



National Fire Protection Association

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WORKING DRAFT OF NEC[®] CODE MAKING **PANEL 4 MEETING OUTPUT**

**CONTENT NOT FINAL –SUBJECT TO REVISION
PRIOR TO LETTER BALLOT AND PUBLICATION OF
SECOND DRAFT REPORT**

Document: National Electrical Code[®]

Revision Cycle: A2019

Meeting Dates: October 29 – November 3, 2018

Committee Activity: Comment Stage

This is a working draft, prepared by NFPA staff, to record the output generated at the Code-Making Panels Second Draft Meetings. It includes draft copies of the Second Revisions and any Global Revisions.

It is being made available to Committee members for the purpose of facilitating early review, particularly for those Committee members who may be seeking input from their respective organizations in preparation for the Letter Ballot of the Committee.

**Second Revision No. 8149-NFPA 70-2018 [Global Comment]**

Add new lead paragraph to 690.31(C) Cables

Type PV wire or cable, and Type Distributed Generation (DG) cable shall be listed.

Informational Note: See UL 4703 for PV wire and UL 3003 for DG cable.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Wed Oct 31 16:43:19 EDT 2018

Committee Statement

Committee Statement: This revision provides a specific requirement that both PV wire or cable, and DG cable must be listed. The informational note points the user to the relevant product standards.

Response Message: SR-8149-NFPA 70-2018

[Public Comment No. 526-NFPA 70-2018 \[New Part after I.\]](#)

**Second Revision No. 8198-NFPA 70-2018 [Global Comment]**

In Article 705, move the following as indicated:

1. "Part IV. Microgrid Systems." to "Part II. Microgrid Systems."
2. Section 705.150 to 705.50.
3. Section 705.160 to 705.60.
4. Section 705.165 to 705.65.
5. Section 705.170 to 705.70.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Thu Nov 01 17:16:56 EDT 2018

Committee Statement

Committee Statement: The Part and Section numbering is updated as a result of the reorganization at first draft.

Response Message: SR-8198-NFPA 70-2018

[Public Comment No. 2188-NFPA 70-2018 \[Section No. 705.150\]](#)

**Second Revision No. 8118-NFPA 70-2018 [Detail]**

Add the following to 694.2:

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

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Tue Oct 30 19:18:34 EDT 2018

Committee Statement

Committee Statement: The added sentence defines the application of 694.2, Definitions.

Response Message: SR-8118-NFPA 70-2018

[Public Comment No. 2123-NFPA 70-2018 \[Section No. 694.2\]](#)

[Public Comment No. 1169-NFPA 70-2018 \[Section No. 694.2\]](#)

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**Second Revision No. 8206-NFPA 70-2018 [Detail]**

Insert the following sentence in 710.2:

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

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Thu Nov 01 17:54:14 EDT 2018

Committee Statement

Committee Statement: A new sentence has been added to clarify that definitions within 710.2 apply only within Article 710.

Response Message: SR-8206-NFPA 70-2018

[Public Comment No. 1179-NFPA 70-2018 \[Section No. 710.2\]](#)

[Public Comment No. 2125-NFPA 70-2018 \[Section No. 710.2\]](#)

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**Second Revision No. 7862-NFPA 70-2018 [Definition: Generating Capacity, Inverter.]**100**Generating Capacity, Inverter.**

The sum of parallel-connected inverter maximum continuous output power at 40°C in watts or kilowatts.
(CMP-4)

Submitter Information Verification**Committee:** NEC-P04**Submittal Date:** Mon Oct 29 11:42:29 EDT 2018**Committee Statement**

Committee Statement: The words "watts or" are added before kilowatts to allow for this term to be used for items less than one kilowatt.

Response Message: SR-7862-NFPA 70-2018

Public Comment No. 710-NFPA 70-2018 [Definition: Generating Capacity, Inverter.]

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**Second Revision No. 7867-NFPA 70-2018 [Definition: Multimode Inverter.]**100**Inverter, Multimode- Inverter .**

Equipment having the capabilities of both the interactive inverter and the stand-alone inverter. (CMP-4)

Submitter Information Verification**Committee:** NEC-P04**Submittal Date:** Mon Oct 29 11:52:04 EDT 2018**Committee Statement****Committee Statement:** This aligns the definition with other parallel definitions in Article 100 for ease of reference to keep it near the basic definition of inverters in Article 100.**Response Message:** SR-7867-NFPA 70-2018Public Comment No. 714-NFPA 70-2018 [Definition: Multimode Inverter.]FOR CODE-MAKING PANEL USE ONLY
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**Second Revision No. 8125-NFPA 70-2018 [Definition: Power Production Equipment.]****100. Power Production Equipment.**

~~The Electrical generating source and all associated distribution equipment to the source disconnecting means that generates electricity from a source equipment supplied by any source other than a utility supplied service service, up to the source system disconnecting means . (CMP-4)~~

Informational Note: Examples of power production equipment include such items as generators, solar photovoltaic systems, and fuel cell systems.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Wed Oct 31 11:28:02 EDT 2018

Committee Statement

Committee Statement: This revised language clarifies the demarcation point between power production equipment and other equipment such as utility sources and distribution equipment for loads.

Response Message: SR-8125-NFPA 70-2018

Public Comment No. 1774-NFPA 70-2018 [Definition: Power Production Equipment.]

**Second Revision No. 8218-NFPA 70-2018 [Definition: Stand-Alone System.]****100. Stand-Alone System.**

A system that is capable of supplying power independent of an electric power production and distribution network.(CMP-4)

~~Informational Note: Though stand-alone systems are capable of operating independent of a utility supply they may include a connection to a utility supply for use when not operating in stand-alone mode.~~

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Thu Nov 01 18:39:30 EDT 2018

Committee Statement

Committee Statement: The informational note is removed to eliminate language that could be perceived as being permissive or confusing.

Response Message: SR-8218-NFPA 70-2018

Public Comment No. 306-NFPA 70-2018 [Definition: Stand-Alone System.]

Public Comment No. 1214-NFPA 70-2018 [Definition: Stand-Alone System.]



Second Revision No. 8243-NFPA 70-2018 [Section No. 690.1]

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690.1 Scope.

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This article applies to solar PV systems, other than those covered by Article 691, including the array circuit(s), inverter(s), and controller(s) for such systems. The systems covered by this article include those interactive with other electric power production sources or stand-alone, or both. These PV systems may have ac or dc output for utilization.

Informational Note No. 1: See Informational Note Figure 690.1(a) and Informational Note Figure 690.1(b).

Informational Note No.2: Article 691 covers the installation of large-scale PV electric supply stations.

Figure Informational Note Figure 690.1(a) Identification of PV Power Source Components.
[REVISE FIGURE PER ATTACHED]

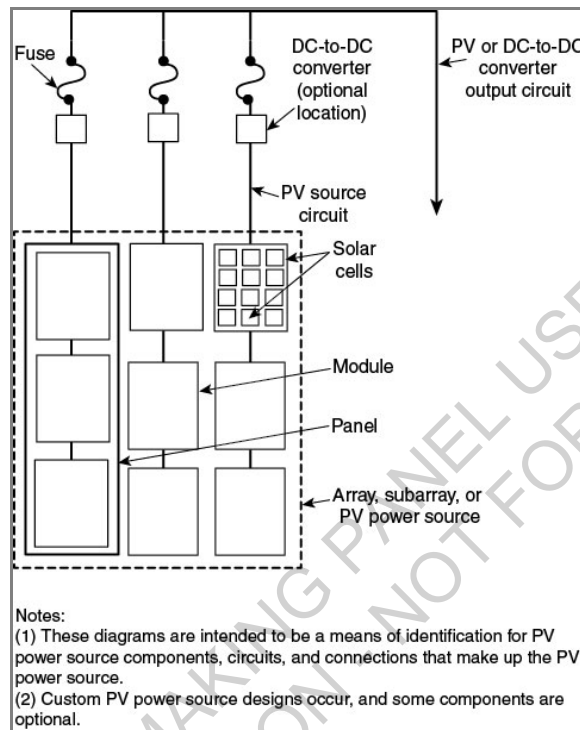
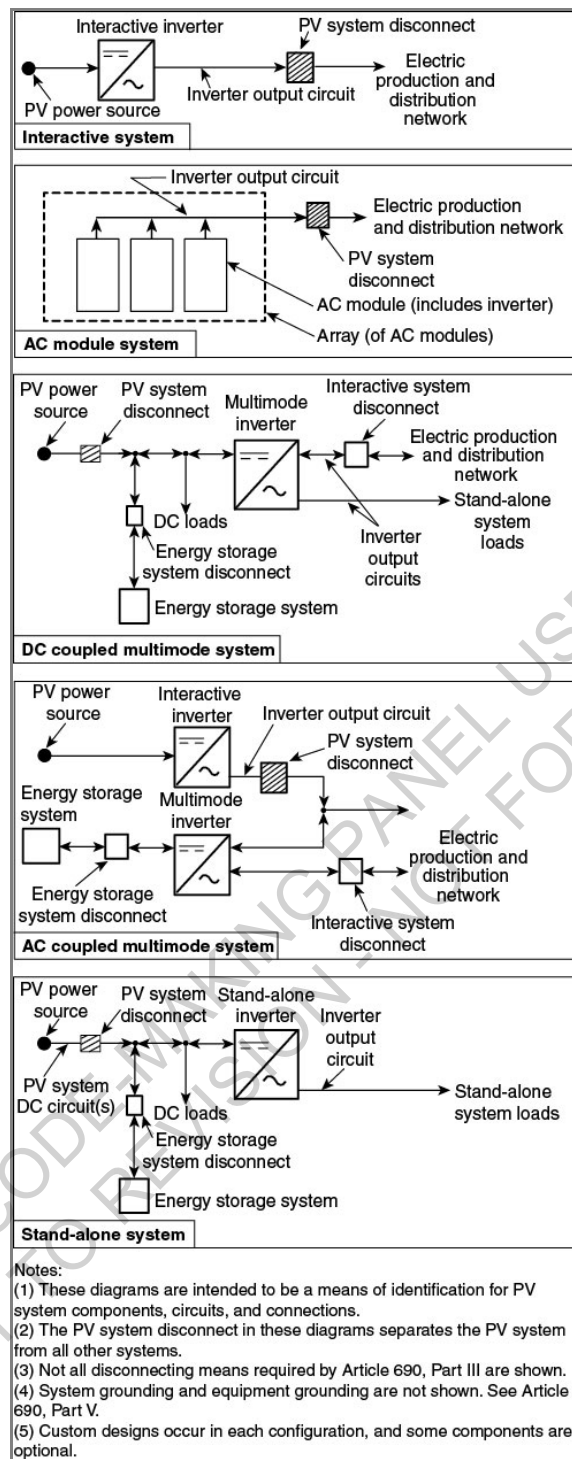


Figure Informational Note Figure 690.1(b) Identification of PV System Components in Common Configurations. **[REVISE FIGURE PER ATTACHED]**



Supplemental Information

File Name	Description Approved
70_CMP04_SR8243_INFig690.1_a_-_b_.pdf	
70_CMP04_SR8243_INFig690.1_a_-_b_.pdf	

Submitter Information Verification

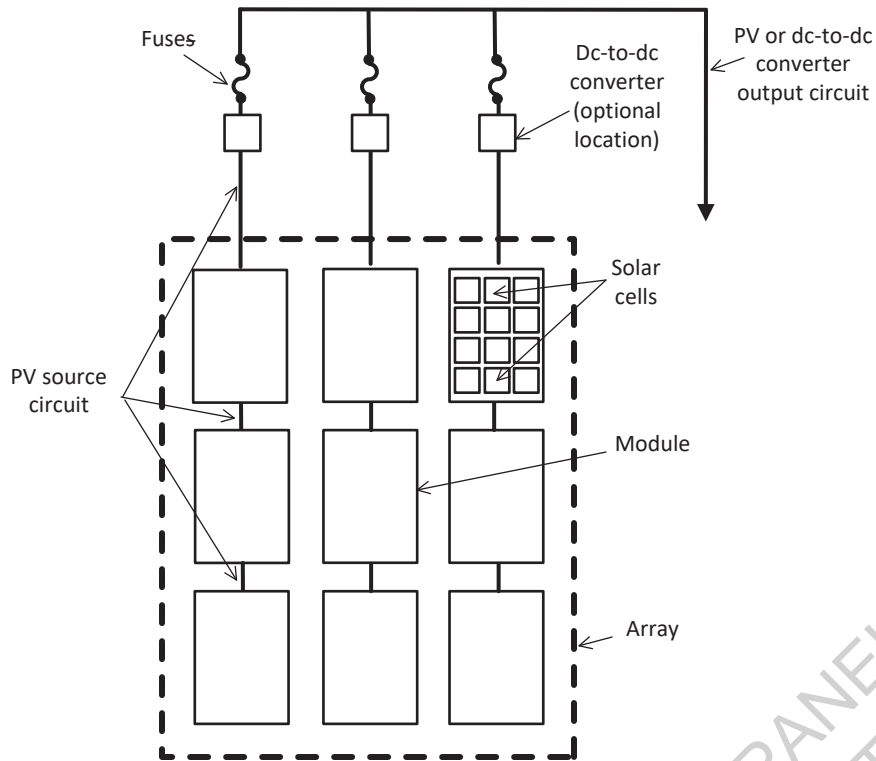
Committee: NEC-P04
Submittal Date: Fri Nov 02 11:16:01 EDT 2018

Committee Statement

Committee Statement: The informational note figures were supposed to be revised on First Revision 8568, but the revisions were not implemented in the draft. This revision enacts those changes.

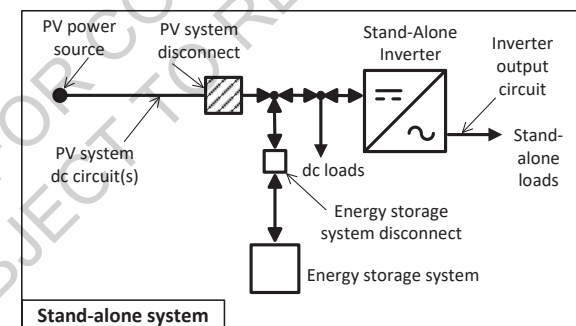
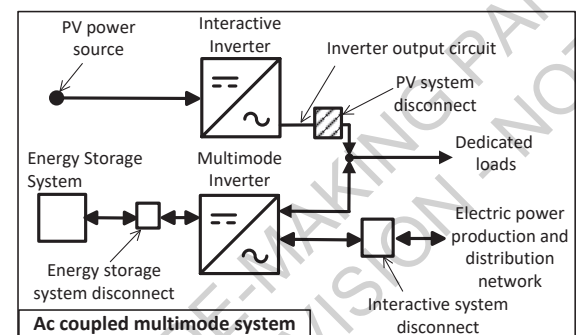
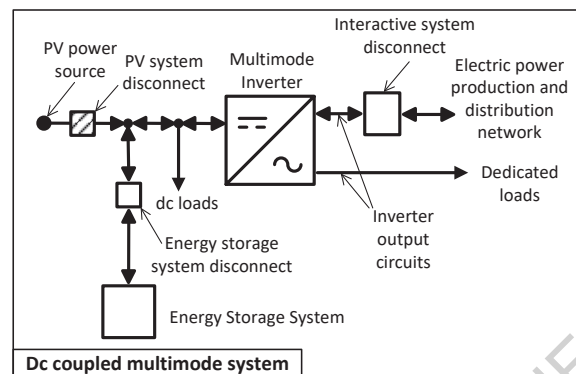
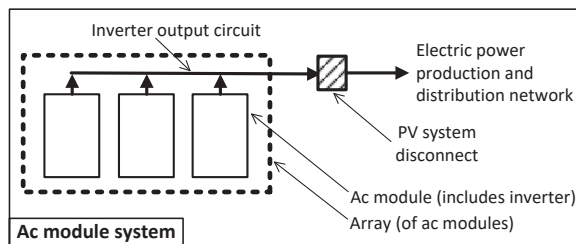
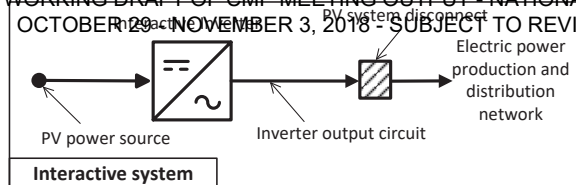
Response Message: SR-8243-NFPA 70-2018

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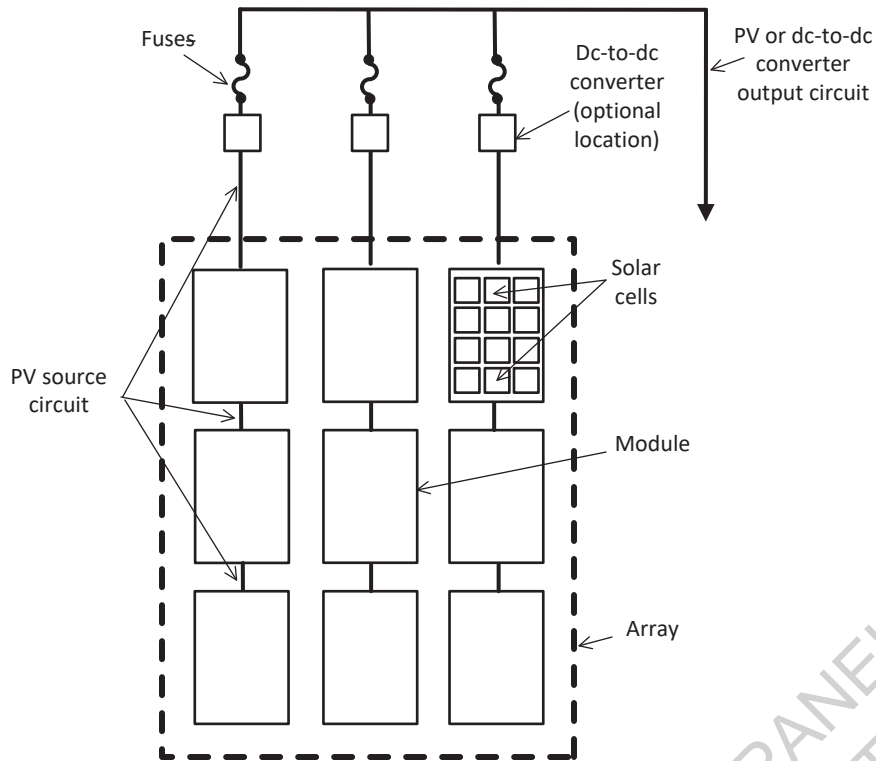
- 1) These diagrams are intended to be a means of identification for PV power source components, circuits, and connections that make up the PV power source.
- 2) Custom PV power source designs occur, and some components are optional.

Figure 690.1(a) Identification of PV Power Source Components



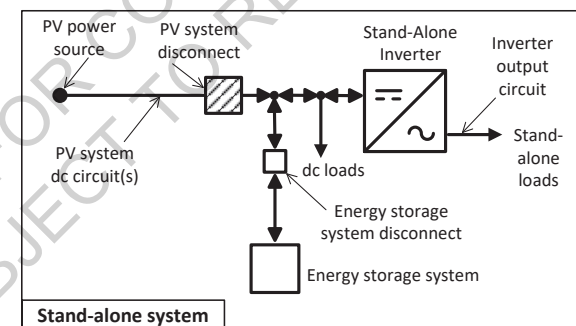
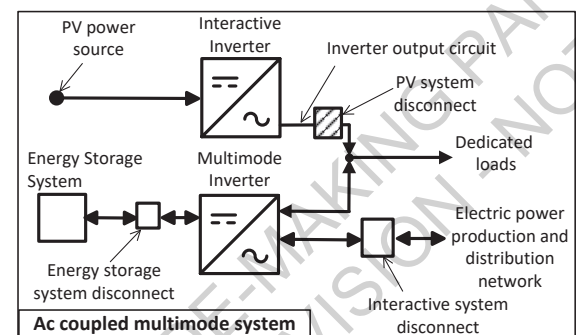
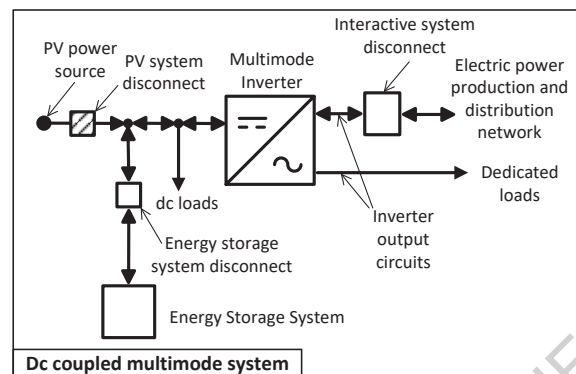
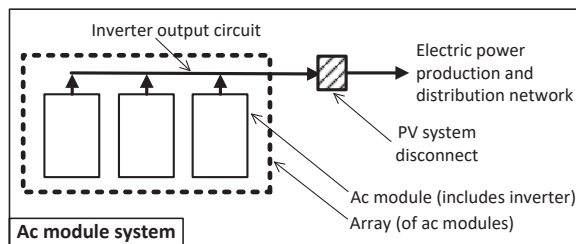
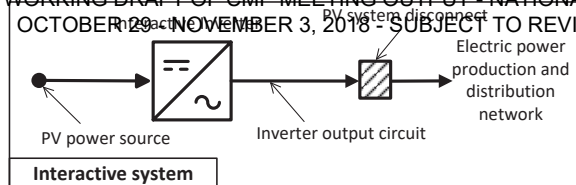
- (1) These diagrams are intended to be a means of identification for PV system components, circuits, and connections.
- (2) The PV system disconnect in these diagrams separates the PV system from all other systems.
- (3) Not all disconnecting means required by Article 690, Part III, are shown.
- (4) System grounding and equipment grounding are not shown. See Article 690, Part V
- (5) Custom designs occur in each configuration, and some components are optional.

Figure 690.1(b) Identification of PV System Components in Common Configurations.



- 1) These diagrams are intended to be a means of identification for PV power source components, circuits, and connections that make up the PV power source.
- 2) Custom PV power source designs occur, and some components are optional.

Figure 690.1(a) Identification of PV Power Source Components



- (1) These diagrams are intended to be a means of identification for PV system components, circuits, and connections.
- (2) The PV system disconnect in these diagrams separates the PV system from all other systems.
- (3) Not all disconnecting means required by Article 690, Part III, are shown.
- (4) System grounding and equipment grounding are not shown. See Article 690, Part V
- (5) Custom designs occur in each configuration, and some components are optional.

Figure 690.1(b) Identification of PV System Components in Common Configurations.

**Second Revision No. 7876-NFPA 70-2018 [Definition: AC Module System.]**690.2**AC Module System.**

An assembly of ac modules ~~that is engineered, field-assembled, and field-installed using subassemblies and wiring methods supplied as a listed system by a singular entity that are matched and intended to be assembled as defined in the installation instructions , wiring methods, materials and subassemblies that are evaluated, identified and defined as a system .~~

Submitter Information Verification**Committee:** NEC-P04**Submittal Date:** Mon Oct 29 12:18:47 EDT 2018**Committee Statement**

Committee Statement: The definition was edited for clarity. The original text referred to "an assembly of ac modules" in the first sentence, but an AC module system includes wiring, materials and other sub-assemblies. Putting these terms in the first sentence clarifies the definition. The information about a "singular entity" is removed as it may be confusing for the AHJ who may see multiple listing labels on equipment versus the system listing that also may come from more than one entity. Installation instructions are covered well in 110.3(B) and the second sentence language related to installation instruction could be viewed as putting a requirement in a definition.

Response Message: SR-7876-NFPA 70-2018

Public Comment No. 1978-NFPA 70-2018 [Definition: AC Module System.]



Second Revision No. 7873-NFPA 70-2018 [Definition: Alternating-Current (ac) Module (Alternating-Cu...]

690.2

Alternating-Current (ac) Module (Alternating-Current Photovoltaic Module).

A complete, environmentally protected unit consisting of solar cells, inverter, and other components, designed to ~~generate~~ produce ac power.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Mon Oct 29 12:11:11 EDT 2018

Committee Statement

Committee Statement: This substitutes the term "produce" for "generate" for clarity.

Response Message: SR-7873-NFPA 70-2018

Public Comment No. 262-NFPA 70-2018 [Definition: Alternating-Current (ac) Module (Alternating-Cu...]

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**Second Revision No. 7885-NFPA 70-2018 [Definition: Bipolar Circuits.]**690.2**Bipolar Circuits Circuit .**

A dc circuit that is comprised of two monopole ~~subarray~~-circuits, each having an opposite polarity connected to a common reference point.

Submitter Information Verification**Committee:** NEC-P04**Submittal Date:** Mon Oct 29 12:53:26 EDT 2018**Committee Statement**

Committee Statement: This revision is related to the SR-7903 to remove the term "subarray" from the definition of "monopole subarray circuit". The definition for "subarray" was removed in the First Revision. Removing this term from this definition does not change the meaning and will improve the application of the Code. The removal of the "s" and the addition of "an" is for editorial purposes.

Response Message: SR-7885-NFPA 70-2018

Public Comment No. 1559-NFPA 70-2018 [Definition: Bipolar Circuits.]



Second Revision No. 7887-NFPA 70-2018 [Definition: DC-to-DC Converter Output Circuit.]

690.2

DC-to-DC Converter Output Circuit.

The dc circuit conductors ~~between~~ connected to the output of a dc combiner for dc -to-dc converter source circuit(s) and the inverter or the dc PV system disconnecting means circuits .

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Mon Oct 29 13:03:46 EDT 2018

Committee Statement

Committee Statement: This aligns the definition with the changes to PV output circuits and further differentiates this definition from the definition of dc-to-dc converter source circuit.

Response Message: SR-7887-NFPA 70-2018

Public Comment No. 1553-NFPA 70-2018 [Definition: DC-to-DC Converter Output Circuit.]

**Second Revision No. 7892-NFPA 70-2018 [Definition: Direct-Current (dc) Combiner.]**

690.2

Direct-Current (dc) Combiner.

~~A device-~~ An enclosure that includes devices used to connect two or more dc PV system dc circuits in parallel, ~~providing one or more dc circuit output(s) .~~

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Mon Oct 29 13:14:01 EDT 2018

Committee Statement

Committee Statement: The revision clarifies that a combiner is an enclosure that includes the devices for paralleling circuits. The previous language could be used to claim that a wire nut was a dc combiner. This also deletes the final phrase from the definition as the output is not relevant to this definition.

Response Message: SR-7892-NFPA 70-2018

Public Comment No. 1178-NFPA 70-2018 [Definition: Direct-Current (dc) Combiner.]

Public Comment No. 165-NFPA 70-2018 [Definition: Direct-Current (dc) Combiner.]

**Second Revision No. 7893-NFPA 70-2018 [Definition: Electronic Power Converter.]**690.2**Electronic Power Converter.**

A device that uses power electronics to convert one form of electrical power into another form of electrical power. ~~These devices have limited current capabilities based on the device ratings at continuous rated power.~~

Informational Note: Examples of electronic power converters include, but are not limited to, inverters, dc-to-dc converters, and electronic charge controllers. These devices have limited current capabilities based on the device ratings at continuous rated power.

Submitter Information Verification**Committee:** NEC-P04**Submittal Date:** Mon Oct 29 13:17:04 EDT 2018**Committee Statement**

Committee Statement: This revision moves the second sentence of the definition into the informational note. The second sentence was informational.

Response Message: SR-7893-NFPA 70-2018

Public Comment No. 1180-NFPA 70-2018 [Definition: Electronic Power Converter.]

Public Comment No. 186-NFPA 70-2018 [Definition: Electronic Power Converter.]

Public Comment No. 429-NFPA 70-2018 [Definition: Electronic Power Converter.]

**Second Revision No. 8127-NFPA 70-2018 [Definition: Grounded, Functionally.]**690.2**Grounded, Functionally.**

A system that has an electrical ground reference for operational purposes that is not solidly grounded.

Informational Note: A functionally grounded system is often connected to ground through an electronic means internal to an inverter or charge controller that provides ground-fault protection. Examples of operational ~~reasons~~ purposes for functionally grounded systems include ground-fault detection and performance-related issues for some power sources.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Wed Oct 31 11:32:18 EDT 2018

Committee Statement

Committee Statement: The language was edited to clarify that most functionally grounded systems are grounded inside the inverter or charge controller. The note also clarifies the operational purposes for functionally grounding a system.

Response Message: SR-8127-NFPA 70-2018

Public Comment No. 167-NFPA 70-2018 [Definition: Grounded, Functionally.]

**Second Revision No. 7902-NFPA 70-2018 [Definition: Module.]**690.2**Module.**

A complete, environmentally protected unit consisting of solar cells and other components designed to ~~generate~~ produce dc power.

Submitter Information Verification**Committee:** NEC-P04**Submittal Date:** Mon Oct 29 13:57:32 EDT 2018**Committee Statement****Committee Statement:** The word generate is replaced with "produce" for clarity.**Response Message:** SR-7902-NFPA 70-2018Public Comment No. 712-NFPA 70-2018 [Definition: Module.]

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**Second Revision No. 7903-NFPA 70-2018 [Definition: Monopole Subarray Circuit.]**690.2**Monopole Subarray Circuit.**

An electrical subset of a PV system that has two conductors in the output circuit, one positive (+) and one negative (-).

Submitter Information Verification**Committee:** NEC-P04**Submittal Date:** Mon Oct 29 14:04:29 EDT 2018**Committee Statement****Committee Statement:** The term "subarray" is removed from the title for consistency with action on SR-7885.**Response Message:** SR-7903-NFPA 70-2018Public Comment No. 1555-NFPA 70-2018 [Definition: Monopole Subarray Circuit.]

**Second Revision No. 7910-NFPA 70-2018 [Definition: Photovoltaic Output Circuit.]**

Photovoltaic- 690.2

PV Output Circuit.

The dc circuit conductors from ~~the output of dc combiners connected to other equipment~~ two or more connected PV source circuits to their point of termination .

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Mon Oct 29 14:18:15 EDT 2018

Committee Statement

Committee Statement: The revised definition provides both the beginning point and ending point of the PV output circuit.

Response Message: SR-7910-NFPA 70-2018

Public Comment No. 718-NFPA 70-2018 [Definition: Photovoltaic Output Circuit.]

Public Comment No. 2149-NFPA 70-2018 [Definition: Photovoltaic Output Circuit.]

**Second Revision No. 7920-NFPA 70-2018 [Definition: Photovoltaic Power Source.]**

Photovoltaic Power Source 690 .

An array or aggregate of arrays that generates dc power.

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Submitter Information Verification

Committee: NEC-P04

Submittal Date: Mon Oct 29 16:01:18 EDT 2018

Committee Statement

Committee Statement: The term is generally self-explanatory and no longer commonly used with the revisions to Article 690. It may be insufficient to properly describe a PV system. It also could be confused with the use of the term Power Source in Article 705.

Response Message: SR-7920-NFPA 70-2018

Public Comment No. 721-NFPA 70-2018 [Definition: Photovoltaic Power Source.]

**Second Revision No. 8129-NFPA 70-2018 [Definition: Photovoltaic Source Circuit.]****Photovoltaic- 690.2, PV Source Circuit.**

The dc circuit conductors between modules and from modules to dc combiners, electronic power converters, or the a dc PV system disconnecting means.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Wed Oct 31 12:19:54 EDT 2018

Committee Statement

Committee Statement: The revision changes the term to "PV Source Circuit" to align with the use of the term throughout the Article. The change from "the" to "a" is to make the definition more general.

Response Message: SR-8129-NFPA 70-2018

Public Comment No. 716-NFPA 70-2018 [Definition: Photovoltaic Source Circuit.]

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**Second Revision No. 8130-NFPA 70-2018 [Definition: Photovoltaic System DC Circuit.]**

~~Photovoltaic- 690.2~~

PV System DC Circuit.

Any dc conductor of a PV system, including PV in PV source circuits, PV output circuits, dc-to-dc converter source circuits, and dc-to-dc converter output circuits.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Wed Oct 31 12:25:25 EDT 2018

Committee Statement

Committee Statement: The revision restricts the defined term to only these four circuits. The defined term revised to be consistent with its use throughout the article.

Response Message: SR-8130-NFPA 70-2018

Public Comment No. 722-NFPA 70-2018 [Definition: Photovoltaic System DC Circuit.]

**Second Revision No. 8144-NFPA 70-2018 [Section No. 690.4(B)]****(B) Equipment.**

Inverters, motor generators, PV modules, ac modules and ac module systems, dc combiners, dc-to-dc converters, rapid shutdown equipment, dc circuit controllers, and charge controllers intended for use in PV systems shall be listed or ~~field-labeled-~~ be evaluated for the application and have a field label applied .

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Wed Oct 31 15:44:28 EDT 2018

Committee Statement

Committee Statement: Stating that equipment has a field evaluation does not guarantee that a field label is applied. NFPA 791 includes a recommendation for a label to be applied but does not mandate it as quoted below. The process of applying a field label for field evaluated equipment is extremely important for AHJs.

"8.1 Label application after all identified issues have been fully resolved, all electrical testing has been satisfactorily completed, and the evaluation has determined that the equipment meets the applicable requirements of the standard(s), a label should be affixed to the equipment."

Response Message: SR-8144-NFPA 70-2018

Public Comment No. 1490-NFPA 70-2018 [Section No. 690.4(B)]

**Second Revision No. 7930-NFPA 70-2018 [Section No. 690.6(A)]****(A) Photovoltaic Source Circuits.**

The requirements of Article 690 pertaining to PV source circuits shall not apply to ac modules or ac module systems. The PV source circuit, conductors, and inverters shall be considered as internal components of an ac module or ac module system. ~~The PV source circuit, conductors, and inverters shall be considered as internal wiring of an ac module.~~

Submitter Information Verification**Committee:** NEC-P04**Submittal Date:** Mon Oct 29 16:32:35 EDT 2018**Committee Statement****Committee Statement:** The last sentence was mistakenly not removed in the first draft and is removed.**Response Message:** SR-7930-NFPA 70-2018[Public Comment No. 26-NFPA 70-2018 \[Section No. 690.6\(A\)\]](#)[Public Comment No. 1025-NFPA 70-2018 \[Section No. 690.6\(A\)\]](#)

**Second Revision No. 7921-NFPA 70-2018 [Section No. 690.6(C)]****~~(C) Flexible Harnesses and Cables.~~**

~~Flexible wiring harnesses and cables in ac module and ac module systems shall be installed in accordance with the instructions included with the listed or labeled equipment. Where not otherwise specified in their instructions, they shall be installed in accordance with the following:~~

- ~~(1) Where not protected by raceways they shall be limited to rooftop locations~~
- ~~(2) Shall closely follow the surface(s) to which they are adjacent~~
- ~~(3) Shall be protected from physical damage where necessary~~
- ~~(4) Shall be secured or supported, at a minimum, every 1.4 m (4 ¹/₂ ft) and within 300 mm (12 in.) of every connector. Sections of cords or cables protected from physical protection by raceways shall not be required to be secured within the raceway~~

~~Exception: Larger support spacings are permitted as defined elsewhere in this Code for the specific wiring method.~~

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Mon Oct 29 16:12:38 EDT 2018

Committee Statement

Committee Statement: Section 690.6(C) is deleted. The relevant items in 690.6(C) are included in 690.31(C) including the text that incorporates wording related to direct burial cables.

Response Message: SR-7921-NFPA 70-2018 The term physical protection is changed to physical damage in 690.31(C).

[Public Comment No. 1568-NFPA 70-2018 \[Section No. 690.6\(C\)\]](#)

[Public Comment No. 431-NFPA 70-2018 \[Section No. 690.6\(C\)\]](#)

[Public Comment No. 1728-NFPA 70-2018 \[Section No. 690.6\(C\)\]](#)

[Public Comment No. 1182-NFPA 70-2018 \[Section No. 690.6\]](#)

[Public Comment No. 1985-NFPA 70-2018 \[Section No. 690.6\]](#)



Second Revision No. 7944-NFPA 70-2018 [Section No. 690.7(A)]

(A) Photovoltaic Source and Output Circuits.

In a dc PV source circuit or output circuit, the maximum PV system voltage for that circuit shall be calculated in accordance with one of the following methods:

Informational Note: One source for lowest-expected, ambient temperature design data for various locations is the chapter titled Extreme Annual Mean Minimum Design Dry Bulb Temperature found in the *ASHRAE Handbook — Fundamentals*, - 2013 - 2017 . These temperature data can be used to calculate maximum voltage.

- (1) ~~Module instructions:~~ The sum of the PV module-rated open-circuit voltage of the series-connected modules corrected for the lowest expected ambient temperature using the open-circuit voltage temperature coefficients in accordance with the instructions included in the listing or labeling of the module.
- (2) ~~Table for crystalline and multicrystalline modules:~~ For crystalline and multicrystalline silicon modules, the sum of the PV module-rated open-circuit voltage of the series-connected modules corrected for the lowest expected ambient temperature using the correction factor ~~factors~~ provided in Table 690.7(A).
- (3) ~~Engineered industry standard method:~~ For PV systems with an inverter generating capacity of 100 kW or greater, a documented and stamped PV system design, using an industry standard method and maximum voltage calculation provided by a licensed professional electrical engineer, ~~shall be permitted~~ .

Informational Note: One industry standard method for calculating maximum voltage of a PV system is published by Sandia National Laboratories, reference SAND 2004-3535, *Photovoltaic Array Performance Model*.

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

<u>Correction Factors for Ambient Temperatures Below 25°C (77°F). (Multiply the rated open-circuit voltage by the appropriate correction factor shown below.)</u>		
<u>Ambient Temperature (°C)</u>	<u>Factor</u>	<u>Ambient Temperature (°F)</u>
24 to 20	1.02	76 to 68
19 to 15	1.04	67 to 59
14 to 10	1.06	58 to 50
9 to 5	1.08	49 to 41
4 to 0	1.10	40 to 32
-1 to -5	1.12	31 to 23
-6 to -10	1.14	22 to 14
-11 to -15	1.16	13 to 5
-16 to -20	1.18	4 to -4
-21 to -25	1.20	-5 to -13
-26 to -30	1.21	-14 to -22
-31 to -35	1.23	-23 to -31
-36 to -40	1.25	-32 to -40

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Mon Oct 29 17:17:52 EDT 2018

Committee Statement

Committee The reference to the ASHRAE Handbook was updated to the current edition.

Statement:

This action is consistent with 2.1.5.1. of the NEC Style Manual and no titles are allowed. An “s” was missing from correction factor as this table has more than one factor. Item 3 is edited to better match the format of items 1 and 2. It is not necessary to say that item 3 is permitted since it is one of three items that are permitted.

**Response
Message:**

SR-7944-NFPA 70-2018

[Public Comment No. 430-NFPA 70-2018 \[Section No. 690.7\(A\)\]](#)

[Public Comment No. 1183-NFPA 70-2018 \[Section No. 690.7\(A\)\]](#)

FOR CODE-MAKING PANEL USE ONLY
SUBJECT TO REVISION - NOT FOR PUBLICATION



Second Revision No. 8132-NFPA 70-2018 [Section No. 690.7 [Excluding any Sub-Sections]]

The maximum voltage of PV system dc circuits shall be the highest ~~calculated~~ voltage between any two ~~conductors of a circuit conductors~~ or any ~~circuit~~ conductor and ground. The maximum voltage shall be used to determine the voltage and voltage to ground of circuits in the application of this Code. Maximum voltage shall be used for conductors, cables, equipment, working space, and other applications where voltage limits and ratings are used.

PV system dc circuits on or in ~~one- and two-family dwellings buildings~~ shall be permitted to have a maximum voltage no greater than 1000 volts. ~~PV source and output system dc~~ circuits on or in one- and two-family dwellings shall be permitted to have a maximum voltage no greater than 600 volts. Where not located on or in buildings, listed dc PV equipment, rated at a maximum voltage no greater than 1500 volts, shall not be required to comply with Parts II and III of Article 490.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Wed Oct 31 12:47:11 EDT 2018

Committee Statement

Committee Statement: Additional editorial changes are made to the first paragraph for clarity. This revision essentially returns the language to that of the 2017 edition. Buildings are permitted with systems no greater than 1000V and one- and two-family dwellings to no greater than 600V.

Response Message: SR-8132-NFPA 70-2018

[Public Comment No. 1401-NFPA 70-2018 \[Section No. 690.7 \[Excluding any Sub-Sections\]\]](#)

[Public Comment No. 1394-NFPA 70-2018 \[Section No. 690.7 \[Excluding any Sub-Sections\]\]](#)

[Public Comment No. 1569-NFPA 70-2018 \[Section No. 690.7 \[Excluding any Sub-Sections\]\]](#)

[Public Comment No. 1536-NFPA 70-2018 \[Section No. 690.7 \[Excluding any Sub-Sections\]\]](#)

[Public Comment No. 2177-NFPA 70-2018 \[Section No. 690.7 \[Excluding any Sub-Sections\]\]](#)

[Public Comment No. 1371-NFPA 70-2018 \[Section No. 690.7 \[Excluding any Sub-Sections\]\]](#)

[Public Comment No. 1748-NFPA 70-2018 \[Section No. 690.7 \[Excluding any Sub-Sections\]\]](#)



Second Revision No. 8133-NFPA 70-2018 [Section No. 690.8(A)]

(A) Calculation of Maximum Circuit Current.

The maximum current for the specific circuit shall be calculated in accordance with one of the methods in 690.8(A)(1) through or (A)(6) 2).

(1) Photovoltaic Source Circuit Currents PV System Circuits .

The maximum current shall be

as

calculated in accordance with 690.8(A)(1)(

1), or where meeting the associated restrictions, as permitted in accordance with either 690.8

a) through (A)(1) (

2

e)

or 690

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8

(

A)(2)

a) Photovoltaic Source Circuit Currents .

The sum of parallel-connected PV module-rated short-circuit currents multiplied by 125 percent maximum current shall be as calculated in either of the following:

- (1) The maximum current shall be the sum of the short-circuit current ratings of the PV modules connected in parallel multiplied by 125 percent.
- (2) For PV systems with an inverter generating capacity of 100 kW or greater, a documented and stamped PV system design, using an industry standard method and maximum current calculation 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 a) .

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.

(

~~2) Currents of Circuits Connected to the Input of Electronic Power Converters.~~

The maximum current for a PV system dc circuit connected to the input of an electronic power converter shall be permitted to be the lesser of the rated input current of the converter, or the current as calculated in 690.8(A)(1) and (A)(3). Where the rated input current of the converter is not provided in the manufacturer's instructions, the rated input current shall be the current at the lowest input voltage in which the device converts continuous rated output power.

Where multiple PV system dc circuits are connected to a single electronic power converter input, the maximum current per circuit shall be the rated input current of the converter divided by the number of circuits connected to the input.

~~(3)~~~~b) Photovoltaic Output Circuit Currents.~~

The maximum current shall be the sum of parallel source circuit maximum currents as calculated in 690.8(A)(1)

or

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A

a)

(2)

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{

4

~~c)~~~~Inverter Output Circuit Current.~~

The maximum current shall be the inverter continuous output current rating.

~~(5)~~~~DC-to-DC Converter Source Circuit Current.~~

The maximum current shall be the dc-to-dc converter continuous output current rating.

{

6

~~d) DC-to-DC Converter Output Circuit Current.~~

The maximum current shall be the sum of parallel connected dc-to-dc converter source circuit currents as calculated in 690.8(A)(

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4)

or

{

A

~~e) -~~

{

5

~~e) Inverter Output Circuit Current.~~

The maximum current shall be the inverter maximum continuous output current rating.

~~(2) Circuits Connected to the Input of Electronic Power Converters.~~

Where a circuit is protected with an overcurrent device not exceeding the conductor ampacity, the maximum current shall be permitted to be the rated input current of the electronic power converter input to which it is connected.

Supplemental Information

<u>File Name</u>	<u>Description</u> <u>Approved</u>
70_CMP04_SR8133_690.8_A_.docx	for staff use

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Wed Oct 31 13:08:14 EDT 2018

Committee Statement

Committee Statement: This SR rectifies the style manual issues with the list in 690.8(A)(1). Small editorial changes are made in the now 690.8(A)(1)(a)(1) to make it a sentence and with (2) to align with edits in 690.7(A)(3). The SR also provides a reorganization of section 690.8(A) to improve the understanding of the section. Inverter Output Circuit Current, is moved to 690.8(A)(1)(e) to come after all the PV system dc circuit items. Section 690.8(A)(2) includes clarifying language to require an overcurrent device in accordance with 240.4(B) to address the allowance to round up to the next standard size. The second paragraph of the original 690.8(A)(2) is deleted.

Response Message: SR-8133-NFPA 70-2018

[Public Comment No. 1753-NFPA 70-2018 \[Section No. 690.8\(A\)\(2\)\]](#)

[Public Comment No. 611-NFPA 70-2018 \[Section No. 690.8\(A\)\(3\)\]](#)

[Public Comment No. 171-NFPA 70-2018 \[Section No. 690.8\(A\)\(2\)\]](#)

[Public Comment No. 1184-NFPA 70-2018 \[Section No. 690.8\(A\)\(1\)\]](#)

[Public Comment No. 173-NFPA 70-2018 \[Section No. 690.8\(A\)\]](#)

[Public Comment No. 1574-NFPA 70-2018 \[Section No. 690.8\(A\)\(2\)\]](#)

[Public Comment No. 432-NFPA 70-2018 \[Section No. 690.8\(A\)\(1\)\]](#)



Second Revision No. 7949-NFPA 70-2018 [Section No. 690.8(B) [Excluding any Sub-Sections]]

Circuit conductors shall be sized to carry not less than the ~~larger of~~ larger ampacity calculated in accordance with 690.8(B)(1) or (B)(2).

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Mon Oct 29 17:30:43 EDT 2018

Committee Statement

Committee Statement: The added language provides clarity for the application of this requirement.

Response Message: SR-7949-NFPA 70-2018

Public Comment No. 1754-NFPA 70-2018 [Section No. 690.8(B) [Excluding any Sub-Sections]]

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SUBJECT TO REVISION - NOT FOR PUBLICATION

**Second Revision No. 7952-NFPA 70-2018 [Section No. 690.9(A)(1)]****(1) Circuits Where Overcurrent Protection Not Required.**

Overcurrent protective devices shall not be required where both of the following conditions are met:

- (1) The ~~circuits~~ conductors have sufficient ampacity for the maximum circuit current.
- (2) The currents from all sources do not exceed the maximum overcurrent protective device rating specified for the PV module or electronic power converter.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Mon Oct 29 17:36:43 EDT 2018

Committee Statement

Committee Statement: The editorial change to 690.9(A)(1) to improves clarity for applying this section.

Response Message: SR-7952-NFPA 70-2018 Circuit currents are continuous by definition and it is not necessary to restate this.

Public Comment No. 1573-NFPA 70-2018 [Section No. 690.9(A)(1)]

**Second Revision No. 7959-NFPA 70-2018 [Section No. 690.9(A)(2)]****(2) Circuits Connected to Source of Overcurrent Where Overcurrent Protection is Required on One End.**

~~Circuits connected to~~ A circuit conductor connected at one end to a current-limited supplies (e.g., PV modules, electronic power converters, interactive inverter output circuits) supply, where the conductor is rated for the maximum circuit current from that supply, and also connected to sources having higher current availability (e.g., parallel strings of modules, utility power), that are a source of overcurrent, shall be protected at the higher current source connection an available maximum circuit current greater than the ampacity of the conductor, shall be protected from overcurrent at the point of connection to the higher current source.

Informational Note: Photovoltaic system dc circuits and electronic power converter outputs powered by these circuits are current-limited circuits and may in some cases do not need overcurrent protection. ~~When connected in parallel~~ Where these circuits are connected to higher current sources, such as parallel-connected PV system dc circuits, ~~batteries energy storage systems, or backfeed from inverters a utility service~~, the overcurrent device is often installed at the higher current source end of the circuit conductor.

Submitter Information Verification**Committee:** NEC-P04**Submittal Date:** Mon Oct 29 17:53:19 EDT 2018**Committee Statement**

Committee Statement: This section is revised for clarity. This rewritten section removes the parenthetical language from the text and places similar language in the informational note. The title is changed to more accurately differentiate this item from (1) and (3).

Response Message: SR-7959-NFPA 70-2018

[Public Comment No. 1756-NFPA 70-2018 \[Section No. 690.9\(A\)\(2\)\]](#)

[Public Comment No. 433-NFPA 70-2018 \[Section No. 690.9\(A\)\(2\)\]](#)

[Public Comment No. 475-NFPA 70-2018 \[Section No. 690.9\(A\)\(2\)\]](#)

[Public Comment No. 1187-NFPA 70-2018 \[Section No. 690.9\(A\)\]](#)

**Second Revision No. 7966-NFPA 70-2018 [Section No. 690.9(A)(3)]****(3) ~~Circuits Connected to Sources of Overcurrent on Both Ends~~ Other Circuits .**

Circuits that do not comply with 690.9(A)(1) or (A)(2) ~~and with sources of overcurrent on both ends of a conductor~~ shall be protected with one of the following methods:

- (1) ~~Conductors~~ conductors not greater than 3 m (10 ft) in length and not in buildings, protected from overcurrent on one end

Conductors

- (2) conductors not greater than 3 m (10 ft) in length and in buildings, protected from overcurrent on one end and in a raceway or metal clad cable
- (3) conductors protected from overcurrent on both ends
- (4) ~~Conductors~~ conductors not installed on or in buildings are permitted to be protected from overcurrent on one end of the circuit where the circuit complies with all of the following conditions:
- The conductors are installed in metal raceways or metal-clad cables, or installed in enclosed metal cable trays, or underground, or where directly entering pad-mounted enclosures.
 - The conductors for each circuit terminate on one end at a single circuit breaker or a single set of fuses that limit the current to the ampacity of the conductors.
 - The overcurrent device for the conductors is an integral part of a disconnecting means or shall be located within 3 m (10 ft) of conductor length of the disconnecting means.
 - The disconnecting means for the conductors is installed outside of a building, or at a readily accessible location nearest the point of entrance of the conductors inside of a building, including installations complying with 230.6.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Mon Oct 29 18:10:06 EDT 2018

Committee Statement

Committee Statement: The title of the section is changed to simply "other circuits" to capture all remaining options covered under this section. Item (1) adds the words "and not in buildings" to further limit when a conductor of no greater than 10' can be protected from overcurrent on one end. Item (2) permits conductors of 10' or less in buildings in raceway or metal clad cable in buildings which is similar to the requirement in 240.21.

Response Message: SR-7966-NFPA 70-2018

Public Comment No. 476-NFPA 70-2018 [Section No. 690.9(A)(3)]



Second Revision No. 7951-NFPA 70-2018 [Section No. 690.9(A) [Excluding any Sub-Sections]]

PV system dc circuit and inverter output conductors and equipment shall be protected against overcurrent. Circuits sized in accordance with 690.8(A)(2) are required to be protected against overcurrent with overcurrent protective devices. Each circuit shall be protected from overcurrent in accordance with 690.9(A)(1), (A)(2), or (A)(3).

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Mon Oct 29 17:34:27 EDT 2018

Committee Statement

Committee Statement: The word "be" was missing from the second sentence of 690.9(A).

Response Message: SR-7951-NFPA 70-2018

Public Comment No. 1571-NFPA 70-2018 [Section No. 690.9(A) [Excluding any Sub-Sections]]

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**Second Revision No. 7981-NFPA 70-2018 [Section No. 690.9(B)]****(B) Device Ratings.**

Overcurrent devices used in PV system dc circuits shall be listed for use in PV systems. Electronic devices that are listed to prevent backfeed current in PV system dc circuits shall be permitted to prevent overcurrent of conductors on the PV array side of the device. Overcurrent devices, where required, shall be rated in accordance with one of the following (1) or (2) below and permitted to be rounded up to the next higher standard size in accordance with 240.4(B) :

- (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) ~~Where a PV system dc circuit is connected to the input of an electronic power converter and the ampacity of the conductor is less than the current calculated in 690.8(A)(1) , the conductor shall be protected with an overcurrent protective device rated or set not greater than the ampacity of the conductor. Conductor lengths of 3 m (10 ft) or less are permitted to be protected with a single overcurrent device located on one end of the conductor.~~

Informational Note: ~~Some electronic protective devices prevent backfeed current, which may be in some cases is~~ the only source of overcurrent in ~~some~~ PV system dc circuits.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Mon Oct 29 18:42:18 EDT 2018

Committee Statement

Committee Statement: This revision removes 690.9(B)(3) as it is repetitive with the new 690.8(A)(5) and 690.9(A). The reference to rounding up to standard device ratings is added for clarity. The informational note is edited for clarity and to comply with the style manual.

Response Message: SR-7981-NFPA 70-2018 RESPONSE TO PC 427: This section is about device ratings under the overcurrent protection Section 690.9 so there is no need to repeat the term "overcurrent protection" in the heading.

[Public Comment No. 434-NFPA 70-2018 \[Section No. 690.9\(B\)\]](#)

[Public Comment No. 1584-NFPA 70-2018 \[Section No. 690.9\(B\)\]](#)

[Public Comment No. 1189-NFPA 70-2018 \[Section No. 690.9\(B\)\]](#)

[Public Comment No. 481-NFPA 70-2018 \[Section No. 690.9\(B\)\]](#)

[Public Comment No. 427-NFPA 70-2018 \[Section No. 690.9\(B\)\]](#)

**Second Revision No. 7989-NFPA 70-2018 [Section No. 690.11]****690.11 Arc-Fault Circuit Protection (Direct Current).**

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

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

Exception: For PV systems not installed on or in buildings, PV output circuits and dc-to-dc converter output circuits that are installed in metallic raceways or metal-clad cables, or installed in enclosed metallic cable trays, or are underground ~~are~~ shall be permitted without arc-fault circuit protection. Detached structures whose sole purpose is to house PV system equipment shall not be considered buildings according to this exception.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Mon Oct 29 19:03:30 EDT 2018

Committee Statement

Committee Statement: The words "with PV system dc circuits" is added to the first sentence to clarify that it is dc circuits that are operating at 80 volts dc or greater, not the PV system. The word "are" is replaced with "shall be" in the exception to comply with the NEC Style Manual.

Response Message: SR-7989-NFPA 70-2018

[Public Comment No. 435-NFPA 70-2018 \[Section No. 690.11\]](#)

[Public Comment No. 483-NFPA 70-2018 \[Section No. 690.11\]](#)

[Public Comment No. 1190-NFPA 70-2018 \[Section No. 690.11\]](#)

**Second Revision No. 7998-NFPA 70-2018 [Section No. 690.12(A)]****(A) Controlled Conductors.**

Requirements for controlled conductors shall apply to the following:

- (1) PV system dc circuits
- (2) Inverter output circuits originating from inverters located within the array boundary

Informational Note: The rapid shutdown function reduces the risk of electrical shock that dc circuits in a PV system could pose for fire fighters. The ac output conductors from PV systems that include inverters will either be de-energized after shutdown initiation or will remain energized by other sources such as a utility service. To prevent PV arrays with attached inverters from having energized ac conductors within the PV array(s), those circuits are also specifically controlled after shutdown initiation.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Mon Oct 29 19:17:24 EDT 2018

Committee Statement

Committee Statement: An informational note, based on FR-8242 and associated public inputs, has been added to help users of the Code better understand the reasoning for controlling inverter output circuits from inverters located within the array boundary. The term "emergency responders" has been changed to "fire fighters" to be consistent with SR-7994.

Response Message: SR-7998-NFPA 70-2018

Public Comment No. 2081-NFPA 70-2018 [Section No. 690.12(A)]

**Second Revision No. 8025-NFPA 70-2018 [Section No. 690.12(B)(2)]**

(2) Inside the Array Boundary.

The PV system shall comply with one of the following:

Provide shock hazard control for emergency responders through the use of a

(1) A PV hazard control

means

system listed for the purpose

The hazard control components

shall be installed

and used

in accordance with the instructions included with the listing or field labeling. Where a hazard control system requires initiation to transition to a controlled state, the rapid shutdown initiation device required in 690.12(C) shall perform this initiation.

Informational Note: A listed or field-labeled PV hazard control system

may be

is typically comprised of either an individual piece of equipment that fulfills the necessary functions, or multiple pieces of equipment coordinated to perform the functions as described in the installation instructions to reduce the risk of electric shock hazard within a damaged PV array for fire fighters. See UL3741 Photovoltaic Hazard Control.

(2) Controlled conductors located inside the boundary shall be limited to not more than 80 volts within 30 seconds of rapid shutdown initiation. Voltage shall be measured between any two conductors and between any conductor and ground.

(3) PV arrays

with

shall have no exposed wiring methods, no exposed conductive parts, and be installed more than 2.

5 m

5 m (

8 ft

8 ft) from exposed grounded conductive parts or ground

shall not be required to comply with 690

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12(B)(2).

Supplemental Information**File Name**

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Description Approved

for staff use

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Tue Oct 30 11:50:34 EDT 2018

Committee Statement

Committee Statement: The first sentence of 690.12(B)(2)(1) has been rewritten to better comply with the NEC Style Manual and clarify the mandatory requirement to meet this subsection. The term "emergency responders" is removed since the first sentence of 690.12 addresses the purpose of 690.12 as a whole. A new sentence has been added to clarify that where initiation is required, the same initiation device in (C)

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will perform this function, and not an additional device or action. A reference to UL 3741 has been added to the informational note to guide users of the Code to this new standard. The informational note has been changed to remove language that may be perceived as setting permissive requirements.

This second revision makes minor edits to items 690.12(B)(2)(2) and 690.12(B)(2)(3) to support existing products and products currently in development. The last phrase of 690.12(B)(2)(3) is removed to prevent misinterpretation of the option. The UL3741 standard is far along in the development process and is enhancing the understanding of fire fighter shock hazards in PV systems. The future publication of the UL3741 standard will make it possible to reevaluate items 690.12(B)(2)(2) and 690.12(B)(2)(3).

Response SR-8025-NFPA 70-2018
Message:

[Public Comment No. 1403-NFPA 70-2018 \[Section No. 690.12\(B\)\(2\)\]](#)

[Public Comment No. 1592-NFPA 70-2018 \[Section No. 690.12\(B\)\]](#)

[Public Comment No. 2152-NFPA 70-2018 \[Section No. 690.12\(B\)\(2\)\]](#)

[Public Comment No. 1735-NFPA 70-2018 \[Section No. 690.12\(B\)\(2\)\]](#)

[Public Comment No. 1192-NFPA 70-2018 \[Section No. 690.12\(B\)\(2\)\]](#)

[Public Comment No. 436-NFPA 70-2018 \[Section No. 690.12\(B\)\(2\)\]](#)

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**Second Revision No. 8005-NFPA 70-2018 [Section No. 690.12(C)]****(C) Initiation Device.**

The initiation device(s) shall initiate the rapid shutdown function of the PV system. The device's "off" position shall indicate that the rapid shutdown function has been initiated for all PV systems connected to that device. For one-family and two-family dwellings ~~or their detached garages, and associated storage buildings,~~ an initiation device(s) shall be located at a readily accessible exterior location ~~on~~ outside the building ~~to which the PV array is attached.~~

~~The~~ For a single PV system, the rapid shutdown initiation shall occur by the operation of any single initiation device. Device(s) shall consist of at least one or more 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~~ Examples of why ~~where~~ an initiation device that complies with 690.12(C)(3) would be used is where a PV system is connected to an optional standby system ~~that remains energized upon loss of utility voltage or stand-alone system.~~

Where multiple PV systems are installed with rapid shutdown functions on a single service, the initiation device(s) shall consist of not more than six switches or six sets of circuit breakers, or a combination of not more than six switches and sets of circuit breakers, mounted in a single enclosure, or in a group of separate enclosures. These initiation device(s) shall initiate the rapid shutdown of all PV systems with rapid shutdown functions on that service. ~~Where auxiliary initiation devices are installed, these auxiliary devices shall control all PV systems with rapid shutdown functions on that service.~~

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Mon Oct 29 19:30:19 EDT 2018

Committee Statement

Committee Statement: The new language added to this section during the first revision that addressed the location of rapid shutdown initiation devices on outbuildings has been deleted since there are multiple potential PV system configurations that would result in confusion by installers and enforcers in how to apply this requirement. The CMP-4 has reverted this sentence to the previous language for the 2017 Code. Since there is a requirement to group all rapid shutdown initiation devices on a service, a Code conflict could exist where multiple PV arrays are attached to different buildings at a premises. Grouping all initiation devices for a service is the most practical method of setting clear requirements and is consistent with the input this committee has received from fire service representatives who train fire fighters.

New language has been added to address the case where more than one initiation device is used on a single PV system. Where such a condition exists one of those devices shall be of the type located in list items 690.12(C)(1) through (3). Additionally, any other devices shall initiate rapid shutdown on that system. This is to clarify that any rapid shutdown initiation cannot require the operation of more than one initiation device, but more than one initiation device are permitted to be installed. The reference to auxiliary device language has been struck as it could be perceived as conflicting with the second revision changes and referred to undefined types of devices.

An editorial change has been made to the informational note to further clarify the types of systems that might often use the type of initiation device indicated in list item (3).

Response Message: SR-8005-NFPA 70-2018

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[Public Comment No. 1488-NFPA 70-2018 \[Section No. 690.12\(C\)\]](#)

[Public Comment No. 1971-NFPA 70-2018 \[Section No. 690.12\(C\)\]](#)

[Public Comment No. 1732-NFPA 70-2018 \[Section No. 690.12\(C\)\]](#)

[Public Comment No. 1396-NFPA 70-2018 \[Section No. 690.12\(C\)\]](#)

[Public Comment No. 1677-NFPA 70-2018 \[Section No. 690.12\(C\)\]](#)

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Second Revision No. 7994-NFPA 70-2018 [Section No. 690.12 [Excluding any Sub-Sections]]

PV system circuits installed on or in buildings shall include a rapid shutdown function to reduce shock hazard for ~~emergency responders~~ fire fighters, in accordance with 690.12(A) through (D).

Exception: Ground mounted PV system circuits that enter buildings, of which the sole purpose is to house PV system equipment, shall not be required to comply with 690.12.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Mon Oct 29 19:11:30 EDT 2018

Committee Statement

Committee Statement: This term more accurately describes the personnel that this section is serving as there are other first responders such as police, utility workers that are not the focus of 690.12.

Response Message: SR-7994-NFPA 70-2018

Public Comment No. 484-NFPA 70-2018 [Section No. 690.12 [Excluding any Sub-Sections]]

**Second Revision No. 8033-NFPA 70-2018 [Section No. 690.13(E)]****(E) Type of Disconnect.**

The PV system disconnecting means shall simultaneously disconnect the PV system conductors that are not solidly grounded from all conductors of other wiring systems. The PV system disconnecting means or its remote operating device or the enclosure providing access to the disconnecting means shall be capable of being locked in accordance with 110.25. The PV system disconnecting means shall be one of the following:

- (1) A manually operable switch or circuit breaker
- (2) A connector meeting the requirements of 690.33(E D)(1) or (D)(3)
- (3) A pull-out switch with the required interrupting rating
- (4) A remote-controlled switch or circuit breaker that is operable locally and opens automatically when control power is interrupted
- (5) A device listed or approved for the intended application

Informational Note: Circuit breakers marked "line" and "load" may not be suitable for backfeed or reverse current.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Tue Oct 30 12:30:27 EDT 2018

Committee Statement

Committee Statement: Lockability requirements of 110.25 are included with language similar to 690.15. This language provides locking methods relevant to residential panelboards and adds the option of a connector listed with the equipment in 690.33(D)(3).

Response Message: SR-8033-NFPA 70-2018

[Public Comment No. 1404-NFPA 70-2018 \[Section No. 690.13\(E\)\]](#)

[Public Comment No. 1585-NFPA 70-2018 \[Section No. 690.13\(E\)\]](#)

**Second Revision No. 8039-NFPA 70-2018 [Section No. 690.15(B)]****(B) Isolating Device.**

An isolating device shall not be required to have an interrupting rating. Where an isolating device is not rated for interrupting the circuit current, it shall be marked "Do Not Disconnect Under Load" or "Not for Current Interrupting." An isolating device shall not be required to simultaneously disconnect all current-carrying conductors of a circuit. The isolating device shall be one of the following:

- (1) A mating 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 device that requires a tool to place the device in the open (off) position
- (4) An isolating device listed for the intended application

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Tue Oct 30 12:54:17 EDT 2018

Committee Statement

Committee Statement: "Mating" was added in (B)(1) to differentiate the type of connector that applies to this section and to be consistent with changes in 690.33. The revision to Item (3) clarifies what is placed in the open position.

Response Message: SR-8039-NFPA 70-2018

Public Comment No. 1617-NFPA 70-2018 [Section No. 690.15(B)]

Public Comment No. 608-NFPA 70-2018 [Section No. 690.15(B)]



Second Revision No. 8042-NFPA 70-2018 [Section No. 690.15(C)]

~~(C) Circuits Connected to Electronic Power Converters.~~

Equipment disconnecting means

D) Type of Disconnecting Means.

Where disconnects are required to isolate equipment, the disconnecting means shall be one of the following applicable types:

1. An equipment disconnecting means in accordance with 690.15(D C) shall be required to isolate dc circuits with a maximum circuit current over 30 amperes connected to the input of electronic power converters. For dc circuits operating at 30 amperes or less connected to the input of electronic power converters, an .

2. An isolating device in accordance with 690.15(B) shall be permitted .

Informational Note:- Examples of circuits connected to the input of electronic power converters include, but are not limited to, the input circuits of dc-to-dc converters, electronic charge controllers, or inverters. If power electronics fail, these devices present a load to connected dc sources

for circuits other than those covered by 690.15(D)(1) .

Supplemental Information

<u>File Name</u>	<u>Description Approved</u>
70_CMP04_SR8042_690.15_C_.docx	for staff use

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Tue Oct 30 13:01:20 EDT 2018

Committee Statement

Committee Statement: This clarifies the requirements related to disconnection of equipment. It changes the title and moves the requirements to the end of 690.15. There are two different requirements for these devices. Circuits above 30 amps must have devices that meet 690.15(D) as the conversion device can present a load to the short-circuit limited circuit in the event of a failure and may not clear an overcurrent device or not even have an overcurrent device. Circuits under 30 amps where isolation is required for servicing equipment, isolating devices are acceptable.

Smaller electronic conversion devices are commonly used with isolating devices (microinverters) at current of 30 amps or less and have been operated safely for well over a decade. This Code has expressly allowed those installations in the past several editions.

Response Message: SR-8042-NFPA 70-2018

Public Comment No. 1607-NFPA 70-2018 [Section No. 690.15(C)]

**Second Revision No. 8045-NFPA 70-2018 [Section No. 690.15(D)]****(D C) Equipment Disconnecting Means.**

Equipment disconnecting means shall have ratings sufficient for the maximum circuit current, available fault current, and voltage that is available at the terminals. Equipment disconnecting means shall simultaneously disconnect all current-carrying conductors that are not solidly grounded of the circuit to which it is connected. Equipment disconnecting means shall be externally operable without exposing the operator to contact with energized parts and shall indicate whether in the open (off) or closed (on) position. Where not within sight ~~and or not~~ within 3 m (10 ft) of the equipment, the disconnecting means or its remote operating device or the enclosure providing access to the disconnecting means shall be capable of being locked in accordance with 110.25. Equipment disconnecting means, where used, shall be one of the same type as required types in 690.13(E)(1) through (5) .

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

Informational Note: A common installation practice is to terminate PV source-side dc conductors in the same manner that utility source-side ac conductors are generally connected on the line side of a disconnecting means. This practice is more likely to de-energize load-side terminals, blades, and fuses when the disconnect is in the open position and no energized sources are connected to the load side of the disconnect.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Tue Oct 30 13:13:25 EDT 2018

Committee Statement

Committee Statement: This SR provides some editorial changes to clarify the last half of the first paragraph. The location where lockability is required was potentially confusing and that sentence was improved for clarity. The last sentence of the first paragraph was edited for clarity to make it clear that the same types used in 690.13 would be appropriate for equipment disconnecting means.

Response Message: SR-8045-NFPA 70-2018

[Public Comment No. 2071-NFPA 70-2018 \[Section No. 690.15\(D\)\]](#)

[Public Comment No. 1397-NFPA 70-2018 \[Section No. 690.15\(D\)\]](#)

[Public Comment No. 1659-NFPA 70-2018 \[Section No. 690.15\(D\)\]](#)

[Public Comment No. 1621-NFPA 70-2018 \[Section No. 690.15\(D\)\]](#)



Second Revision No. 8037-NFPA 70-2018 [Section No. 690.15 [Excluding any Sub-Sections]]

~~Isolating devices-~~ Disconnecting means of the type required in 690.15(D) shall be provided to disconnect PV modules, ac PV modules, fuses, dc-to-dc converters, inverters, and charge controllers from all conductors that are not solidly grounded. ~~Equipment disconnecting means and PV system disconnecting means shall meet the requirements of isolating devices.~~

~~Informational Note: The purpose of these isolating devices is the safe and convenient replacement or service of specific PV system equipment without exposure to energized conductors.~~

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Tue Oct 30 12:45:05 EDT 2018

Committee Statement

Committee Statement: The SR points directly to 690.15(D) to clarify the types of disconnecting means allowed for disconnection of equipment. This SR also removes the requirement that all PV modules have isolating devices as some modules are connected using terminals. The last sentence is removed as this information is included in 690.15(D)(2). The informational note was deleted as unnecessary for the application of this section.

Response Message: SR-8037-NFPA 70-2018

[Public Comment No. 1610-NFPA 70-2018 \[Section No. 690.15 \[Excluding any Sub-Sections\]\]](#)

[Public Comment No. 1530-NFPA 70-2018 \[Section No. 690.15 \[Excluding any Sub-Sections\]\]](#)

[Public Comment No. 1398-NFPA 70-2018 \[Section No. 690.15 \[Excluding any Sub-Sections\]\]](#)



Second Revision No. 8050-NFPA 70-2018 [Section No. 690.31(A)]

FOR CODE-MAKING PANEL USE ONLY
SUBJECT TO REVISION - NOT FOR PUBLICATION

(A) Wiring Systems.

FOR CODE-MAKING PANEL USE ONLY
SUBJECT TO REVISION - NOT FOR PUBLICATION

All raceway and cable wiring methods included in this Code, other wiring systems and fittings specifically listed for use in PV arrays, and wiring as part of a listed system shall be permitted. Where wiring devices with integral enclosures are used, sufficient length of cable shall be provided to facilitate replacement.

Where PV source and output circuits operating at voltages greater than 30 volts are installed in readily accessible locations, circuit conductors shall be guarded or installed in Type MC cable or in raceway. For ambient temperatures exceeding 30°C (86°F), conductor ampacities shall be corrected in accordance with Table 690.31(A)(a). The ampacity of 105°C (221°F) and 125°C (257°F) conductors shall be permitted to be determined by Table 690.31(A)(b). For ambient temperatures greater than 30°C (86°F), the ampacities of these conductors shall be corrected in accordance with Table 690.31(A)(b).

Table 690.31(A)(a) Correction Factors

Ambient Temperature (°C)	Temperature Rating of Conductor		Ambient Temperature (°F)
	105°C (221°F)	125°C (257°F)	
30	1	1	86
31–35	0.97	0.97	87–95
36–40	0.93	0.95	96–104
41–45	0.89	0.92	105–113
46–50	0.86	0.89	114–122
51–55	0.82	0.86	123–131
56–60	0.77	0.83	132–140
61–65	0.73	0.79	141–149
66–70	0.68	0.76	150–158
71–75	0.63	0.73	159–167
76–80	0.58	0.69	168–176
81–85	0.52	0.65	177–185
86–90	0.45	0.61	186–194
91–95	0.37	0.56	195–203
96–100	0.26	0.51	204–212
101–105	—	0.46	213–221
106–110	—	0.4	222–230
111–115	—	0.32	231–239
116–120	—	0.23	240–248

Table 690.31(A)(b) Ampacities of Insulated Conductors Rated Up To and Including 2000 Volts, 105°C Through 125°C (221°F Through 257°F), Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried), Based on Ambient Temperature of 30°C (86°F)

AWG	Types	
	PVC, CSPE, CPE, XLPE 105°C	XLPE, EPDM 125°C
18	15	16
16	19	20
14	29	31
12	36	39
10	46	50
8	64	69
6	81	87
4	109	118
3	129	139
2	143	154
1	168	181
1/0	193	208
2/0	229	247

<u>AWG</u>	<u>Types</u>	
	<u>PVC, CSPE CPE, XLPE 105°C</u>	<u>XLPE, EPDM 125°C</u>
3/0	263	284
4/0	301	325

Informational Note: See 110.14(C) for conductor temperature limitations due to termination provisions.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Tue Oct 30 13:27:26 EDT 2018

Committee Statement

Committee Statement: Editorial changes to the second paragraph better explain the use of the two new tables. The cable type CSPE is changed to CPE in Table 690.31(A)(b) to match the product standard. While PVC, CPE, XLPE, and EPDM are not included in general wiring in Chapter 3, Chapter 6 modifies Chapter 3 and there are reasons that PV systems may need higher rated conductors in certain high temperature environments like rooftops.

Response Message: SR-8050-NFPA 70-2018

[Public Comment No. 612-NFPA 70-2018 \[Section No. 690.31\(A\)\]](#)

[Public Comment No. 1730-NFPA 70-2018 \[Section No. 690.31\(A\)\]](#)

[Public Comment No. 1681-NFPA 70-2018 \[Section No. 690.31\(A\)\]](#)

**Second Revision No. 8055-NFPA 70-2018 [Section No. 690.31(B)(1)]****(1) Identification.**

PV system dc circuit conductors shall be identified at all termination, connection, and splice points by color coding, marking tape, tagging, or other approved means. ~~Circuits- Conductors~~ relying on other than color coding for polarity identification shall be identified by an approved permanent marking means such as labeling, sleeving, or shrink-tubing that is suitable for the conductor size. The permanent marking means for nonsolidly grounded positive conductors shall include imprinted plus signs (+) or the word POSITIVE or POS durably marked on insulation of a color other than green, white, or gray. The permanent marking means for nonsolidly grounded negative conductors shall include imprinted negative signs (-) or the word NEGATIVE or NEG durably marked on insulation of a color other than green, white, gray, or red. Only solidly grounded PV system dc circuit conductors shall be marked in accordance with 200.6.

Exception: Where the identification of the conductors is evident by spacing or arrangement, further identification shall not be required.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Tue Oct 30 13:44:29 EDT 2018

Committee Statement

Committee Statement: Conductors is a more accurate term to use instead of circuits at the start of second sentence. The revision also adds "dc" in two places to align with the definition for the circuits this requirement covers.

Response Message: SR-8055-NFPA 70-2018

Public Comment No. 1785-NFPA 70-2018 [Section No. 690.31(B)(1)]



Second Revision No. 8053-NFPA 70-2018 [Section No. 690.31(B) [Excluding any Sub-Sections]]

PV system dc circuits and Class 1 remote control, signaling, and power-limited circuits of a PV system shall be permitted to occupy the same equipment wiring enclosure, cable, or raceway. PV system dc circuits shall not occupy the same equipment wiring enclosure, cable, or raceway as other non-PV systems, or inverter output circuits, unless the PV system dc circuits and Class 1 control circuits are separated from other circuits by a barrier or partition. PV system circuit conductors shall be identified and grouped as required by 690.31(B)(1) through and (B)(2).

Exception: PV system dc circuits utilizing multiconductor jacketed cable or metal-clad cable assemblies or listed wiring harnesses identified for the application shall be permitted to occupy the same wiring method as inverter output circuits and other non-PV systems. All conductors, harnesses, or assemblies shall have an insulation rating equal to at least the maximum circuit voltage applied to any conductor within the enclosure, cable, or raceway.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Tue Oct 30 13:40:03 EDT 2018

Committee Statement

Committee Statement: The past several code cycles have prohibited PV system dc circuits from occupying the same wiring method as inverter output circuits without the use of partitions for separation. An option was added for barriers, in addition to partitions. An exception was added for other multiconductor cable assemblies, listed for the application, in the same wiring method. A barrier is a more generic term than partition and would allow approved methods to keep these circuits from direct contact.

Response Message: SR-8053-NFPA 70-2018

[Public Comment No. 1764-NFPA 70-2018 \[Section No. 690.31\(B\) \[Excluding any Sub-Sections\]\]](#)

[Public Comment No. 2076-NFPA 70-2018 \[Section No. 690.31\(B\) \[Excluding any Sub-Sections\]\]](#)

**Second Revision No. 8056-NFPA 70-2018 [Section No. 690.31(C)(1)]****(1) Single-Conductor Cable.**

~~Single-conductor PV wire or cable, and single-conductor Type USE-2 identified as sunlight resistant shall be permitted in exposed outdoor locations in PV system dc circuits within the PV array – shall be permitted to be one of the following:~~

~~(1) PV wire or cable~~

~~(2) single-conductor cable marked sunlight resistant and Type USE-2 and Type RHW-2~~

~~Exposed cables shall be supported and secured at intervals not to exceed 600 mm (24 in.) by cable ties, straps, hangers, or similar fittings listed and identified for securement and support in outdoor locations. PV wire or cable is shall be permitted in all locations where RHW-2 is permitted.~~

~~*Exception: PV systems meeting the requirements of 691.4 shall be permitted to have support and securement intervals as defined in the engineered design.*~~

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Tue Oct 30 13:52:05 EDT 2018

Committee Statement

Committee Statement: This SR changes the first "and" to an "or" to make it clear that either cable is acceptable. The SR also requires Type USE-2 to have Type RHW-2 and sunlight resistant markings as well. This requires that cables with these markings pass the 720-hour weather resistance test. No further identification is necessary that could further complicate a field inspection. Type RHW-2 is necessary where conductors enter a building so requiring this rating simplifies the job of enforcement as they do not need to worry about whether the cable enters the building at any location. AHJs that do not see the USE-2/RHH/RHW-2 marking may reject a perfectly good cable. Simply requiring these pertinent markings addresses the concern related to the need for a 720-hour weather resistance test and requires that AA-8000 alloy be used for aluminum cables. The word "is" is changed to "shall be" in the last sentence to comply with the style manual.

The new exception clarifies that the engineered design may supersede the requirements in Article 690.

Response Message: SR-8056-NFPA 70-2018

[Public Comment No. 1898-NFPA 70-2018 \[Section No. 690.31\(C\)\(1\)\]](#)

[Public Comment No. 1929-NFPA 70-2018 \[Section No. 690.31\(C\)\(1\)\]](#)

[Public Comment No. 1897-NFPA 70-2018 \[Section No. 690.31\(C\)\(1\)\]](#)

**Second Revision No. 8060-NFPA 70-2018 [Section No. 690.31(C)(2)]****(2) Cable Tray.**

~~PV system dc circuits using single~~ Single -conductor PV wire or cable of all sizes or Distributed Generation (DG) cable of all sizes, with or without a cable tray rating, shall be permitted in cable trays installed in outdoor locations, provided that the cables are supported at intervals not to exceed 300 mm (12 in.) and secured at intervals not to exceed 1.4 m (4½ ft).

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

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Tue Oct 30 14:04:39 EDT 2018

Committee Statement

Committee Statement: This SR adds DG cable as another cable allowed in cable tray without size restrictions. The informational note is also updated to include DG cable. The opening clause limiting to PV system dc circuits is unnecessary as this section is addressing construction of the cable, not the circuit. Conductor separation is covered in 690.31(A).

Response Message: SR-8060-NFPA 70-2018

Public Comment No. 2035-NFPA 70-2018 [Section No. 690.31(C)(2)]



Second Revision No. 8062-NFPA 70-2018 [Section No. 690.31(C)(3)]

(3) Multiconductor Cable.

~~Distributed generation (DG) cable and other jacketed multiconductor cable assemblies used in accordance with their listings shall be permitted in outdoor locations. The cable shall be secured~~

Jacketed Cables.

Where part of a listed PV assembly, multiconductor jacketed cables shall be installed in accordance with the included instructions. Where not part of a listed assembly, or where not otherwise covered in this Code, multiconductor jacketed cables, including DG cable, shall be installed in accordance with the product listing and shall be permitted in PV systems. These cables shall be installed in accordance with the following:

(1) In raceways, where on or in buildings other than rooftops

(2) Where not in raceways, in accordance with the following:

_____ (a) Marked sunlight resistant in exposed outdoor locations

_____ (b) Protected or guarded, where subject to physical damage

_____ (c) Closely follow the surface of support structures

_____ (d) Secured at intervals not exceeding 1.

8 m

8 m (

6 ft).

6 ft)

_____ (e) Secured within 600 mm (24 in.) of mating connectors or entering enclosures

_____ (f) Marked direct burial where buried in the earth

Supplemental Information

<u>File Name</u>	<u>Description Approved</u>
70_CMP04_SR8062_690.31_C_3_.docx	for staff use

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Tue Oct 30 14:17:01 EDT 2018

Committee Statement

Committee Statement: This SR completely revises and reorganize this section and incorporates the FR language on multiconductor cables from 690.6 into this section. These cables should not be restricted only to ac module systems but should be permitted to be used throughout PV systems based on their listings. This SR specifically permits cables marked sunlight resistant to be used outdoors and cables marked direct burial to be direct buried. The list of items is edited for readability and to match item structure. The secure requirement for cables entering mating connectors or enclosures has been increased from 12 inches to 24 inches to allow proper bending of cables.

The fact that DG cable has not yet been approved as an ANSI standard does not mean that it will not be approved shortly or that DG cable should be held out of the 2020 NEC. There are eight manufacturers of DG cable from a single NRTL. Multiconductor cables on or in buildings that are not located on rooftops must be in raceways.

WORKING DRAFT OF CMP MEETING OUTPUT - NATIONAL ELECTRICAL CODE - NFPA 70
OCTOBER 29 - NOVEMBER 3, 2018 - SUBJECT TO REVISION - NOT FOR PUBLICATION

Response SR-8062-NFPA 70-2018

Message:

[Public Comment No. 1995-NFPA 70-2018 \[New Section after 690.31\(C\)\(3\)\]](#)

[Public Comment No. 1904-NFPA 70-2018 \[Section No. 690.31\(C\)\(3\)\]](#)

[Public Comment No. 1786-NFPA 70-2018 \[Section No. 690.31\(C\)\(3\)\]](#)

FOR CODE-MAKING PANEL USE ONLY
SUBJECT TO REVISION - NOT FOR PUBLICATION



Second Revision No. 8073-NFPA 70-2018 [Section No. 690.31(D)]

(D) Direct-Current Circuits on or in a Building Buildings .

Where inside buildings, PV system dc circuits inside buildings greater than that exceed 30 volts and 70 watts or 8 amperes shall be contained in metal raceways, in Type MC metal-clad cable that complies with 250.118(10), or in metal enclosures. Wiring methods on or in a building shall comply with the additional installation requirements in 690.31(G)(1) through (4).

Exception: PV hazard control systems installed in accordance with 690.12(B)(2) (1) shall be permitted to be provided with or listed for use with nonmetallic enclosure(s), nonmetallic raceway(s), and cables of a permitted type other than Type MC metal-clad cable(s), at the point of penetration of the surface of the building to the PV hazard control actuator.

Wiring methods on or in a building shall comply with the additional installation requirements in 690.31 (D)(1) and (2).

(1) Flexible Wiring Methods.

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

(2) Marking and Labeling Required.

Unless located and arranged so the purpose is evident, the following wiring methods and enclosures that contain PV system dc circuit conductors shall be marked with the wording PHOTOVOLTAIC POWER SOURCE or SOLAR PV DC CIRCUIT by means of permanently affixed labels or other approved permanent marking:

- (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

The labels or markings shall be visible after installation. All letters shall be capitalized and shall be a minimum height of 9.5 mm ($\frac{3}{8}$ in.) in white on a red background. Labels shall appear on every section of the wiring system that is separated by enclosures, walls, partitions, ceilings, or floors. Spacing between labels or markings, or between a label and a marking, shall not be more than 3 m (10 ft). Labels required by this section shall be suitable for the environment where they are installed.

Supplemental Information

<u>File Name</u>	<u>Description Approved</u>
70_CMP04_SR8073_690.31_D_.docx	for staff use

Submitter Information Verification

Committee: NEC-P04
Submittal Date: Tue Oct 30 15:42:36 EDT 2018

Committee Statement

Committee Statement: The words, "inside buildings" is relocated to lead the first sentence for clarity. The 70 watt threshold is changed to 8 amps to better align with action taken in 690.42 and related standards for ground-fault detection. The exception is edited to clarify that the alternative wiring methods are permitted rather than required and moved above the requirements of (D)(1) through (4) so that it is clear that

PV hazard control systems are not exempt from (D)(1) through (4).

Response SR-8073-NFPA 70-2018
Message:

[Public Comment No. 1758-NFPA 70-2018 \[Section No. 690.31\(D\) \[Excluding any Sub-Sections\]\]](#)

[Public Comment No. 437-NFPA 70-2018 \[Section No. 690.31\(D\) \[Excluding any Sub-Sections\]\]](#)

[Public Comment No. 1769-NFPA 70-2018 \[Section No. 690.31\(D\) \[Excluding any Sub-Sections\]\]](#)

[Public Comment No. 1193-NFPA 70-2018 \[Section No. 690.31\(D\)\]](#)

[Public Comment No. 801-NFPA 70-2018 \[Section No. 690.31\(D\) \[Excluding any Sub-Sections\]\]](#)

FOR CODE-MAKING PANEL USE ONLY
SUBJECT TO REVISION - NOT FOR PUBLICATION

**Second Revision No. 8078-NFPA 70-2018 [Section No. 690.31(E)]****(E) Bipolar Photovoltaic Systems.**

Where the sum, without consideration of polarity, of the voltages of the two monopole ~~subarray~~ circuits exceeds the rating of the conductors and connected equipment, monopole ~~subarray~~ circuits in a bipolar PV system shall be physically separated, and the electrical output circuits from each monopole ~~subarray~~ circuit shall be installed in separate raceways until connected to the inverter. The disconnecting means and overcurrent protective devices for each monopole ~~subarray~~ circuit output shall be in separate enclosures. All conductors from each separate monopole ~~subarray~~ circuit shall be routed in the same raceway. Solidly grounded bipolar PV systems shall be clearly marked with a permanent, legible warning notice indicating that the disconnection of the grounded conductor(s) may result in overvoltage on the equipment.

Exception: Listed switchgear rated for the maximum voltage between circuits and containing a physical barrier separating the disconnecting means for each monopole ~~subarray~~ circuit shall be permitted to be used instead of disconnecting means in separate enclosures.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Tue Oct 30 16:15:14 EDT 2018

Committee Statement

Committee Statement: The term "subarray" is removed in all cases to align with changes to this definition in 690.2. The term "circuit" is added in the exception to match the definition.

Response Message: SR-8078-NFPA 70-2018

Public Comment No. 1766-NFPA 70-2018 [Section No. 690.31(E)]

**Second Revision No. 8080-NFPA 70-2018 [Section No. 690.31(F)]****(F) Wiring Methods and Mounting Systems.**

Roof-mounted PV array mounting systems shall be permitted to be held in place with an approved means other than those required by 110.13 and shall utilize wiring methods that allow any expected movement of the array.

Informational Note: Expected movement of unattached PV arrays is often included in structural calculations.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Tue Oct 30 16:35:48 EDT 2018

Committee Statement

Committee Statement: The informational note is added to broadly inform that expected movement may be determined with structural calculations. There may be ways to prevent movement relative to the electrical wiring methods that do not require structural calculations.

Response Message: SR-8080-NFPA 70-2018 The requirements of ASCE 7-16 should not become a requirement for the electrical portion of every rooftop system that is not fully fastened.

Public Comment No. 2103-NFPA 70-2018 [Section No. 690.31(F)]

**Second Revision No. 8085-NFPA 70-2018 [Section No. 690.33]****690.33– 33 _ Mating_ Connectors.**

~~Connectors~~ Mating connectors, other than ~~these connectors~~ covered by 690.32, shall comply with 690.33(A) through (E D).

(A) Configuration.

The mating connectors shall be polarized and shall have a configuration that is noninterchangeable with receptacles in other electrical systems on the premises.

(B) Guarding.

The mating connectors shall be constructed and installed so as to guard against inadvertent contact with live parts by persons.

(C) Type.

The mating connectors shall be of the latching or locking type. ~~Connectors. Mating connectors~~ that are readily accessible and that are used in circuits operating at over 30 volts dc or 15 volts ac shall require a tool for opening. Where mating connectors are not of the identical type and brand, they shall be listed and identified for intermatability, as described in the manufacturer's instructions.

(D) Interruption of Circuit.

~~Connectors. Mating connectors~~ shall be one of the following:

- (1) Rated for interrupting current without hazard to the operator.
- (2) A type that requires the use of a tool to open and marked "Do Not Disconnect Under Load" or "Not for Current Interrupting."
- (3) Supplied as part of listed equipment and used in accordance with instructions provided with the listed connected equipment.

Informational Note: Some listed equipment, such as micro inverters, are evaluated to make use of mating connectors as disconnect devices even though the mating connectors are marked as "Do Not Disconnect Under Load" or "Not for Current Interrupting."

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Tue Oct 30 17:23:39 EDT 2018

Committee Statement

Committee Statement: The generic term "connector" is too broad for this section since connectors suitable for use in PV circuits exist in multiple configurations, not just the mating (i.e. pin and socket) types covered in this section. The term "mating" has been added to further clarify the type of connectors covered in section 690.33. This term aligns with changes underway in applicable UL product safety standards.

A reference to "intermatability" has been added in subsection (C) to ensure that two different brand or types of mating connectors can only be installed together where they have been listed and identified for this use. The term "intermatability" is used in UL 6703, the product safety standard covering PV connectors.

Response Message: SR-8085-NFPA 70-2018

[Public Comment No. 1405-NFPA 70-2018 \[Section No. 690.33\(C\)\]](#)

[Public Comment No. 1787-NFPA 70-2018 \[Section No. 690.33\]](#)

[Public Comment No. 1982-NFPA 70-2018 \[Section No. 690.33\]](#)

**Second Revision No. 8087-NFPA 70-2018 [Section No. 690.41(A)]****(A) PV System Grounding Configurations.**

One or more of the following system ~~grounding~~ configurations shall be employed:

- (1) 2-wire PV arrays with one functionally grounded conductor
- (2) Bipolar PV arrays according to 690.7(C) with a functional ground reference (center tap)
- (3) PV arrays not isolated from the grounded inverter output circuit
- (4) 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

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Tue Oct 30 17:29:22 EDT 2018

Committee Statement

Committee Statement: The term "grounding" is deleted since only one of the permitted system types in the list includes solidly grounded circuit conductors.

The word "exception" was deleted in Item (5) since the exception was changed to positive language in the first draft.

Response Message: SR-8087-NFPA 70-2018 The allowable configurations stated in 690.41(A)(1) through (3) describe methods used in existing listed equipment and are appropriate to provide a ground reference required for the PV system dc ground-fault protection equipment to function properly. The use of the term "grounding" in the subsection has been slightly modified based on the submitter's comment. The use of the term "system grounding" in the title of this subdivision does not convey any mandatory requirement and is intentionally titled to aid a user of the Code to easily locate these requirements.

Public Comment No. 1456-NFPA 70-2018 [Section No. 690.41(A)]

**Second Revision No. 8099-NFPA 70-2018 [Section No. 690.41(B)(3)]****(3) Indication of Faults.**

~~Equipment performing ground~~ Ground -fault protection mounted in not readily accessible locations shall have means to provide remote- equipment shall provide indication of ground faults at a readily accessible location .

Informational Note: Examples of ~~remote indication may be provided by means such as~~ indication include , but are not limited to, the following: remote indicator light, display, monitor, signal to a monitored alarm system, or receipt of notification by web-based services.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Tue Oct 30 17:58:36 EDT 2018

Committee Statement

Committee Statement: Language in this section has been changed to better clarify the requirements.

The use of terms that may be perceived as permissive language have been removed from the informational note.

Response Message: SR-8099-NFPA 70-2018

Public Comment No. 439-NFPA 70-2018 [Section No. 690.41(B)(3)]

Public Comment No. 1194-NFPA 70-2018 [Section No. 690.41(B)(2)]



Second Revision No. 8092-NFPA 70-2018 [Section No. 690.41(B) [Excluding any Sub-Sections]]

PV system dc circuits ~~greater than~~ that exceed 30 volts and 70 watts or 8 amperes shall be provided with dc ground-fault protection meeting the requirements of 690.41(B)(1) and (B)(2) to reduce fire hazards.

Solidly grounded PV arrays ~~source circuits~~ with not more than two PV ~~source circuits and with all PV system dc circuits~~ modules in parallel and not on or in buildings shall be permitted without ground-fault protection.

Informational Note: Not all inverters, charge controllers, or dc-to-dc converters include ground-fault protection. Equipment that does not have ground-fault protection ~~may have~~ often includes the following statement in the manual: "Warning: This unit is not provided with a GFDI device."

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Tue Oct 30 17:36:19 EDT 2018

Committee Statement

Committee Statement: The limits on voltage and current that are allowed for PV system dc system circuits without ground-fault protection have been updated to align with updates to UL-61730 covering class III PV modules. PV modules smaller than these values are generally recognized in multiple standards as providing an insufficient level of energy to ignite common materials found adjacent to PV system dc circuit conductors. Adding these limits provide an allowance for small PV modules to be used for traditional dedicated applications where smaller low-voltage modules are all that is required. Changes were also made to clarify that only solidly-grounded PV source circuits that do not exceed two modules in parallel can be installed without ground fault protection only where those circuits are not on or in buildings.

The use of terms that could be perceived as permissive language have also been removed from the informational note.

Response Message: SR-8092-NFPA 70-2018

[Public Comment No. 803-NFPA 70-2018 \[Section No. 690.41\(B\) \[Excluding any Sub-Sections\]\]](#)

[Public Comment No. 1759-NFPA 70-2018 \[Section No. 690.41\(B\) \[Excluding any Sub-Sections\]\]](#)

[Public Comment No. 1195-NFPA 70-2018 \[Section No. 690.41\(B\) \[Excluding any Sub-Sections\]\]](#)

[Public Comment No. 438-NFPA 70-2018 \[Section No. 690.41\(B\) \[Excluding any Sub-Sections\]\]](#)

**Second Revision No. 8101-NFPA 70-2018 [Section No. 690.43]****690.43 Equipment Grounding and Bonding.**

Exposed non-current-carrying metal parts of PV module frames, electrical equipment, and conductor enclosures of PV systems shall be connected to an equipment grounding conductor in accordance with 250.134 or 250.136(A), regardless of voltage. Equipment grounding conductors and devices shall comply with 690.43(A) through (E D).

(A) Photovoltaic Module Mounting Systems and Devices.

Devices and systems used for mounting PV modules that are also used for bonding module frames shall be listed, labeled, and identified for bonding PV modules. Devices that mount adjacent PV modules shall be permitted to bond adjacent PV modules.

(B) Equipment Secured to Grounded Metal Supports.

Devices listed, labeled, and identified for bonding and grounding the metal parts of PV systems shall be permitted to bond the equipment to grounded metal supports. Metallic support structures shall have identified bonding jumpers connected between separate metallic sections or shall be identified for equipment bonding and shall be connected to the equipment grounding conductor.

(C) With Circuit Conductors.

Equipment grounding conductors for the PV array and support structure where installed, shall be contained within the same raceway or cable, or otherwise run with the PV system conductors where those circuit conductors leave the vicinity of the PV array.

(D) Bonding for Over 250 Volts.

The bonding requirements contained in 250.97 shall apply only to solidly grounded PV system circuits operating over 250 volts to ground.

~~(E) Conductor Installation.~~

~~Equipment grounding and bonding conductors shall comply with 250.120 .~~

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Tue Oct 30 18:05:02 EDT 2018

Committee Statement

Committee Statement: The language in subsection (E) has been deleted since the single reference to 250.120 is inadequate to provide complete guidance as to the requirements covering the installation of equipment grounding conductors in PV systems. Deleting this section will not cause gaps or conflicts in the Code since Chapter 2, and thus Parts 6 and 7 of Article 250 are not modified by any other sections in Article 690 so will still apply.

The reference to the subsection letters in the main paragraph have been updated to reflect this deletion.

Response Message: SR-8101-NFPA 70-2018

Public Comment No. 805-NFPA 70-2018 [Section No. 690.43(E)]

Public Comment No. 2107-NFPA 70-2018 [Section No. 690.43]

**Second Revision No. 8107-NFPA 70-2018 [Section No. 690.45]****690.45** Size of Equipment Grounding Conductors.

~~(A) PV System AC and DC Circuits .~~

Equipment grounding conductors for PV system circuits shall be sized in accordance with 250.122. Where no overcurrent protective device is used in the circuit, an assumed overcurrent device rated in accordance with 690.9(B) shall be used when applying Table 250.122.

~~(B) PV System DC Circuits .~~

Increases in equipment grounding conductor size to address voltage drop considerations shall not be required.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Tue Oct 30 18:38:29 EDT 2018

Committee Statement

Committee Statement: This revision simplifies the sizing of grounding conductors and allows ac equipment grounding conductors to remain the same based on the overcurrent device rating regardless of size increases for performance related reasons.

Response Message: SR-8107-NFPA 70-2018

Public Comment No. 2108-NFPA 70-2018 [Section No. 690.45]

**Second Revision No. 8102-NFPA 70-2018 [Section No. 690.56(C)]****(C) Buildings with Rapid Shutdown.**

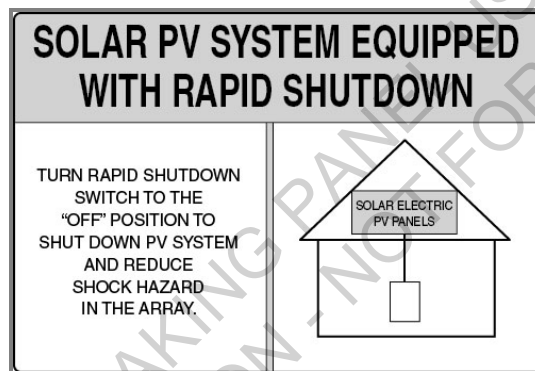
Buildings with PV systems shall have a permanent label located at each service equipment location to which the PV systems are connected or at an approved readily visible location and shall indicate the location of ~~all identified~~ rapid shutdown initiation devices, ~~if not at the same location~~. The label shall include a simple diagram of a building with a roof and shall include the following words:

SOLAR PV SYSTEM IS EQUIPPED WITH RAPID SHUTDOWN. TURN RAPID SHUTDOWN SWITCH TO THE "OFF" POSITION TO SHUT DOWN PV SYSTEM AND REDUCE SHOCK HAZARD IN ARRAY.

The title "SOLAR PV SYSTEM IS EQUIPPED WITH RAPID SHUTDOWN" shall utilize capitalized characters with a minimum height of 9.5 mm ($\frac{3}{8}$ in.) in black on yellow background, and the remaining characters shall be capitalized with a minimum height of 4.8 mm ($\frac{3}{16}$ in.) in black on white background.

Informational Note: See Informational Note Figure 690.56(C).

Informational Note Figure 690.56(C) Label for Roof-Mounted PV Systems with Rapid Shutdown.

**(1) Buildings with More Than One Rapid Shutdown Type.**

For buildings that have PV systems with more than one rapid shutdown type or a PV system ~~systems~~ with no rapid shutdown, a detailed plan view diagram of the roof shall be provided showing each different PV system and with a dotted line around areas that remain energized after the rapid shutdown switch ~~is operated~~ initiated.

(2) Rapid Shutdown Switch.

A rapid shutdown switch shall have a label that includes the following wording located on or no more than 1 m (3 ft) from the switch:

RAPID SHUTDOWN SWITCH FOR SOLAR PV SYSTEM

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

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Tue Oct 30 18:10:22 EDT 2018

Committee Statement

Committee Statement: The phrases "all identified" and "if not at the same location" have been removed from the main paragraph since marking and location requirements for rapid shutdown initiation devices are in 690.56(C)(2) and 690.12(C) respectfully.

The figure title has been changed to include the identification that it is an informational note.

Editorial changes were made to (C)(1) to further clarify the requirements.

**Response
Message:**

SR-8102-NFPA 70-2018

[Public Comment No. 1762-NFPA 70-2018 \[Section No. 690.56\(C\) \[Excluding any Sub-Sections\]\]](#)

[Public Comment No. 1763-NFPA 70-2018 \[Section No. 690.56\(C\)\(1\)\]](#)

[Public Comment No. 1165-NFPA 70-2018 \[Section No. 690.56\(C\)\]](#)

[Public Comment No. 1487-NFPA 70-2018 \[Section No. 690.56\(C\) \[Excluding any Sub-Sections\]\]](#)

FOR CODE-MAKING PANEL USE ONLY
SUBJECT TO REVISION - NOT FOR PUBLICATION

**Second Revision No. 8221-NFPA 70-2018 [Section No. 691.5]****691.5 Equipment.**

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

- (1) Listing and labeling
- (2) Field labeling Be evaluated for the application and have a field label applied
- (3) Where products complying with 691.5(1) or (2) are not available, by engineering review validating that the electrical equipment is evaluated and tested to relevant standards or industry practice

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Thu Nov 01 18:47:10 EDT 2018

Committee Statement

Committee Statement: Stating that equipment has a field evaluation does not guarantee that a field label is installed. NFPA 791 includes a recommendation for a label to be installed but does not mandate it as quoted below. The process of applying a field label for field evaluated equipment is extremely important for AHJs.

Response Message: SR-8221-NFPA 70-2018

Public Comment No. 1492-NFPA 70-2018 [Section No. 691.5]

**Second Revision No. 8112-NFPA 70-2018 [Section No. 691.9]****691.9 Disconnecting Means for Isolating Photovoltaic Equipment.**

Isolating devices shall not be required within sight of equipment and ~~may~~ shall be permitted to be located remotely from equipment. The engineered design ~~per~~ required by 691.6 shall document disconnection procedures and means of isolating equipment.

Informational Note: For information on electrical system maintenance, see NFPA 70B-2019, *Recommended Practice for Electrical Equipment Maintenance*. For information on written procedures and conditions of maintenance, including lockout/tagout procedures, see *NFPA 70E-2018*.

Buildings whose sole purpose is to house and protect supply station equipment shall not be required to comply with 690.12. Written standard operating procedures shall be available at the site detailing necessary shutdown procedures in the event of an emergency.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Tue Oct 30 18:56:09 EDT 2018

Committee Statement

Committee Statement: Replaced the word "per" with the term "required by" rather than the phrase "in accordance with" for improved clarity. Additionally replaced "may" with the term "shall be permitted to".

Response Message: SR-8112-NFPA 70-2018

Public Comment No. 1166-NFPA 70-2018 [Section No. 691.9]

**Second Revision No. 8115-NFPA 70-2018 [Section No. 691.11]****691.11 Fence Bonding and Grounding.**

Fence grounding requirements and details shall be included in the documentation required in 691.6.

Informational Note: See 250.194 for fence bonding and grounding requirements enclosing substation portions of an electric supply station. ~~Other~~ Grounding requirements for other portions of electric supply station fencing ~~may be~~ are assessed based on the presence of overhead conductors, proximity to generation and distribution equipment, and associated step and touch potential.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Tue Oct 30 19:02:33 EDT 2018

Committee Statement

Committee Statement: Added the term "Grounding requirements for" to add clarity and replaced the permissive term "may be" with "are" to eliminate the term "may".

Response Message: SR-8115-NFPA 70-2018

[Public Comment No. 1168-NFPA 70-2018 \[Section No. 691.11\]](#)

[Public Comment No. 1996-NFPA 70-2018 \[Section No. 691.11\]](#)

**Second Revision No. 8117-NFPA 70-2018 [Section No. 692.4(B)(2)]**

~~(2)– Interconnected – DC Microgrid Systems.~~

Plaques or directories shall be installed in accordance with 712.10(A) .

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Tue Oct 30 19:11:49 EDT 2018

Committee Statement

Committee Statement: The title has been changed to reflect Article 712, Direct Current Microgrids. All sections of 712.10 may apply in different applications.

Response Message: SR-8117-NFPA 70-2018

Public Comment No. 1861-NFPA 70-2018 [Section No. 692.4(B)]

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**Second Revision No. 8224-NFPA 70-2018 [Section No. 692.6]****692.6 Listing Requirement.**

The fuel cell system shall be ~~listed or field-labeled for its intended application.~~ approved for the application in accordance with one of the following:

- (1) Be listed for the application
- (2) Be evaluated for the application and have a field label applied

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Thu Nov 01 18:50:23 EDT 2018

Committee Statement

Committee Statement: Stating that equipment has a field evaluation does not guarantee that a field label is installed. NFPA 791 includes a recommendation for a label to be installed but does not mandate it as quoted below. The process of applying a field label for field evaluated equipment is extremely important for AHJs.

Response Message: SR-8224-NFPA 70-2018

Public Comment No. 1513-NFPA 70-2018 [Section No. 692.6]

**Second Revision No. 8235-NFPA 70-2018 [Section No. 692.64]****692.64** Unbalanced Interconnections.

Unbalanced interconnections shall be in accordance with 705.400 45 .

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Thu Nov 01 19:45:08 EDT 2018

Committee Statement

Committee Statement: The text from 705.100 in the previous edition is now located in 705.45.

Response Message: SR-8235-NFPA 70-2018

FOR CODE-MAKING PANEL USE ONLY
SUBJECT TO REVISION - NOT FOR PUBLICATION

**Second Revision No. 8119-NFPA 70-2018 [Section No. 694.7(B)]****(B) Equipment.**

Wind electric systems shall be ~~listed and labeled or field labeled for the application.~~ approved for the application in accordance with one of the following:

- (1) Be listed
- (2) Be evaluated for the application and have a field label applied

Wind electric systems undergoing evaluation for type certification and listing shall be permitted to be operated in a controlled location with access limited to qualified personnel.

Informational Note: Testing for certification and listing is typically performed under the supervision of a qualified electrical testing organization. ~~Qualified testing organizations may also be used for electrical system assessments to assist local authorities having jurisdiction.~~

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Tue Oct 30 19:28:19 EDT 2018

Committee Statement

Committee Statement: Stating that equipment has a field evaluation does not guarantee that a field label is installed. NFPA 791 includes a recommendation for a label to be installed but does not mandate it as quoted below. The process of applying a field label for field evaluated equipment is extremely important for AHJs.

The second sentence in the informational note does not add to understanding of the section and is not directly relevant to the sentence it supports. Deleting the sentence addresses the word "may".

Response Message: SR-8119-NFPA 70-2018

Public Comment No. 1771-NFPA 70-2018 [Section No. 694.7(B)]

Public Comment No. 1170-NFPA 70-2018 [Section No. 694.7]

Public Comment No. 1518-NFPA 70-2018 [Section No. 694.7(B)]

**Second Revision No. 8121-NFPA 70-2018 [Section No. 694.7(E)]****(E) Receptacles.**

A receptacle shall be permitted to be supplied by a wind electric system branch or feeder circuit for maintenance or data acquisition use. Receptacles shall be protected with an overcurrent device with a rating not to exceed the current rating of the receptacle. All- In addition to the requirements in 210.8, all 125-volt, single-phase, 15- and 20-ampere receptacles installed for maintenance of the wind turbine shall have ground-fault circuit-interrupter protection for personnel.

Submitter Information Verification**Committee:** NEC-P04**Submittal Date:** Tue Oct 30 19:39:34 EDT 2018**Committee Statement**

Committee Statement: The additional text clarifies that the general requirements for GFCIs from 210.8 are also applicable.

Response Message: SR-8121-NFPA 70-2018

[Public Comment No. 1649-NFPA 70-2018 \[Section No. 694.7\(E\)\]](#)

**Second Revision No. 8226-NFPA 70-2018 [Section No. 694.7(F)]**

(F) Poles or Towers Supporting Wind Turbines Used as a Raceway.

A pole or tower shall be permitted to be used as a raceway if approved in accordance with one of the following:

(1) Be evaluated as part of the listing for the wind turbine

~~or otherwise shall be listed or field labeled~~

(1)

(2) Be listed for the

~~purpose.~~

(1) application

(2) Be evaluated for the application and have a field label applied

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Thu Nov 01 19:01:19 EDT 2018

Committee Statement

Committee Statement: Stating that equipment has a field evaluation does not guarantee that a field label is installed. NFPA 791 includes a recommendation for a label to be installed but does not mandate it as quoted below. The process of applying a field label for field evaluated equipment is extremely important for AHJs.

Response Message: SR-8226-NFPA 70-2018

Public Comment No. 1519-NFPA 70-2018 [Section No. 694.7(F)]

**Second Revision No. 8122-NFPA 70-2018 [Section No. 694.54(B)]**

~~(B)– Interconnected –~~ DC Microgrid Systems.

Plaques or directories shall be installed in accordance with 712.10(A) .

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Tue Oct 30 19:43:47 EDT 2018

Committee Statement

Committee Statement: The title has been changed to reflect Article 712, Direct Current Microgrids. All sections of 712.10 may apply in different applications.

Response Message: SR-8122-NFPA 70-2018

Public Comment No. 1864-NFPA 70-2018 [Section No. 694.54]

FOR CODE-MAKING PANEL USE ONLY
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**Second Revision No. 8146-NFPA 70-2018 [Definition: Microgrid Interconnect Device****(MID).]**705.2**Microgrid Interconnect Device (MID).**

A device that ~~allows~~ enables a microgrid system to separate from and reconnect to operate in parallel with a primary power source. (CMP-4)

Informational Note. Microgrid controllers typically are used to measure and evaluate electrical parameters and provide the logic for the signal to initiate and complete transition processes. IEEE Std 2030.7 and IEEE Std 2030.8 provide information on microgrid controllers. IEEE Std 1547 provides information on interconnection requirements.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Wed Oct 31 16:02:44 EDT 2018

Committee Statement

Committee Statement: Grammatical changes are made to this definition with a new informational note added to distinguish these devices, which isolate or connect different sources in parallel, as being different from transfer switches, which always isolate different sources from one another.

Response Message: SR-8146-NFPA 70-2018

Public Comment No. 1772-NFPA 70-2018 [Definition: Microgrid Interconnect Device (MID).]

**Second Revision No. 8147-NFPA 70-2018 [Definition: Power Source Output Circuit.]****[705.2] Power Source Output Circuit.**

The conductors between power production equipment ~~or a power source~~ and the service or distribution equipment.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Wed Oct 31 16:13:10 EDT 2018

Committee Statement

Committee Statement: The phrase "or power source" is deleted from this term since it is unnecessary. The defined term "power production equipment" is general enough to cover any source as a system.

Response Message: SR-8147-NFPA 70-2018

[Public Comment No. 1775-NFPA 70-2018 \[Definition: Power Source Output Circuit.\]](#)

FOR CODE-MAKING PANEL USE ONLY
SUBJECT TO REVISION - NOT FOR PUBLICATION

**Second Revision No. 8228-NFPA 70-2018 [Section No. 705.6]****705.6 Equipment Approval.**

All equipment shall be approved for the intended use. Interactive equipment intended to operate in parallel with electric power production sources including, but not limited to, interactive inverters, engine generators, energy storage equipment, and wind turbines shall be listed for interactive function or field-labeled be evaluated for interactive function and have a field label applied , or both, ~~for the intended use of interconnection service~~ .

Submitter Information Verification**Committee:** NEC-P04**Submittal Date:** Thu Nov 01 19:05:30 EDT 2018**Committee Statement**

Committee Statement: Stating that equipment has a field evaluation does not guarantee that a field label is installed. NFPA 791 includes a recommendation for a label to be installed but does not mandate it as quoted below. The process of applying a field label for field evaluated equipment is extremely important for AHJs.

Response Message: SR-8228-NFPA 70-2018

Public Comment No. 1521-NFPA 70-2018 [Section No. 705.6]

**Second Revision No. 8154-NFPA 70-2018 [Section No. 705.10]****705.10** Identification of Power Sources.

A permanent plaque or directory shall be installed at each service equipment location, or at an approved readily visible location. The plaque or directory shall denote the location of each power source disconnecting means for the ~~premises-~~ building or structure and be grouped with other plaques or directories for other on-site sources. The plaque or directory shall be marked with the wording "CAUTION: MULTIPLE SOURCES OF POWER". Any posted diagrams shall be correctly oriented with respect to the diagram's location. The marking shall comply with 110.21(B).

Exception: Installations with multiple co-located power production sources shall be permitted to be identified as a group(s). The plaque or directory shall not be required to identify each power source individually.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Wed Oct 31 19:08:20 EDT 2018

Committee Statement

Committee Statement: Changes are made to this section to align with related changes to identification of power sources in other articles in a continued effort to harmonize all directory requirements for onsite sources under a variety of applications.

Response Message: SR-8154-NFPA 70-2018

Public Comment No. 1848-NFPA 70-2018 [Section No. 705.10]

**Second Revision No. 8155-NFPA 70-2018 [Section No. 705.11(B)]****(B) Conductors.**

The power source output circuit conductors from the service conductors point of connection to the first overcurrent protection device shall be sized in accordance with 705.28 and in no case sized smaller than #6- 6 AWG copper or #4- 4 AWG aluminum. These conductors shall be installed in accordance with 230.30 or 230.43.

Submitter Information Verification**Committee:** NEC-P04**Submittal Date:** Wed Oct 31 19:39:03 EDT 2018**Committee Statement****Committee Statement:** The "#" symbol was removed to comply with the NEC Style Manual.**Response Message:** SR-8155-NFPA 70-2018[Public Comment No. 440-NFPA 70-2018 \[Section No. 705.11\(B\)\]](#)[Public Comment No. 1171-NFPA 70-2018 \[Section No. 705.10\]](#)

**Second Revision No. 8156-NFPA 70-2018 [Section No. 705.11(C)]****(C) Overcurrent Protection.**

The power source output circuit conductors shall be protected from overcurrent in accordance with 705.28 and 705.30. If fuses are not integral with the disconnecting means the disconnecting means shall be located on the service side of the fuses. Where the power source output circuit conductors make their connection to the service outside of a building, they shall be protected by overcurrent devices in a readily accessible location outside the building or at the first readily accessible location where the power source conductors enter the building. Where the power source output circuit conductors make their connection to the service inside a building, they shall be protected with one of the following methods:

- (1) ~~Within 5 m (16.5 ft).~~ With an overcurrent device located within 3 m (10 ft) of conductor length in dwelling units and 5 m (16.5 ft) of conductor length in other than dwelling units from the point of connection to the service
- (2) ~~Within~~ In other than a dwelling unit, with an overcurrent device located within 20 m (71 ft) ~~With cable limiters at the~~ of conductor length from the point of connection to the service ~~and an overcurrent device~~, provided that cable limiters installed in all ungrounded conductors are located within 20 ~~5~~ m (71 ~~16.5~~ ft) of conductor length from the point of connection to the service

Submitter Information Verification**Committee:** NEC-P04**Submittal Date:** Thu Nov 01 11:03:22 EDT 2018**Committee Statement**

Committee Statement: Conductor lengths in this section were chosen to address installations where equipment distances would be impractical or impossible to apply consistently. These lengths represent practical values that will allow suitable listed equipment to be installed in a manner that does not violate it's listing.

Where cable limiters are used they must be installed in all ungrounded conductors, including parallel conductors. A practical conductor length has been added from the point of connection to an in-line cable limiter to allow the location of the cable limiter to be placed where easily serviceable.

These distances change based upon occupancy type because cable limiters are not commonly used in dwelling units.

Response Message: SR-8156-NFPA 70-2018

[Public Comment No. 1776-NFPA 70-2018 \[Section No. 705.11\]](#)

[Public Comment No. 1657-NFPA 70-2018 \[Section No. 705.11\(C\)\]](#)

[Public Comment No. 309-NFPA 70-2018 \[New Section after 705.11\(C\)\]](#)



Second Revision No. 8159-NFPA 70-2018 [Section No. 705.11(D)]

(D) Bonding and Grounding.

All metal enclosures, metallic wiring methods, and metal parts associated with the power source output conductors in 705.11(B) shall be bonded in accordance with 250.92(B). This metallic equipment shall be connected to the grounding electrode system for the service at the power source disconnecting means with only one of the methods. The grounding terminal or bus for the disconnecting means in 705.11(D)(1) or (D)(2). Where the power sources use a grounded conductor, 705.11(D)(1) shall apply.

(1) Grounded Conductor Brought to Power Source Disconnecting Means.

Where a grounded service conductor is brought to the power source disconnecting means, the grounded conductor shall be connected to the disconnecting means grounded conductor terminal or bus. A bonding conductor shall connect the grounded service conductor to the metallic equipment enclosing the power source output circuit conductors. This bonding conductor shall be

F) shall be connected to a supply side bonding jumper, sized in accordance with 250.102, based on the size of the

power source output circuit

conductors in 705.

11 {

2) Grounded Conductor Not Brought to Power Source Disconnecting Means. Where a grounded service conductor is not brought to the power source disconnecting means, the metallic equipment enclosing the power source output circuit conductors shall be bonded to the grounding electrode system using a separate bonding conductor sized in accordance with 250.102 based on the size of the power source output circuit conductors

B). The supply side bonding jumper shall be connected to the grounded service conductor within or ahead of the service disconnecting means. If the power production equipment requires a grounded conductor, no connection shall be made between the supply side bonding jumper and the grounded conductor at the disconnecting means in 705.11(F).

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Thu Nov 01 11:25:00 EDT 2018

Committee Statement

Committee Statement: The revised text better explains the bonding and grounding methods for this type of equipment. The first draft text permitted the possibility of parallel paths and was unclear on the use of grounded conductors. These requirements provide adequately sized conductors for an effective fault current path back to the utility source.

Response Message: SR-8159-NFPA 70-2018

[Public Comment No. 1999-NFPA 70-2018 \[Section No. 705.11\(D\) \[Excluding any Sub-Sections\]\]](#)

[Public Comment No. 363-NFPA 70-2018 \[Section No. 705.11\(D\)\]](#)

[Public Comment No. 1990-NFPA 70-2018 \[Section No. 705.11\(D\)\]](#)

**Second Revision No. 8176-NFPA 70-2018 [Section No. 705.11(E)]****(E) Connections.**

The connection of power source output circuit conductors to the service conductors shall be made using listed connectors as described in 110.14 and comply with all enclosure fill requirements. Any modifications to existing equipment shall be made in accordance with the manufacturer's instructions or the modification must be field-labeled.

~~Informational Note: Electric utilities enforce their requirements for connections to equipment under their control. See 90.2.~~

evaluated for the application and have a field label applied. For meter socket enclosures or other equipment under the exclusive control of the electric utility, only connections approved by the electric utility shall be permitted.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Thu Nov 01 13:58:20 EDT 2018

Committee Statement

Committee Statement: Stating that equipment has a field evaluation does not guarantee that a field label is installed. NFPA 791 includes a recommendation for a label to be installed but does not mandate it as quoted below. The process of applying a field label for field evaluated equipment is extremely important for AHJs.

This change incorporates the informational note into positive Code text to clarify that connections in equipment under the exclusive control of a utility shall only be made where approved by the utility, in accordance with 90.2(B).

Response Message: SR-8176-NFPA 70-2018

Public Comment No. 1531-NFPA 70-2018 [Section No. 705.11(E)]

Public Comment No. 310-NFPA 70-2018 [Section No. 705.11(E)]

Public Comment No. 1671-NFPA 70-2018 [Section No. 705.11(E)]

**Second Revision No. 8178-NFPA 70-2018 [Section No. 705.11(F)]****(F) Disconnecting Means.**

The power source disconnecting means shall meet the requirements of 705.20. The power source disconnecting means shall not be considered as one of the service disconnecting means as required by 230.70. The requirements of 230.71- ~~or and~~ 230.72 shall ~~not~~ apply to the power source disconnecting means ~~that are installed in accordance with 230.2(A)(5) or 230.40 Exception No. 5.~~ The conductors ~~between the point of connection and the disconnect shall be connected to~~ connected to the service conductors shall be terminated on the line side of the disconnect. Equipment containing a power source disconnecting means rated 1000 V or less shall be listed as suitable for use as service equipment.

Submitter Information Verification**Committee:** NEC-P04**Submittal Date:** Thu Nov 01 14:11:57 EDT 2018**Committee Statement**

Committee Statement: The revised text mandates SUSE rating of this disconnecting means and recognizes the application of the service disconnect rules that are defined in Article 230, as applying to this section.

The same hazards that exist for service entrance equipment exist for line side connections. While most of the safeguards implied by equipment marked as being suitable for use as service equipment are included in this section, some are not. In particular, barriers around line-side components that are not de-energized when the disconnect is opened in certain types of equipment, such as UL 891 switchboards, are covered by requiring marking as suitable for use as service equipment.

Additional references to 230.2(A)(5) and 230.40 Exception No. 5 identify requirements already in existence to clarify that premises are permitted to have an additional service for parallel power production and service entrance conductors connected to the supply side of normal service disconnecting means are permitted to supply several systems.

Response Message: SR-8178-NFPA 70-2018

[Public Comment No. 315-NFPA 70-2018 \[Section No. 705.11\(F\)\]](#)

[Public Comment No. 1209-NFPA 70-2018 \[Section No. 705.11\(F\)\]](#)

[Public Comment No. 1678-NFPA 70-2018 \[Section No. 705.11\(F\)\]](#)



Second Revision No. 8148-NFPA 70-2018 [Section No. 705.12(B)]

FOR CODE-MAKING PANEL USE ONLY
SUBJECT TO REVISION - NOT FOR PUBLICATION

(B) Bus or Conductor Ampere Rating.

FOR CODE-MAKING PANEL USE ONLY
SUBJECT TO REVISION - NOT FOR PUBLICATION

~~One hundred twenty-five percent of the~~ The power source output circuit current multiplied by 125 percent shall be used in ampacity calculations for the following: 705.12(B)(1) through (B)(2).

(1) Feeders.

Where the power source output connection is made to a feeder, the feeder shall have an ampacity greater than or equal to 125 percent of the power-source output circuit current. Where the power-source output connection is made to a feeder at a location other than the opposite end of the feeder from the primary source overcurrent device, that portion of the feeder on the load side of the power source output connection shall be protected by one of the following:

— The feeder ampacity shall be not less than the sum of the primary source overcurrent device and 125 percent of the power-source output circuit current.

— An overcurrent device at the load side of the power source connection point shall be rated not greater than the ampacity of the feeder.

(2) Taps.

Where power source output connections are made at feeders, all taps shall be sized based on the sum of 125 percent of all power source(s) output circuit current(s) and the rating of the overcurrent device protecting the feeder conductors for sizing tap conductors using the calculations in 240.21(B) .

(3) Busbars.

One of the following methods shall be used to determine the ratings of busbars:

- 1) — The sum of 125 percent of the power source(s) output circuit current and the rating of the overcurrent device protecting the busbar shall not exceed the ampacity of the busbar.

Informational Note: This general rule assumes no limitations in the number of the loads or sources applied to busbars or their locations.

- 2) — Where two sources, one a primary power source and the other another power source, are located at opposite ends of a busbar that contains loads, the sum of 125 percent of the power-source(s) output circuit current and the rating of the overcurrent device protecting the busbar shall not exceed 120 percent of the ampacity of the busbar. The busbar shall be sized for the loads connected in accordance with Article 220 . A permanent warning label shall be applied to the distribution equipment adjacent to the back-fed breaker from the power source that displays the following or equivalent wording:

WARNING: POWER SOURCE OUTPUT CONNECTION —DO NOT RELOCATE THIS OVERCURRENT DEVICE.

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

- 3) — The sum of the ampere ratings of all overcurrent devices on panelboards, both load and supply devices, excluding the rating of the overcurrent device protecting the busbar, shall not exceed the ampacity of the busbar. The rating of the overcurrent device protecting the busbar shall not exceed the rating of the busbar. Permanent warning labels shall be applied to distribution equipment displaying the following or equivalent wording:

WARNING: THIS EQUIPMENT FED BY MULTIPLE SOURCES. TOTAL RATING OF ALL OVERCURRENT DEVICES EXCLUDING MAIN SUPPLY OVERCURRENT DEVICES SHALL NOT EXCEED AMPACITY OF BUSBAR.

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

- 4) — A connection at either end of a center-fed panelboard in dwellings shall be permitted where the sum of 125 percent of the power-source(s) output circuit current and the rating of the overcurrent device protecting the busbar does not exceed 120 percent of the current rating of the busbar.
- 5) — Connections shall be permitted on switchgear, switchboards, and panelboards in configurations other than those permitted in 705.12(B) (3)(

a

1) through (

d

4) where designed under engineering supervision that includes available fault-current and busbar load

calculations.

6) Connections shall be permitted on busbars of panelboards that supply lugs connected to feed-through lugs and conductors

connected to the lugs opposite the main source of supply. The ampacity of the busbar and connected feeders shall not be less than the sum of the primary source overcurrent device and 125 percent of the power-source output circuit current.

Informational Note to a: This general rule assumes no limitation in the number of the loads or sources applied to busbars or their locations.

. The feed-through conductors shall be sized in accordance with 705.12(B)(1). Where an overcurrent device is installed at the supply end of the feed-through conductors, the busbar in the supplying panelboard shall be permitted to be sized in accordance with 705.12(B)(3)(2).

Supplemental Information

<u>File Name</u>	<u>Description Approved</u>
70_CMP04_SR8148_705.12_B_.docx	for staff use

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Wed Oct 31 16:21:56 EDT 2018

Committee Statement

Committee Statement: Editorial changes have been made to the main paragraph of this section, along with the reinstatement of the subsection titles, to better align with the NEC Style Manual.

The informational note has been moved to be located directly after subsection (B)(3) list item (1) to comply with the Style Manual [2015 3.1.3].

705.12(B)(3)(6) is further edited to clarify how panelboards with feed-through conductors shall be sized and how the feed-through conductors are sized.

Response Message: SR-8148-NFPA 70-2018

Public Comment No. 210-NFPA 70-2018 [Section No. 705.12(B)]

Public Comment No. 2195-NFPA 70-2018 [Section No. 705.12(B)]

Public Comment No. 115-NFPA 70-2018 [Section No. 705.12(B)]

Public Comment No. 1777-NFPA 70-2018 [Section No. 705.12(B)]

**Second Revision No. 8150-NFPA 70-2018 [Section No. 705.12(D)]**

(D) Suitable for Backfeed.

Fused disconnects, unless otherwise marked, shall be considered suitable for backfeed. Circuit breakers , if ~~backfed,~~ not marked "line" and "load" shall be considered suitable for ~~such operation.~~

Informational Note:-

backfeed. Circuit breakers marked

"line" and "load" may not be

"line" and "load" shall be considered suitable for backfeed or reverse current if specifically rated.

Supplemental Information

<u>File Name</u>	<u>Description Approved</u>
70_CMP04_SR8150_705.12_D_.docx	for staff use

Submitter Information Verification

Committee: NEC-P04

Submission Date: Wed Oct 31 17:02:24 EDT 2018

Committee Statement

Committee Statement: This SR provides editorial changes to further clarify the requirement and moves the informational note into the regulatory text to remove the "may" in the note.

Response Message: SR-8150-NFPA 70-2018

Public Comment No. 1778-NFPA 70-2018 [Section No. 705.12(D)]



Second Revision No. 8184-NFPA 70-2018 [Section No. 705.12 [Excluding any Sub-Sections]]

The output of an interconnected electric power source shall be permitted to be connected to the load side of the service disconnecting means of the other source(s) at any distribution equipment on the premises. Where distribution equipment, including switchgear, switchboards, or panelboards, is or feeders are fed simultaneously by a primary source (s) of electricity and one or more other power source(s), and where this distribution equipment is are capable of supplying multiple branch circuits or feeders, or both, the interconnecting provisions for other power sources equipment shall comply with 705.12(A) through (E). Where a PCS is installed in accordance with 705.13, the setting of the PCS controller shall be considered the power-source output circuit current in 705.12(A) through (E).

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Thu Nov 01 15:02:33 EDT 2018

Committee Statement

Committee Statement: A reference to 705.13 has been added to clarify the current values to be used in the calculations within 705.12 where connecting feeders connected to PCS to other distribution equipment. Removal of specific equipment terms has been removed to ensure that the rules in subsections of 705.12(B) are properly applied without conflicts.

Response Message: SR-8184-NFPA 70-2018

[Public Comment No. 1911-NFPA 70-2018 \[Section No. 705.12\]](#)

**Second Revision No. 8151-NFPA 70-2018 [Section No. 705.13]****705.13 Power Control Systems.**[SEE ATTACHED FOR CHANGES]

A power control system (PCS) is a system that controls the output of one or more power production sources, energy storage systems (ESS), and other equipment. The PCS limits current and loading on the busbars and conductors supplied by the PCS.

The sum of the individual production power source output ratings of all sources controlled by a PCS shall be permitted to exceed the rating of the busbars or the ampacity of the conductors supplied by the PCS-controlled power production sources. A PCS shall be listed for the purpose and installed in accordance with the following:

- (1) The PCS shall monitor or control all currents supplying a busbar or conductor. The PCS listing shall include functionality as an overcurrent protective device.
- (2) The sum of all controlled power source currents plus all monitored currents from other sources of supply shall not exceed the ratings of any busbar conductor ampacity supplied by the power production source currents.
- (3) The rating of any single power source output overcurrent protective device shall not exceed the rating of the busbar or the ampacity of the conductors to which it is connected.
- (4) The controlled maximum continuous output setting of the PCS controller shall be used as the power source output current rating used for the calculation of currents in connections complying with 705.11 or 705.12.
- (5) The access to power control settings of the PCS shall be restricted to qualified personnel only in accordance with the requirements of 240.6(C)(1), (C)(2), or (C)(3).

Supplemental Information

<u>File Name</u>	<u>Description Approved</u>
70_CMP04_SR8151_705.13.docx	for staff use

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Wed Oct 31 17:23:09 EDT 2018

Committee Statement

Committee Statement: The first paragraph was converted to requirements to comply with the Style Manual.

This second revision is a continued refinement of the language developed during the first draft process. Most of the changes are reorganizing the information for clarity. The language related to 705.11 and 705.12 needed to be clarified as it is related much more to how things are monitored. PCS connected using 705.11 requires that the PCS monitor the service conductors and prevent their overload.

The language was revised to differentiate monitoring from control functions. A PCS will often be evaluated as an overcurrent device or be connected to an overcurrent device to protect the output in the event of a control failure.

Access to settings are revised to simply refer to 240.6 as all subsections may apply.

Response Message: SR-8151-NFPA 70-2018

Public Comment No. 2169-NFPA 70-2018 [Section No. 705.13]

**Second Revision No. 8152-NFPA 70-2018 [Section No. 705.14]****705.14** Output Characteristics.

The output of a ~~generator or other electric~~ power production source operating in parallel with an electrical supply system shall be compatible with the voltage, wave shape, and frequency of the system to which it is connected. Synchronous generators operating in parallel with an electrical supply system shall be provided with the necessary equipment to establish and maintain a synchronous condition.

Informational Note: The term *compatible* does not necessarily mean matching the primary source wave shape.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Wed Oct 31 17:27:36 EDT 2018

Committee Statement

Committee Statement: In the first draft, the section that was moved from 705.143 to the second sentence of 705.14 was not correctly recorded. This SR also deletes the extraneous wording in the first sentence.

Response Message: SR-8152-NFPA 70-2018 See also Second Revisions No. 8193 and 8196.

Public Comment No. 319-NFPA 70-2018 [Part IV.]



Second Revision No. 8153-NFPA 70-2018 [Section No. 705.20]

FOR CODE-MAKING PANEL USE ONLY
SUBJECT TO REVISION - NOT FOR PUBLICATION

705.20 Disconnecting Means, Source.

Means shall be provided to disconnect all conductors that are not solidly grounded of an power source output circuit conductors of electric power production source(s) from all other conductors equipment from conductors of other systems .

The disconnecting means shall consist of a manual or power operated switch(es) or circuit breaker(s) that complies with the following: comply with the following:

- (1) Be one of the following types:
 - (2) A manually operable switch or circuit breaker
 - (3) A load-break-rated pull-out switch
 - (4) A power-operated or remote-controlled switch or circuit breaker that is manually operable locally and opens automatically when control power is interrupted
 - (5) A device listed or approved for the intended application
- (6) Simultaneously disconnect all ungrounded conductors of the circuit
- (7) Located where readily accessible
- (8) Externally operable without exposing the operator to contact with live parts and, if power operated, of a type that is opened by hand in the event of a power-supply failure
Where disconnecting means are readily accessible to unqualified persons, any enclosure door or hinged cover that exposes
- (9) exposed live parts
- (10) Enclosures with doors or hinged covers with exposed live parts when open shall be locked or require a tool to open ; or be lockable where readily accessible to unqualified persons
- (11) Plainly indicate whether in the open (off) or closed (on) position
- (12) Have ratings sufficient for the maximum circuit current, available fault current, and voltage that is available at the terminals
- (13) Where the Be marked in accordance with the warning in 690.13(B), where the line and load terminals are capable of being energized in the open position, marked in accordance with the warning in 690.13(B)

Informational Note :- In parallel generation systems . With interconnected power sources , some equipment, including knife blade switches and fuses, is likely to be energized from on both directions sides . See 240.40 .
- (14) Simultaneously disconnect all ungrounded conductors of the circuit
- (15) Be lockable in the open (off) position in accordance with 110.25
- (16) Disconnecting means shall be one of the following:
 - (17) A manually operable switch or circuit breaker
 - (18) A load-break-rated pull-out switch
 - (19) A remote-controlled switch or circuit breaker that is operable locally and opens automatically when control power is interrupted
 - (20) A device listed or approved for the intended application
- (21)
- (22)
- (23)
 - (a)
 - (b) _
 - (c)
 - (d)

Supplemental Information

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Submitter Information Verification

Committee: NEC-P04

Submittal Date: Wed Oct 31 17:50:48 EDT 2018

Committee Statement

Committee Statement: Changes made to this section relocate the mandatory disconnect types to the top of the list and consolidate duplicative language to improve the usability of the Code. The use of undefined terms have been removed and several editorial changes have been made to improve grammar.

Response Message: SR-8153-NFPA 70-2018

[Public Comment No. 1842-NFPA 70-2018 \[New Section after 705.20\]](#)

[Public Comment No. 1829-NFPA 70-2018 \[Section No. 705.20\]](#)

FOR CODE-MAKING PANEL USE ONLY
SUBJECT TO REVISION - NOT FOR PUBLICATION



Second Revision No. 8190-NFPA 70-2018 [Section No. 705.28]

705.28 Circuit Sizing and Current.

(A) Calculation of Maximum Circuit Current.

~~The~~ Where not elsewhere required or permitted in this Code, the maximum current for the circuit shall be the continuous output current rating of the power source production equipment .

(B) Conductor Ampacity.

~~The loads on power source output circuit conductors are continuous currents. The circuit conductors~~ Where not elsewhere required or permitted in this Code, the circuit conductors shall be sized to carry not less than 125 percent ~~the largest~~ of the following:

(1) The maximum currents

as calculated

(1) in 705.28(B)

~~B). Power source output circuit conductors that are connected to a feeder~~

(1) A) multiplied by 125 percent without adjustment or correction factors

(2) The maximum currents in 705.28(A) with adjustment and correction factors

(3) Where connected to feeders, if smaller than the feeder conductors,

~~shall be sized to carry not less than the larger of the current~~

(1) the ampacity as calculated in

~~705.28(B) or as calculated in accordance with~~

(1) 240.21(B) based on the over-current device protecting the feeder

~~7~~

(1)

(C) Ampacity of Neutral Conductor Conductors .

~~The ampacity of the neutral. Neutral conductors shall comply with either~~ be permitted to be sized in accordance with 705.28(C)(1) or and (C)(2).

(1) Neutral Conductor for Single-Phase, 2-Wire Power Source Output.

~~If a single-phase, 2-wire power source output is connected to the neutral and one ungrounded conductor (only) of a 3-wire system or of a 3-phase, 4-wire, wye-connected system, the maximum load connected between the neutral and any one ungrounded conductor plus the power source output rating shall not exceed the ampacity of the neutral conductor.~~

Line-to-Neutral Power Sources.

~~Where not elsewhere required or permitted in this Code, the ampacity of a neutral conductor to which a single-phase line-to-neutral power source is connected shall not be smaller than the ampacity in 705.28(B).~~

(2) Neutral Conductor Used Solely for Instrumentation, Voltage, Detection, or Phase Detection.

~~A power production equipment neutral conductor used solely for instrumentation, voltage detection, or phase detection, and connected to a single-phase or 3-phase power source, shall be permitted to be sized at less than the ampacity of the other current-carrying conductors and shall be sized equal to or larger than the equipment grounding conductor. in accordance with 250.102.~~

Supplemental Information

<u>File Name</u>	<u>Description Approved</u>
70_CMP04_SR8190_705.28.docx	for staff use

Submitter Information Verification**Committee:** NEC-P04**Submittal Date:** Thu Nov 01 16:40:25 EDT 2018**Committee Statement**

Committee Statement: This revision aligns the current and ampacity requirements with similar work done by this panel in Article 690 and provides an opening sentence in 705.28 for clarity. Changes made to this subsection allow for current and ampacity calculations for specific power sources if defined elsewhere in the Code. Where guidance is not otherwise provided, clarified requirements are provided here for conductors that need correction or adjustment in 705.28(B). A list is created to clarify that the ampacity is the largest of three possible calculations. The language in 705.28(C) is revised to align with language in 690 and to clarify how line-to-neutral connected equipment and neutrals not used for power output are sized.

Response Message: SR-8190-NFPA 70-2018

Public Comment No. 1779-NFPA 70-2018 [Section No. 705.28(B)]

FOR CODE-MAKING PANEL USE ONLY
SUBJECT TO REVISION - NOT FOR PUBLICATION

**Second Revision No. 8193-NFPA 70-2018 [Section No. 705.30]****705.30** Overcurrent Protection.**(A)** Circuit and Equipment.

Power source output circuit conductors and equipment shall be ~~protected in accordance with Article 240 provided with overcurrent protection~~ . Circuits connected to more than one electrical source shall have overcurrent devices located ~~so as~~ to provide overcurrent protection from all sources.

(B) Overcurrent Device Ratings.

The overcurrent devices in other than generator systems shall be sized to carry not less than 125 percent of the maximum currents as calculated in 705.28(A). The rating or setting of overcurrent devices shall be permitted in accordance with 240.4(B) and (C)

Exception: Circuits containing an assembly together with its overcurrent device(s) that is listed for continuous operation at 100 percent of its rating shall be permitted to be utilized at 100 percent of its rating.

(C) Power Transformers.

~~Overcurrent protection for a transformer with a source(s)~~ Transformers with sources on each side shall be provided ~~with overcurrent protection~~ in accordance with 450.3 ~~by considering first one side of the transformer, then the other side of the transformer, as the primary~~ . The primary shall be the side connected to the largest source of available fault current. Secondary protection shall not be required for a transformer secondary that has a current rating not less than the sum of the rated continuous output currents of the power sources connected to that secondary .

(D) Generators.

Generators shall be ~~protected~~ provided with overcurrent protection in accordance with 445.12.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Thu Nov 01 16:50:49 EDT 2018

Committee Statement

Committee Statement: This revision further refines the language that was reorganized in the first revision. Editorial change to 705.30(A) and (D) is to align with similar language in Article 690 and elsewhere in the Code. This revision also restores language that was inadvertently removed from 705.30(C) in the first draft related to the informational note. The information from the note is converted into legislative text for clarity of enforcement.

Response Message: SR-8193-NFPA 70-2018

**Second Revision No. 8196-NFPA 70-2018 [New Section after 705.40]****705.45 Unbalanced Interconnections.****(A) Single Phase.**

Single-phase power sources in interactive systems shall be connected to 3-phase power systems in order to limit unbalanced voltages at the point of interconnection to not more than 3 percent.

Informational Note: For interactive power sources, unbalanced voltages can be minimized by the same methods that are used for single-phase loads on a 3-phase power system. See ANSI/C84.1-2016, Electric Power Systems and Equipment — Voltage Ratings (60 Hertz).

(B) Three Phase.

Three-phase power sources in interactive systems shall have all phases automatically de-energized upon loss of, or unbalanced, voltage in one or more phases unless the interconnected system is designed so that significant unbalanced voltages will not result.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Thu Nov 01 17:11:27 EDT 2018

Committee Statement

Committee Statement: This revision restores language that was inadvertently removed from 705.45 in the first draft. This language existed as 705.100 in the previous edition.

Response Message: SR-8196-NFPA 70-2018

**Second Revision No. 8195-NFPA 70-2018 [Section No. 705.40]****705.40** Loss of Primary Source.

~~An~~ The output of electric power production ~~source~~ equipment shall be automatically disconnected from all ungrounded conductors of the interconnected systems when one or more of the phases ~~opens~~ to which it is connected opens. The electric power production ~~source~~ equipment shall not be reconnected until all the phases of the ~~source~~ interconnected system to which it is connected are restored. This requirement shall not be applicable to ~~an~~ electric power production ~~source~~ equipment providing power ~~for~~ to an emergency or legally required standby system.

Exception: A listed interactive inverter shall ~~trip or shall~~ be permitted to automatically cease exporting power when one or more of the phases of the ~~source~~ interconnected system opens and shall not be required to automatically disconnect all ungrounded conductors from the primary source. A listed interactive inverter shall be permitted to automatically or manually resume exporting power to the ~~utility~~ interconnected system once all phases of the source to which it is connected are restored.

Informational Note No. 1: Risks to personnel and equipment associated with the primary source could occur if an interactive electric power production source can operate as an intentional island. Special detection methods are required to determine that a primary source supply system outage has occurred and whether there should be automatic disconnection. When the primary source supply system is restored, special detection methods ~~can be~~ are typically required to limit exposure of power production sources to out-of-phase reconnection.

Informational Note No. 2: Induction-generating equipment ~~connected~~ on systems with significant capacitance can become self-excited upon loss of the primary source and experience severe overvoltage as a result.

~~An interactive~~ Interactive power production ~~source~~ equipment shall be permitted to operate in a ~~stand-alone or islanded~~ island mode to supply loads that have been disconnected from the electric power production and distribution network.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Thu Nov 01 17:02:55 EDT 2018

Committee Statement

Committee Statement: Minor edits are made to the text and exception for clarification. All the instances of "source" are changed to be more specific and accurate of what is being referred to. The words "or more" are added when discussing loss of phase, since it is possible to lose 2 out of 3 phases in a 3-phase system. The exception adds that an inverter shall either trip or cease exporting power.

Response Message: SR-8195-NFPA 70-2018

[Public Comment No. 320-NFPA 70-2018 \[New Section after 705.40\]](#)

[Public Comment No. 1815-NFPA 70-2018 \[Section No. 705.40\]](#)

**Second Revision No. 8199-NFPA 70-2018 [Section No. 705.150]****705.150** System Operation.

Microgrid systems shall be permitted to disconnect from the primary source of power or other interconnected electric power production sources and operate ~~in stand-alone or islanded~~ as an isolated microgrid system operating in island mode.

Submitter Information Verification**Committee:** NEC-P04**Submittal Date:** Thu Nov 01 17:29:14 EDT 2018**Committee Statement**

Committee Statement: The revision edits the section for clarity to refer to isolated microgrids and island mode for consistency with other sections. Changes in terminology in this section better align with that used in other standards.

Response Message: SR-8199-NFPA 70-2018

[Public Comment No. 318-NFPA 70-2018 \[Section No. 705.150\]](#)

[Public Comment No. 1780-NFPA 70-2018 \[Section No. 705.150\]](#)

**Second Revision No. 8200-NFPA 70-2018 [Section No. 705.160]****705.160** Primary Power Source Connection.

Connections to primary power sources that are external to the microgrid system shall comply with the requirements of 705.11- and , 705.12, or 705 .13. Power source conductors connecting to a microgrid system, including conductors supplying distribution equipment, shall be considered as power source output conductors.

Submitter Information Verification**Committee:** NEC-P04**Submittal Date:** Thu Nov 01 17:32:39 EDT 2018**Committee Statement**

Committee Statement: This revision adds a reference to 705.13 to allow for the connection of PCS equipment and adds an "or" to clarify that only one of these sections is required for compliance.

Response Message: SR-8200-NFPA 70-2018

[Public Comment No. 1781-NFPA 70-2018 \[Section No. 705.160\]](#)

[Public Comment No. 2185-NFPA 70-2018 \[Section No. 705.160\]](#)

**Second Revision No. 8229-NFPA 70-2018 [Section No. 705.170]****705.170** Microgrid Interconnect Devices (MID).

Microgrid interconnect devices shall comply with the following:

- (1) Be required for any connection between a microgrid system and a primary power source
- (2) ~~Be listed or field-labeled~~ evaluated for the application and have a field label applied or be listed for the application
- (3) Have sufficient number of overcurrent devices located to provide overcurrent protection from all sources

Informational Note: MID functionality is often incorporated in an interactive or multimode inverter, energy storage system, or similar device identified for interactive operation.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Thu Nov 01 19:15:43 EDT 2018

Committee Statement

Committee Statement: Stating that equipment has a field evaluation does not guarantee that a field label is installed. NFPA 791 includes a recommendation for a label to be installed but does not mandate it as quoted below. The process of applying a field label for field evaluated equipment is extremely important for AHJs.

Response Message: SR-8229-NFPA 70-2018

Public Comment No. 1523-NFPA 70-2018 [Section No. 705.170]

**Second Revision No. 8202-NFPA 70-2018 [Section No. 710.1]****710.1 Scope.**

This article covers electric power production ~~sources operating in stand-alone or islanded mode. It also covers installations that are~~ systems that operate in island mode and installations not connected to an electric power production and distribution network.

Informational Note: These ~~sources~~ systems are capable of operating in ~~stand-alone or islanded island~~ mode, independent from the ~~an~~ electric power production and distribution network, and ~~may be either interactive or~~ include isolated microgrid systems ~~or interactive with other power sources~~. Stand-alone systems ~~may include~~ often include a single or a completable interconnection of sources such as engine generators, solar PV, wind, ESS, or batteries.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Thu Nov 01 17:39:05 EDT 2018

Committee Statement

Committee Statement: CMP-4 requests that the Correlating Committee review these changes to the scope of Article 710, which better align the scope with the revised content of the Article. The informational note was revised to remove language that could be perceived as being permissive and to recognize that stand-alone systems could include single or multiple sources, where they are compatible with each other.

Response Message: SR-8202-NFPA 70-2018

[Public Comment No. 1177-NFPA 70-2018 \[Section No. 710.1\]](#)

[Public Comment No. 1783-NFPA 70-2018 \[Section No. 710.1\]](#)

**Second Revision No. 8208-NFPA 70-2018 [Definition: Stand-Alone (Islanded) Mode.]****Stand-Alone (Islanded)- [710.2, move to 100]****Island Mode.**

The ~~mode when~~ operational mode for stand-alone power production equipment or an isolated microgrid, or for a multimode inverter or an interconnected microgrid that is disconnected from ~~the~~ an electric power production and distribution network or other primary power source. (CMP-4)

Informational Note:- For isolated stand-alone systems and isolated microgrids, stand-alone or islanded mode is the primary mode of operation. Isolated microgrids are distinguished from interconnected microgrids, which are ~~defined~~ addressed in Article 705. 2.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Thu Nov 01 17:57:15 EDT 2018

Committee Statement

Committee Statement: Changes are made to this definition to better clarify the use of the term and how it applies to various applications that operate in island mode.

Response Message: SR-8208-NFPA 70-2018

Public Comment No. 308-NFPA 70-2018 [Definition: Stand-Alone (Islanded) Mode.]

Public Comment No. 1782-NFPA 70-2018 [Definition: Stand-Alone (Islanded) Mode.]

**Second Revision No. 8209-NFPA 70-2018 [Section No. 710.6]****710.6 Equipment Approval.**

All equipment shall be ~~listed or field-labeled~~ approved for the intended use in accordance with one of the following:

- (1) Be listed for the application
- (2) Be evaluated for the application and have a field label applied

Informational Note: Inverters identified as "multimode" and "stand-alone" are specifically identified and certified to operate in this application. Stand-alone inverters operate in island mode. Multimode inverters operate in either island mode (previously called "stand-alone mode") or interactive mode, if it has been installed with the optional utility grid connection. A multimode inverter will only operate in island mode if it is never connected to an electric utility supply. Stand-alone inverters are not evaluated for and are not intended for connection to export power in parallel with an electric utility.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Thu Nov 01 18:05:46 EDT 2018

Committee Statement

Committee Statement: Stating that equipment has a field evaluation does not guarantee that a field label is installed. NFPA 791 includes a recommendation for a label to be installed but does not mandate it as quoted below. The process of applying a field label for field evaluated equipment is extremely important for AHJs.

A new informational note has been added to clarify how different terms in product standards are used in Article 710.

Response Message: SR-8209-NFPA 70-2018

Public Comment No. 1525-NFPA 70-2018 [Section No. 710.6]

**Second Revision No. 8210-NFPA 70-2018 [Section No. 710.10]****710.10 Identification of Power Sources.**

A permanent plaque or directory shall be installed at a building supplied by a stand-alone system at each service equipment location, or at an approved readily visible location. The plaque or directory shall denote the location of each power source disconnecting means for the ~~premises- building~~ or be grouped with other plaques or directories for other on-site sources. ~~The~~ Where multiple sources supply the building the plaque or directory shall be marked with the wording "CAUTION: MULTIPLE SOURCES OF POWER". The marking shall comply with 110.21(B).

Exception: Installations with multiple co-located power production sources shall be permitted to be identified as a group(s). The plaque or directory shall not be required to identify each power source individually.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Thu Nov 01 18:14:51 EDT 2018

Committee Statement

Committee Statement: Changes made to this section harmonize the directory requirements for onsite sources across various articles.

Response Message: SR-8210-NFPA 70-2018

Public Comment No. 1854-NFPA 70-2018 [Section No. 710.10]

**Second Revision No. 8213-NFPA 70-2018 [Section No. 710.15]****710.15 General.**

Premises wiring systems shall be adequate to meet the requirements of this Code for similar installations supplied by a feeder or service. The wiring on the supply side of the building or structure disconnecting means shall comply with the requirements of this Code, except as modified by 710.15(A) through (F).

(A) Supply Output.

Power supply to premises wiring systems fed by stand-alone or isolated microgrid power sources shall be permitted to have less capacity than the calculated load. The capacity of the sum of all sources of the stand-alone supply shall be equal to or greater than the load posed by the largest single utilization equipment connected to the system. Calculated general lighting loads shall not be considered as a single load.

Informational Note: For general-use loads the system capacity can be calculated using the sum of the capacity of the firm sources, such as generators and ESS inverters. For specialty loads intended to be powered directly from a variable source, the capacity can be calculated using the sum of the variable sources, such as PV or wind inverters, or the combined capacity of both firm and variable sources.

(B) Sizing and Protection.

The circuit conductors between a stand-alone source and a building or structure disconnecting means shall be sized based on the sum of the output ratings of the stand-alone source(s). For three-phase interconnections, the phase loads shall be controlled or balanced to be compatible with specifications of the sum of the power supply capacities.

(C) Single 120-Volt Supply.

Stand-alone and isolated microgrid systems shall be permitted to supply 120 volts to single-phase, 3-wire, 120/240-volt service equipment or distribution panels where there are no 240-volt outlets and where there are no multiwire branch circuits. In all installations, the sum of the ratings of the power sources shall be less than the rating of the neutral bus in the service equipment. This equipment shall be marked with the following words or equivalent:

WARNING:SINGLE 120-VOLT SUPPLY. DO NOT CONNECT MULTIWIRE BRANCH CIRCUITS!The warning sign(s) or label(s) shall comply with 110.21(B).

(D) Three-phase Supply.

Stand-alone and microgrid systems shall be permitted to supply three-phase, 3-wire or 4-wire systems.

(E) Energy Storage or Backup Power System Requirements.

Energy storage or backup power supplies shall not be required.

(E F) Backfed Back-fed Circuit Breakers.

Plug-in-type backfed back-fed circuit breakers connected to an interconnected supply shall be secured in accordance with 408.36(D). Circuit breakers marked "line" and "load" shall not be backfed.

(F G) Voltage and Frequency Control.

The stand-alone or isolated microgrid supply shall be controlled so that voltage and frequency remain within suitable limits for the connected loads.

Submitter Information Verification

Committee: NEC-P04

Submittal Date: Thu Nov 01 18:20:37 EDT 2018

Committee Statement

Committee Statement: New language has been added to (B) and a new (D) to recognize that stand-alone systems often include three-phase applications.

**Response
Message:**

The term back-fed has been changed to add a hyphen to align with the majority of usage of this term in the Code.

SR-8213-NFPA 70-2018

[Public Comment No. 1784-NFPA 70-2018 \[Section No. 710.15\]](#)

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