light to result in hazardous levels of voltage and current; furthermore it is very difficult to cover the array in a reliable manner – covers are likely to fall off or blow off in the wind, and irradiance can also energize modules through the backsheet.

Replacing "irradiated" with "energized" removes a very loaded word that is subject to misinterpretation from the text and substitutes a term that is used in other places in Article 690, including in Section 690.2 Definitions.

**Panel Meeting Action: Accept in Part**

1) Reject the deletion of "or opaque covering".

2) Accept the change to "energized"

**Panel Statement:** The panel rejects removal of opaque covering. It needs to be retained for microinverters and ac modules.

**Number Eligible to Vote: 13**

**Ballot Results:** Affirmative: 13

**Comment on Affirmative:**

BOWER, W.: Opaque covering is used as a viable means of disabling an ac module or micro inverter system, but it is generally not as practical for large PV arrays. Factors such as wind can make using a large opaque covering unsafe if it blows off even part of the modules.

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4-284 Log #2273 NEC-P04 **Final Action: Reject**
**(690.19 (New) )**

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**Submitter:** Leo F. Martin, Sr., Martin Electrical Consulting

**Recommendation:** Add a new section 690.19

690.19 Interrupting and Short Circuit Current Rating. Consideration shall be given to the contribution of fault currents from all interconnected power sources for the interrupting and short-circuit current ratings of equipment on interactive systems.

**Substantiation:** 705.16 Addresses interrupting and short-circuit current rating. Creation of 690.19 will provide for interrupting and short-circuit current rating for solar photovoltaic (PV) systems.

**Panel Meeting Action: Reject**

**Panel Statement:** There is no need for a new section. Equipment already has this information provided in the listing. This is already covered by 705.16. Section 690.9 addresses the submitter's concerns.

The requirements found in Article 690 already mandate that PV systems and components be sized to accommodate the maximum short circuit current ratings that are delivered by the PV system. Short circuit current ratings and interrupting ratings are not required to be calculated in excess of these ratings as PV systems are a finite source of energy.

**Number Eligible to Vote: 13**

**Ballot Results:** Affirmative: 13

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* 4-284a Log #CP415 NEC-P04 **Final Action: Accept**
**(690.31)**

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**TCC Action: It was the action of the Correlating Committee that the panel action on this proposal be reconsidered and the text be rewritten to use letters rather than numbers for each list item in the sub-list of 690.31(G)(3) in compliance with 2.1.5.3, Level 3 of the NEC Style Manual.**

**The Correlating Committee directs that the panel change the word "when" to "where" in the first sentence in this proposal and in 690.31(D) since this is not a condition of time.**

**The Correlating Committee further directs the panel to address the permissive use of the word "may" in the Informational Notes in accordance with the NEC Style Manual.**

**This action will be considered as a public comment.**

**Submitter:** Code-Making Panel 4,

* **Recommendation:** Revise 690.31 to read as follows:

690.31 Methods Permitted.

(A) Wiring Systems. All raceway and cable wiring methods included in this Code, other wiring systems and fittings specifically listed for use on 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 photovoltaic source and output circuits operating at maximum system voltages greater than 30 volts are installed in readily accessible locations, circuit conductors shall be guarded or installed in a raceway.

Informational Note: Photovoltaic modules operate at elevated temperatures when exposed to high ambient temperatures and to bright sunlight. These temperatures may routinely exceed 70°C (158°F) in many locations. Module interconnection conductors are available with insulation rated for wet locations and a temperature rating of 90°C (194°F) or greater.

(B) Identification and Grouping. PV source circuits and PV output circuits shall not be contained in the same raceway, cable tray, cable, outlet box, junction box, or similar fitting as conductors, feeders, branch circuits of other non-PV systems, or inverter output circuits unless the conductors of the different systems are separated by a partition. PV system conductors shall be identified and grouped as required by 690.31(B)(1) through (4). The means of identification shall be permitted by separate color coding, marking tape, tagging, or other approved means.

(1) PV Source Circuits. PV source circuits shall be identified at all points of termination, connection, and splices.

(2) PV Output and Inverter Circuits. The conductors of PV output circuits and inverter input and output circuits shall be identified at all points of termination, connection, and splices.

(3) Conductors of Multiple Systems. Where the conductors of more than one PV system occupy the same junction box, raceway, or equipment, the conductors of each system shall be identified at all termination, connection, and splice points.

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

(4) Grouping. Where the conductors of more than one PV system occupy the same junction box or raceway with a removable cover(s), the ac and dc conductors of each system shall be grouped separately by cable ties or similar means at least once, and then shall be grouped at intervals not to exceed 1.8 m (6 ft).

Exception: The requirement for grouping shall not apply if the circuit enters from a cable or raceway unique to the circuit that makes the grouping obvious.

(C) Single-Conductor Cable. Single-conductor cable type USE-2, and single-conductor cable listed and labeled as photovoltaic (PV) wire shall be permitted in exposed outdoor locations in PV source circuits for PV module interconnections within the PV array.

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

Informational Note: Photovoltaic (PV) wire [also photovoltaic (PV) cable] has a nonstandard outer diameter. Conduit fill may be calculated using Table 1 of Chapter 9.

(D) Multi-conductor Cable. Multi-conductor cable type TC-ER or USE-2 shall be permitted in outdoor locations in PV inverter output circuits when used with utility-interactive inverters mounted in not-readily-accessible locations. The cable shall be secured at intervals not exceeding 1.8m (6 ft.). Equipment grounding for the utilization equipment shall be provided by an equipment grounding conductor within the cable.

(E) Flexible Cords and Cables. Flexible cords and cables, where used to connect the moving parts of tracking PV modules, shall comply with Article 400 and shall be of a type identified as a hard service cord or portable power cable; they shall be suitable for extra-hard usage, listed for outdoor use, water resistant, and sunlight resistant. Allowable ampacities shall be in accordance with 400.5. For ambient temperatures exceeding 30°C (86°F), the ampacities shall be derated by the appropriate factors given in Table 690.31(E).

***Insert Existing Table 690.31(C) Correction Factors Renumbered as Table 690.31(E)***(not submitted)

(F) Small-Conductor Cables. Single-conductor cables listed for outdoor use that are sunlight resistant and moisture resistant in sizes 16 AWG and 18 AWG shall be permitted for module interconnections where such cables meet the ampacity requirements of 690.8. Section 310.15 shall be used to determine the cable ampacity adjustment and correction factors.

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

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

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

* (3) Marking or Labeling Required. The following wiring methods and enclosures that contain PV power source conductors shall be marked with the wording "Warning: Photovoltaic Power Source" by means of permanently affixed labels or other approved permanent marking:

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

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

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

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

(H) Flexible, Fine-Stranded Cables. Flexible, fine-stranded cables shall be terminated only with terminals, lugs, devices, or connectors in accordance with 110.14.

(I) Bipolar Photovoltaic Systems. Where the sum, without consideration of polarity, of the PV system voltages of the two monopole subarrays exceeds the rating of the conductors and connected equipment, monopole subarrays in a bipolar PV system shall be physically separated, and the electrical output circuits from each monopole subarray shall be installed in separate raceways until connected to the inverter. The disconnecting means and overcurrent protective devices for each monopole subarray output shall be in separate enclosures. All conductors from each separate monopole subarray shall be routed in the same raceway. 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 shall be permitted to be used instead of disconnecting means in separate enclosures.

(J) Module Connection Arrangement. The connection to a module or panel shall be arranged so that removal of a module or panel from a photovoltaic source circuit does not interrupt a grounded conductor to other PV source circuits

**Substantiation:** This panel proposal was prepared to address the various proposals acted upon by the panel. The section has been reorganized through the actions taken. Wording in sections was revised to coincide with the reorganization. The existing and revised portions of 690.14 were variously incorporated into CP-412, CP-413, CP-414 and CP-415.

**Panel Meeting Action: Accept**
**Number Eligible to Vote: 13**
**Ballot Results:** Affirmative: 13
**Comment on Affirmative:**

BOWER, W.: The language is too restrictive and essentially requires inverter output circuits to be separate into a different raceway. It would be better to say "Identification and Grouping. PV source circuits, PV output circuits, and inverter output circuits shall not be contained in the same raceway, cable tray, cable, outlet box, junction box, or similar fitting as conductors, feeders, or branch circuits of other non-PV systems, unless the conductors of the different systems are separated by a partition.

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4-285 Log #2202 NEC-P04 **Final Action: Accept**
**(690.31(A))**

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**Submitter:** John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum
**Recommendation:** Revise text to read as follows:

Revise language in second paragraph as follows:

Where photovoltaic source and output circuits operating at maximum system voltages greater than 30 volts are installed in readily accessible locations, circuit conductors shall be guarded or installed in a raceway.

**Substantiation:** PV modules do not have conduit-ready junction boxes. The great majority of modules being produced today are constructed with factory-attached pigtail leads using exposed, single-conductor cables and connectors. Only a few manufacturers have special order modules available that can be used with conduits. This Code requirement, as written, cannot be met.

Added words "guarded or" informs the installer and inspectors that there are solutions other than raceways to render wiring methods not readily accessible in readily accessible areas.

Adding guards behind and close to the modules will not only make module conductors not readily accessible; it may also make them rodent resistant. Rodent damage to PV wiring is becoming an increasingly common problem.

**Panel Meeting Action: Accept**
**Number Eligible to Vote: 13**
**Ballot Results:** Affirmative: 13
**Comment on Affirmative:**

ROGERS, J.: This proposal addresses a real issue that is encountered in the field, however, the word "guarded" is too open ended to be reliably and uniformly enforced. If a requirement such as this is important enough to be added to the NEC then more descript language should be part of it.

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4-286 Log #2301 NEC-P04 **Final Action: Reject**
**(690.31(A))**

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**Submitter:** Scott Pieper, Arvada, CO
**Recommendation:** Add text to read as follows:

All cable from the modules on a standoff system shall be securely strapped to the standoff rails with a minimum 3 mm wide sun light resistant cable tie.

**Substantiation:** I have some installs on standoff systems, installers use cheap flimsy cable ties that are not sun light resistant. In a few years time, the wires not secured properly will fall down and rub on the roof (shingles).

**Panel Meeting Action: Reject**
**Panel Statement:** All materials used for support must be durable and able to withstand the environment. This proposal adds no new requirement. The proposed requirement is specific to only one method.
**Number Eligible to Vote: 13**
**Ballot Results:** Affirmative: 13

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4-287 Log #3146 NEC-P04 **Final Action: Accept**
**(690.31(A))**

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**Submitter:** Christopher Flueckiger, Underwriters Laboratories Inc.
**Recommendation:** Add text to read as follows:

**690.31 Methods Permitted.**

**(A) Wiring Systems.** All raceway and cable wiring methods included in this *Code*, ~~and~~ other wiring systems and fittings specifically listed ~~intended and identified~~ for use on photovoltaic arrays, and wiring as part of a listed system shall be permitted.

**Substantiation:** UL recently published the Outline of Investigation for Distributed Generation Wiring Harnesses, Subject 9703 and it is written to specifically cover PV DC and AC wire harnesses. It is intended that the harness be evaluated for the end application to the applicable requirements for the individual components and the overall assembly.

SU9703 Scope

1.1 These requirements cover wiring harnesses intended to interconnect distributed generation system devices.

1.2 These requirements cover distributed generation wiring harnesses intended for factory and field wiring and may include assemblies of cables intended for interconnection of PV modules, solar collectors, and other distributed generation sources, interconnection of inverters, converters, controllers, and chargers as well as distributed generation system communication harnesses and system output harnesses.

1.3 The products covered by these requirements are intended to be installed in accordance with the National Electrical Code, ANSI/NFPA 70.

The Subject 9703 document includes the following sections:

1 Scope, 2 General, 2.1 Components, 2.2 Units of measurement, 2.3 References, 3 Glossary,

CONSTRUCTION:

4 Enclosure, 5 Protection of Users - Accessibility of Uninsulated Live Parts, 6 Electric Shock, 7 Wiring Terminals, 8 Wire and Cable, 9 Field Wiring Compartments, 10 Electrical Connections, 11 Live Parts, 12 Spacings, 13 Barriers, 14 Connectors, 15 Printed-Wiring Boards, 16 Fuses and Fuse Holders.

PERFORMANCE

17 General, 18 Temperature, 19 Dielectric Voltage-Withstand Test, 20 Leakage Current Test, 21 Mold Stress-Relief Distortion, 22 Strain Relief Test, 23 Crush Test, 24 Push Test, 25 Impact Test, 26 Terminal Torque Test, 27 Grounding Impedance Test, 28 Bonding Conductor Test, 29 Compression Test, 30 Current Overload Test, 31 Corrosive Atmosphere Test, 32 Metallic Coating Thickness Test, 33 Water Spray Test, 34 Wet Insulation-Resistance Test, 35 Temperature Cycling Test, 36 Humidity Cycling Test,

This proposal provides a means for compliance of listed wire harnesses or wire harnesses used as a part of a listed system, when they are used within their ratings. Field assembled wire harnesses that are not listed need to be evaluate and found code compliant in the field.

**Panel Meeting Action: Accept**
**Number Eligible to Vote: 13**
**Ballot Results:** Affirmative: 13

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4-288 Log #2130 NEC-P04 **Final Action: Accept in Principle**
**(690.31(B) through (F))**

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**Submitter:** Chad Kennedy, Square D Company/Schneider Electric
**Recommendation:** Revise text to read as follows;

**(B) Identification and Grouping.** Photovoltaic source circuits and PV output circuits shall not be contained in the same raceway, cable tray, cable, outlet box, junction box, or similar fitting as conductors, feeders, or branch circuits of other non-PV systems, unless the conductors of the different systems are separated by a partition. Photovoltaic system conductors shall be identified and grouped as required by 690.31(B)(1) through (4). The means of identification shall be permitted by separate color coding, marking tape, tagging, or other approved means.

**(1) Photovoltaic Source Circuits.** Photovoltaic source circuits shall be identified at all points of termination, connection, and splices.

**(2) Photovoltaic Output and Inverter Circuits.** The conductors of PV output circuits and inverter input and output circuits shall be identified at all points of termination, connection, and splices.

**(3) Conductors of Multiple Systems.** Where the conductors of more than one PV system occupy the same junction box, raceway, or equipment, the conductors of each system shall be identified at all termination, connection, and splice points.

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

**(4) Grouping.** Where the conductors of more than one PV system occupy the same junction box or raceway with a removable cover(s), the ac and dc conductors of each system shall be grouped separately by wire ties or similar means at least once, and then shall be grouped at intervals not to exceed 1.8 m (6 ft).

*Exception: The requirement for grouping shall not apply if the circuit enters from a cable or raceway unique to the circuit that makes the grouping obvious.*

~~**(B)**~~ **(C) Single-Conductor Cable.** Single-conductor cable type USE-2, and single-conductor cable listed and labeled as photovoltaic (PV) wire shall be permitted in exposed outdoor locations in photovoltaic source circuits for