circuit breaker
B. A connector
C. A load break fused pull out switch
D. A remote-controlled circuit breaker

48. What is the maximum distance between supports that single conductor PV cable installed in a cable tray is required to be secured?

A. 3 ft.
B. 10 ft.
C. 24 inches
D. 4.5 ft.

49. Where are PV source circuits required to be identified?

A. Connections
B. Terminations
C. Splices
D. All listed answers

50. True or False? A PV isolating device is required to have an interrupting rating.

A. True
B. False

51. What type of outer diameter does photovoltaic wire and PV cable have?

A. Induction resistant
B. Standard
C. Nonstandard
D. Capacitive resistant

52. How are PV source circuits required to be identified?

A. Marking tape
B. Tagging
C. Separate color coding
D. All listed answers

53. What is a PV system isolating device required to be rated to do?

A. Have an equal interrupter rating as the overcurrent device
B. Open the maximum circuit voltage under load
C. Open the maximum circuit current under load
D. Handle the maximum instantaneous short circuit condition of the installed PV system

690.31 (G) Photovoltaic System Direct Current Circuits on or in a Building. Where PV system dc circuits run inside a building, they shall be contained in metal raceways, Type MC metal-clad cable that complies with 250.118(10), or metal enclosures from the point of penetration of the surface of the building to the first readily accessible disconnecting means. The disconnecting means shall comply with 690.13(B) and (C) and 690.15(A) and (B). The wiring methods shall comply with the additional installation requirements in 690.31(G)(1) through (4).

690.31 (G)(1) Embedded in Building Surfaces. Where circuits are embedded in built-up, laminate, or membrane roofing materials in roof areas not covered by PV modules and associated equipment, the location of circuits shall be clearly marked using a marking protocol that is approved as being suitable for continuous exposure to sunlight and weather

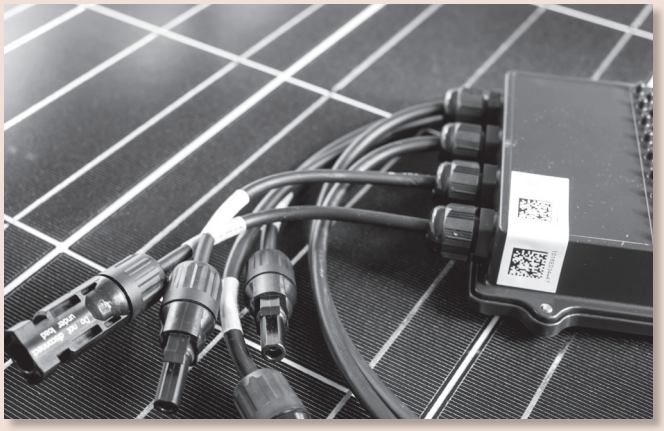
690.31 (G)(2) Flexible Wiring Methods. Where flexible wiring systems that contain photovoltaic dc systems. Where flexible metal conduit (FMC) smaller than metric designator 21 (trade size 3⁄4) or Type MC cable smaller than 25 mm (1 in.) in diameter containing PV power circuit conductors is installed across ceilings or floor joists, the raceway or cable shall be protected by substantial guard strips that are at least as high as the raceway or cable. Where run exposed, other than within 1.8 m (6 ft) of their connection to equipment, these wiring methods shall closely follow the building surface or be protected from physical damage by an approved means.

(Revised) 690.31(G)(3) Marking and Labeling Required. The following wiring methods and enclosures that contain PV system dc circuit conductors hall be marked with the wording "WARNING: PHOTOVOLTAIC POWER SOURCE" by means of permanently affixed labels or other approved permanent marking:

(1) Exposed raceways, cable trays, and other wiring methods

(2) Covers or enclosures of pull boxes and junction boxes

(3) Conduit bodies in which any of the available conduit openings are unused

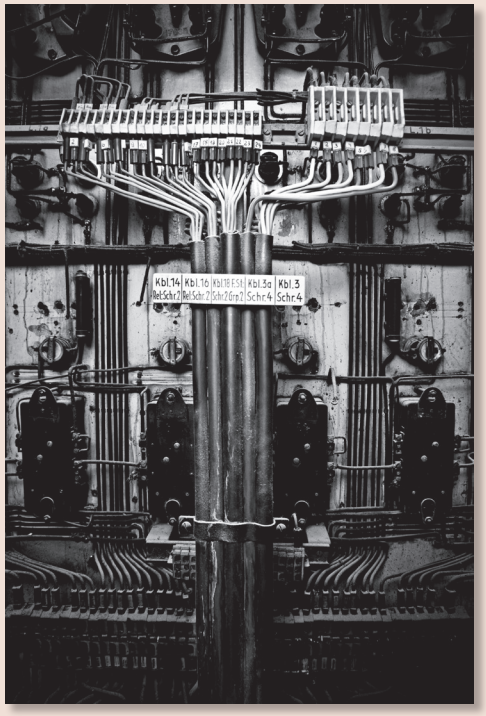


(Revised) 690.31 (G)(4) Marking and Labeling Methods and Locations. The labels or markings shall be visible after installation. The labels shall be reflective, and all letters shall be capitalized and shall be a minimum height of 9.5 mm (3⁄8 in.) in white on a red background. PV system dc circuit labels shall appear on every section of the wiring system that is separated by enclosures, walls, partitions, ceilings, or floors. Spacing between labels or markings, or between a label and a marking, shall not be more than 3 m (10 ft). Labels required by this section shall be suitable for the environment where they are installed.

690.32 Component Interconnections. Fittings and connectors that are intended to be concealed at the time of on-site assembly, where listed for such use, shall be permitted for on-site interconnection of modules or other array components. Such fittings and connectors shall be equal to the wiring method employed in insulation, temperature rise, and fault-current withstand, and shall be capable of resisting the effects of the environment in which they are used.

(Revised) 690.43 (B) Equipment Secured to Grounded Metal Supports. Devices listed, labeled, and identified for bonding and grounding the metal parts of PV systems shall be permitted to bond the equipment to grounded metal supports. Metallic support structures shall have identified bonding jumpers connected between separate metallic sections or shall be identified for equipment bonding and shall be connected to the equipment grounding conductor.

(Revised) 690.43 (C) With Circuit Conductors. Equipment grounding conductors for the PV array and support structure (where installed) shall be contained within the same raceway, cable, or otherwise run with the PV array circuit conductors when those circuit conductors leave the vicinity of the PV array.



EXAM QUESTIONS

54. What type of label(s) are you required to use for the identification of junction boxes that contain PV circuits?

A. Opaque
B. Listed
C. Permanent
D. Removable

55. What type of environment do outdoor PV system marking labels need to be rated for when installed on a building?

A. Exposure to precipitation
B. Exposure to weather
C. Exposure to sunlight
D. All listed answers

56. What type of raceway is required for PV system dc circuits run inside a building?

A. Metal raceways
B. Open Air
C. PVC schedule 40
D. PVC schedule 80

57. Within how many feet of PV equipment connections does a 3/4" diameter metal-clad cable installed across ceiling floor joists required to closely follow the building surface?

A. 10 feet
B. 6 feet
C. 5 feet
D. 3 feet

58. How are junction boxes that contain PV system conductors required to be marked?

A. WARNING: PHOTOVOLTAIC POWER
B. WARNING: PHOTOVOLTAIC POWER SOURCE
C. WARNING: PHOTOVOLTAIC SOURCE
D. WARNING: DC POWER SOURCE

59. What listed conductor enclosure or raceway is required to have a label if PV circuits are installed?

A. Pull boxes
B. Conduit bodies
C. Cable trays
D. All listed answers

60. A flexible metal conduit that has a 1/2" diameter and is installed across ceiling floor joists that contain PV conductors is required to be protected from damage by what approved method?

A. 3/8" mesh
B. 1/4" particle board
C. Mesh weave
D. Guard Strips

61. How are conduits or cable tray systems that contain circuits for PV systems required to be identified?

A. With paint
B. On their own conduit or tray rack
C. With a label
D. Rigidly attached to the structure with angle bracing at 5 foot intervals

62. What is the maximum distance PV system labels are to be installed from one another?

A. 5ft
B. 10ft
C. 8ft
D. 6ft

63. How are the letters used for a PV system warning label required to be presented on the label?

A. Red
B. Bold
C. Capitalized
D. All listed answers

64. Concealed fittings used to connect PV equipment must be capable of resisting what listed factor(s)?

A. Environment in which they are used
B. Voltage gradients
C. Hysteresis
D. All listed answers

65. What is the minimum letter height required for a PV label?

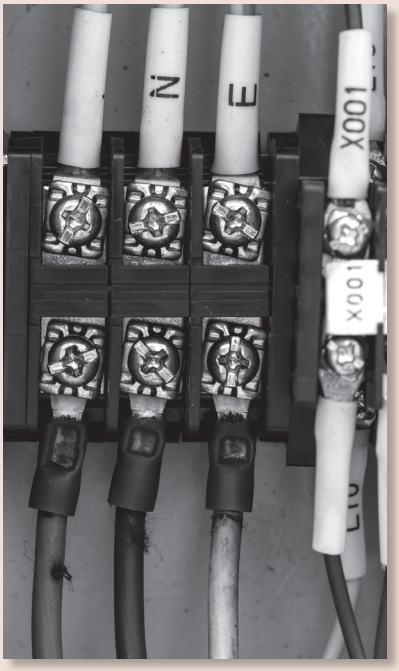
A. 3/16"
B. 1/8"
C. 1/4"
D. 3/8"

66. What type of material is a PV warning label required to be made of?

A. Stainless steel
B. Reflective
C. Non-corrosive
D. Bio degradable

(Revised) 690.45 Size of Equipment Grounding Conductors. Equipment grounding conductors for PV source and PV output circuits shall be sized in accordance with 250.122. Where no overcurrent protective device is used in the circuit, an assumed overcurrent device rated in accordance with 690.9(B) shall be used when applying Table 250.122. Increases in equipment grounding conductor size to address voltage drop considerations shall not be required. An equipment grounding conductor shall not be smaller than 14 AWG.

(Revised) 690.46 Array Equipment Grounding Conductors. For PV modules, equipment grounding conductors smaller than 6 AWG shall comply with 250.120(C).



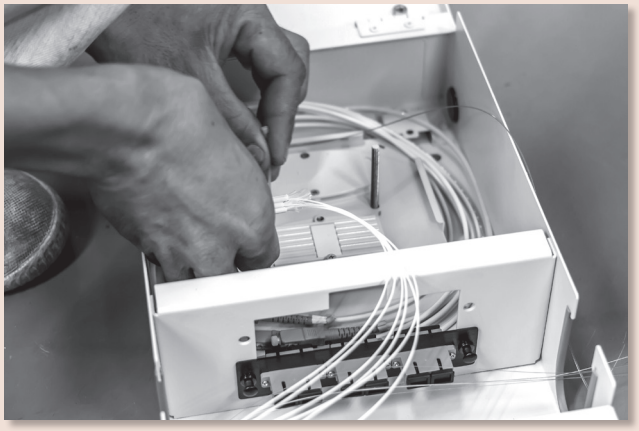
(Revised) 680.47(A) Buildings or Structures Supporting a PV Array. A building or structure supporting a PV array shall have a grounding electrode system installed in accordance with Part III of Article 250.

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.

(New) 680.47 (B) Additional Auxiliary Electrodes for Array Grounding. Grounding electrodes shall be permitted to be installed in accordance with 250.52 and 250.54 at the location of ground and roof-mounted PV arrays. The electrodes shall be permitted to be connected directly to the array frame(s) or structure. The grounding electrode conductor shall be sized according to 250.66. The structure of a ground-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.



EXAM QUESTIONS

67. What is the structure of a ground-mounted PV system array considered if meeting the requirements of 250.52?

A. Equipment grounding conductor
B. A grounding electrode
C. Intersystem bond
D. All listed answers

68. What section of Article 690 references where to size PV array equipment grounding conductors?

A. 690.45
B. 690.5
C. 690.41
D. 690.3

69. What is the smallest equipment grounding conductor allowed by Article 690?

A. 12 AWG
B. 10 AWG
C. 14 AWG
D. 1/0

70. A building that supports a PV array is required to have its grounding electrode system installed in accordance with what part of Article 250?

A. Part II
B. Part III
C. Part VII
D. Part VI

71. What table is required to be used to size a PV output circuit equipment grounding conductor?

A. 250.66
B. 250.120(C)
C. 690.5
D. 250.122

72. True or False? PV system grounding electrodes are not permitted to be connected directly to the PV system array frame(s).

A. True
B. False

73. What section of Article 250 is used to size the grounded conductor for solidly grounded PV systems?

A. 250.166
B. 250.122
C. 250.66
D. 250.120(C)

74. What section of Article 250 is used to determine the installation requirements for PV system grounding electrodes?

A. 250.52 and 250.54
B. 250.122
C. 250.66
D. 250.120(C)

75. What part of Article 250 must be followed when connecting PV array equipment grounding conductors to the grounding electrode system of their supporting building?

A. Part II
B. Part III
C. Part VII
D. Part VI

76. What section is used to size the grounding electrode conductor for a PV system?

A. 250.166
B. 250.122
C. 250.66
D. 250.120(C)

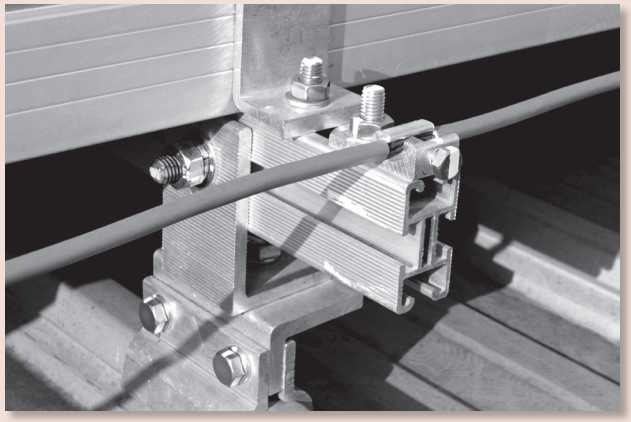
77. An array equipment grounding conductor for PV modules smaller than 6 AWG must follow the requirements of what section?

A. 250.66
B. 250.120(C)
C. 690.5
D. 250.122

690.50 Equipment Bonding Jumpers. Equipment bonding jumpers, if used, shall comply with 250.120(C).

690.51 Modules. Modules shall be marked with identification of terminals or leads as to polarity, maximum overcurrent device rating for module protection, and with the following ratings:

(1) Open-circuit voltage
(2) Operating voltage
(3) Maximum permissible system voltage
(4) Operating current
(5) Short-circuit current
(6) Maximum power



690.52 Alternating-Current Photovoltaic Modules. Alternating-current modules shall be marked with identification of terminals or leads and with identification of the following ratings:

(1) Nominal operating ac voltage
(2) Nominal operating ac frequency

(3) Maximum ac power

(4) Maximum ac current

(5) Maximum overcurrent device rating for ac module protection

(Revised) 690.53 Direct-Current Photovoltaic Power Source. A permanent label for the dc PV power source indicating the information specified in (1) through (3) shall be provided by the installer at dc PV system disconnecting means and at each dc equipment disconnecting means required by 690.15. Where a disconnecting means has more than one dc PV power source, the values in 690.53(1) through (3) shall be specified for each source.

(1) Maximum voltage

Informational Note to (1): See 690.7 for voltage.

(2) Maximum circuit current

Informational Note to (2): See 690.8(A) for calculation of maximum circuit current.

(3) Maximum rated output current of the charge controller or dc-to-dc converter (if installed)

690.54 Interactive System Point of Interconnection. All interactive system(s) points of interconnection with other sources shall be marked at an accessible location at the disconnecting means as a power source and with the rated ac output current and the nominal operating ac voltage.

(Revised) 690.55 Photovoltaic Systems Connected to Energy Storage Systems. The PV system output circuit conductors shall be marked to indicate the polarity where connected to energy storage systems.

(Revised) 690.56 (A) Facilities with Stand-Alone Systems. Any structure or building with a photovoltaic 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. The plaque or directory shall indicate the location of system disconnecting means and that the structure contains a stand-alone electrical power system.

(Revised) 690.56 (B) Facilities with Utility Services and Photovoltaic Systems. Plaques or directories shall be installed in accordance with 705.10.

(Revised) 690.56 (C)(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.

(Revised) 690.56 (C)(3) Rapid Shutdown Switch. A rapid shutdown switch shall have a label located on or no more than 1 m (3 ft) from the switch that includes the following wording:

RAPID SHUTDOWN SWITCH FOR SOLAR PV SYSTEM

The label shall be reflective, with all letters capitalized and having a minimum height of 9.5 mm (3⁄8 in.), in white on red background.

(Revised) 690.71 General. An energy storage system connected to a PV system shall be installed in accordance with Article 706.

(New) 690.72 Self-Regulated PV Charge Control. The PV source circuit shall be considered to comply with the requirements of 706.23 if:

(1) The PV source circuit is matched to the voltage rating and charge current requirements of the interconnected battery cells, and

(2) The maximum charging current multiplied by 1 hour is less than 3 percent of the rated battery capacity expressed in ampere-hours or as recommended by the battery manufacturer

EXAM QUESTIONS

78. How many provisions must be met for a PV source circuit to be considered complying with the requirements of 706.23?

A. 1
B. 2
C. 3
D. 4

79. What is the required background color for a rapid shutdown switch label?

A. Orange
B. Yellow
C. Red
D. White

80. What alternating-current module ratings are NOT required to be marked at each terminal?

A. Maximum ac capacitive reactance
B. Nominal operating ac frequency
C. Maximum ac current
D. Maximum overcurrent device rating for ac module protection

81. What article must be referenced when installing an energy storage system connected to a PV system?

A. 691
B. 705.10
C. 250
D. 706

82. What section determines how to calculate the maximum PV source circuit current?

A. 690.7
B. 690.8(A)
C. 690.15
D. 250.120(C)

83. What are PV system output circuit conductors required to be marked with where connected to energy storage systems?

A. Capacitive reactance
B. Frequency
C. Polarity
D. Maximum over current protection

84. What is the label for a rapid shut down switch required to say?

A. PV SYSTEM RAPID SHUTDOWN SWITCH
B. RAPID SHUTDOWN SWITCH
C. SOLAR PV SYSTEM RAPID SHUTDOWN SWITCH
D. RAPID SHUTDOWN SWITCH FOR SOLAR PV SYSTEM

85. What PV module ratings are NOT required to be marked at each terminal?

A. Instantaneous short-circuit current
B. Maximum power
C. Short-circuit current
D. Maximum permissible system voltage

86. What section are plaques installed at facilities with utility services and photovoltaic systems required to comply with?

A. 706
B. 705.10
C. 250
D. 691

87. In general, where is a stand-alone PV system not connected to a utility service required to have its permanent directory installed?

A. No such requirement for a stand-alone PV system
B. In the interior of the structure
C. At the meter base
D. On the exterior of the structure

88. What is the dotted line on the diagram required to indicate for buildings that have PV systems with both rapid shutdown types installed?

A. Where the modules are physically located
B. The areas that are de-energized after the rapid shutdown switch is operated
C. The areas that remain energized after the rapid shutdown switch is operated
D. Where the solar array is located

89. What is the maximum distance from a rapid shutdown switch that the required label can be installed?

A. 18 inches
B. 3 ft.
C. 2 ft.
D. 6 ft.

90. What is the required letter color for a rapid shutdown switch label?

A. Red
B. Yellow
C. Orange
D. White