17-157 Log #2543a NEC-P17 **Final Action: Reject**
(682.2.Equipotential Plane)

Submitter: William Gross, Electric Service of Clinton
Recommendation: Add new text to read as follows:
Equipotential Plane. An area where wire mesh or other conductive elements are embedded in, or placed under concrete, bonded to all metal structures and fixed nonelectrical equipment that may become energized, and connected to the electrical grounding system to prevent a difference in voltage from developing within the plane.
Substantiation: Similar definitions for this term occur in separate articles sections 547.2 and 682.2. The term and definition should be moved to Article 100. Prescriptive requirements for equipotential plane construction in other articles should be contained in that article.
This proposal has also been sent to Code-Making Panels 5 and 19 for review in their respective sections.
Panel Meeting Action: Reject
Panel Statement: No technical substantiation has been provided for the modifications made to the definition. Also refer to the panel statement on Proposal 17-150.
Number Eligible to Vote: 9
Ballot Results: Affirmative: 9

ARTICLE 690 — SOLAR PHOTOVOLTAIC (PV) SYSTEMS

4-167 Log #3418 NEC-P04 **Final Action: Accept in Principle**
(690.X (New))

Submitter: Joerg Grosshennig, SMA Solar Technology AG
Recommendation: Add text to read as follows:
690.XX Utility-Interactive Photovoltaic Systems on Buildings Response to Emergency Shutdown.
For utility-interactive PV systems with dc voltages higher than 120 V mounted on buildings, all wiring penetrating the buildings shall be deenergized, either outside the building or within 6 feet of the point of entry into the building, within 10 seconds of loss of utility voltage or when the PV power source disconnecting means is opened.
For utility-interactive PV systems mounted on buildings with a maximum circuit current above 100 amps, photovoltaic output circuits shall be deenergized from all sources within 10 seconds when the utility supply is deenergized or when the PV power source disconnecting means is opened. The maximum circuit current on the array side of the above mentioned deenergizing device shall be no greater than 240 amps.
Substantiation: In order to increase the electrical and fire safety of PV systems on buildings, this proposal is intended to reduce hazard to firefighters by deenergizing conductors that enter buildings. It is meant to increase fire fighter safety inside buildings where there is a certain risk of touching live parts due to limited vision (smoke) and space constraints.
On the roof, it is easier to keep a safe distance to live parts because of a better visibility and less space constraints. In order to allow for opening the roof for ventilation, areas not covered by PV modules need to be defined by building codes or other regulations. Deenergizing each module is not addressing this problem because there is still a mechanical barrier (modules, mounting structure) which would create a significant loss of time for the fire fighter.
The proposal addresses the deenergization of PV power sources that enter a building in the event of a utility outage, or manual inverter shutdown by shutting down the utility connection or PV array connection to the inverter. PV output circuit conductors include all wiring between source-circuit combiners and the inverter or utilization load. In order to meet the requirements of this provision, some means will be necessary to shut off the source-combiner PV output circuit. A contactor combiner or remote trip breaker could meet this requirement.
For large PV systems with PV Power Source currents above 100-amps (systems of 30kW and larger), the requirement to deenergize conductors would apply regardless of whether the conductors entered the building or not. At multiple-inverter systems this requirement is in regard to the source current of **each** array (connected to a single inverter). The 100 amps requirement limits the maximum fault current in the system and the maximum area covered by PV modules (need for uncovered roof area!).
The 240 amp maximum circuit current requirement is to limit the PV output circuit size to no more than what is allowed into a 300-amp standard OCPD. While higher currents are designed in today's PV systems, these high currents unnecessarily increase the hazards of uncontrolled current flow. Also, by limiting the maximum current of a source-combiner circuit, differential current measurements required for new ground-fault standards can be done a reasonable resolution.
Since many inverters have large capacitors, a period of 10 seconds is allowed to offer inverter manufacturers options on how to deenergize these circuits on the array side of the capacitors.
Panel Meeting Action: Accept in Principle
Panel Statement: The CMP-4 task group on fire fighter safety recommended Proposal 4-253 to address the submitter's concern regarding reducing voltage to the building in a timely manner. The panel action taken on Proposal 4-253 reduces voltage to 80 volts rather than 120 volts. The last sentence makes this proposal relevant to larger systems whereas Proposal 4-253 is for all systems. See action on Proposal 4-253 which addresses the submitter's concerns.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13
Comment on Affirmative:
BOWER, W.: In tracing the path for this change, I believe that 4-253 wording is still deficient in that it does not properly allow for conversion from the utility interactive mode to an intentional stand-alone (aka UPS) mode. I suggest the language be edited to say "...within 10 seconds of when emergency shutdown is initiated, when the PV power source disconnecting means is opened, or in accordance with utility requirements for interconnection. When the PV source circuits are deenergized, the maximum voltage with respect to ground potential at the PV module and exposed module conductors shall be 80 volts. This is a comment only but should be addressed during the comment period.

4-168 Log #553 NEC-P04 **Final Action: Reject**
(690.1)

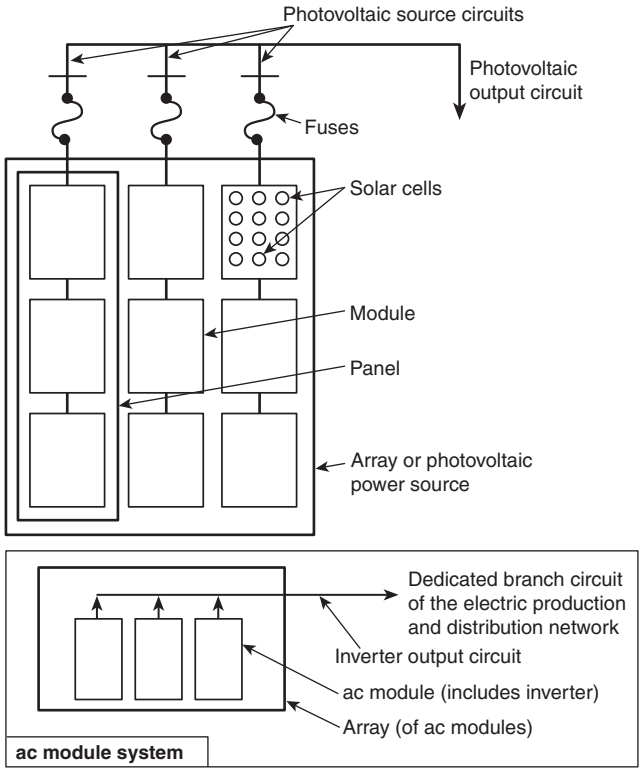
Submitter: Dale Rooney, Municipality of Anchorage
Recommendation: Add new last sentence to read as follows:
This article shall not apply to photovoltaic systems which comply with the limitations of Chapter 9, Tables 11 (A) or (B).
Substantiation: The available fault current and open circuit voltage of a solar panel is inherently limited by the construction of the panel. Recognizing smaller panels as the equivalent of class 2 power supplies and exempting them from any additional requirements in Article 690 would allow for the development of simple, low cost systems which could charge portable electronic devices and provide power for low voltage LED lights both of which would be invaluable in emergencies.
Small systems like these could be implemented in urban areas where tenants can't install larger systems because they don't own the property but have south facing windows or porches. This change could enable anyone with a desire to reduce their carbon footprint, even if just in a small way, to do so for as little as a few hundred dollars.
Panel Meeting Action: Reject
Panel Statement: Article 690 covers PV systems attached to or part of building wiring systems. The requirements for these systems should be covered in Article 690 and not elsewhere in the NEC.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-169 Log #543 NEC-P04 **Final Action: Reject**
(Figure 690.1(A))

Submitter: Philip Heim, Local 343 IBEW
Recommendation: Reverse direction of Blocking Diodes so that photovoltaic output flows from fuses into arrowhead of divides.
Substantiation: I was taught that current flows is passed by a diode when current flows into the arrowhead (marked end of a divide) and current is blocked from the opposite direction. As diagramed current flow would be blocked from flowing out of the solar cells.
Panel Meeting Action: Reject
Panel Statement: The substantiation is technically incorrect. See panel action on Proposal 4-170 where the diodes have been removed from the figure.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-170 Log #2175 NEC-P04 **Final Action: Accept**
(Figure 690.1(A))

Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum
Recommendation: Remove the blocking diodes from the diagram as noted below.



Notes:
1. These diagrams are intended to be a means of identification for photovoltaic system components, circuits, and connections.
2. Disconnecting means required by Article 690, Part III, are not shown.
3. System grounding and equipment grounding are not shown. See Article 690, Part V.

Figure 690.1(A) Identification of Solar Photovoltaic System Components.

Substantiation: Some AHJs view the blocking diodes as mandatory since this figure is not in an Annex or Informative Note as required by the NEC Style Manual for non mandatory material. Blocking diodes are no longer used in PV arrays and to keep them in the diagram may be confusing. They are a hold over from systems of the 1970s and 1980s before the NEC and UL standards required fuses to protect PV conductors and PV modules.
Panel Meeting Action: Accept
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-171 Log #2173 NEC-P04 **Final Action: Reject**
(690.2)

Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum
Recommendation: Revise text to read as follows:
Inverter Input Circuit Conductors between the inverter and the battery in stand-alone inverter system. ~~systems or the conductors between the inverter and the photovoltaic output circuits for electrical production and distribution network~~.
Substantiation: This portion of the definition should be deleted because there is no demarcation line between the PV output circuit and the inverter input circuit. Either the PV source or PV output circuit runs to the inverter DC input terminals in a system with only a DC PV array. See Figure 690.1(B).
Panel Meeting Action: Reject
Panel Statement: The definition is correct as it is written. It applies to other types of systems and does not coordinate with diagram in 690.1(B).
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-172 Log #3392 NEC-P04 **Final Action: Reject**
(690.2.DC to DC Converter (New))

Submitter: Marvin Hamon, Hamon Engineering
Recommendation: Add the following definition:
DC to DC Converter. DC utilization equipment in the PV Source Circuit or PV Output Circuit, or integrated into the PV module, used to modify and control DC power.
Substantiation: There is currently no definition in NEC 690 for DC to DC Converters. These devices are becoming more common and have particular requirements that will need to be addressed in future versions of the NEC. This definition will also make it clear that the PV source or output circuit ends at the input to the device by defining it as DC utilization equipment. This will prevent the application of 690.7(A) requirements to the output of these devices.
Panel Meeting Action: Reject
Panel Statement: A DC to DC converter is conversion equipment not utilization equipment.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-173 Log #2176 NEC-P04 **Final Action: Accept**
(690.2.Direct Current (dc) Combiner)

Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum
Recommendation: Add new text to read as follows:
Direct Current (dc) Combiner. A device used in the PV Source and PV Output circuits to combine two or more dc circuit inputs and provide one dc circuit output.
Substantiation: There are many names being given in the PV industry for DC combiners, Source Circuit Combiners, Recombiners, Subcombiners, etc. Since the requirements should be the same no matter where in the circuit the combiner is located, there needs to be a term that covers all DC Combiners.
Panel Meeting Action: Accept
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-174 Log #1260 NEC-P04 **Final Action: Reject**
(690.2. Hybrid System)

Submitter: Marcelo M. Hirschler, GBH International
Recommendation: Revise text to read as follows:
Hybrid System. A system comprised of multiple power sources. ~~These power sources may include photovoltaic, wind, micro-hydro generators, engine-driven generators, and others, but do not include electrical production and distribution network systems. Energy storage systems, such as batteries, do not constitute a power source for the purpose of this definition.~~
Informational Note: These power sources may include photovoltaic, wind, micro-hydro generators, engine-driven generators, and others, but do not include electrical production and distribution network systems. Energy storage systems, such as batteries, do not constitute a power source for the purpose of this definition.
Substantiation: The NFPA Manual of Style requires definitions to be in single sentences. The information provided in the subsequent sentences is not really a part of the definition; it is further information that is best placed in an informational note.
Panel Meeting Action: Reject
Panel Statement: There is no requirement in the NEC Manual of Style that definitions be only one sentence.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-175 Log #1261 NEC-P04 **Final Action: Reject**
(690.2. Interactive System)

Submitter: Marcelo M. Hirschler, GBH International
Recommendation: Revise text to read as follows:
Interactive System. A solar photovoltaic system that operates in parallel with and may deliver power to an electrical production and distribution network. ~~For the purpose of this definition, an energy storage subsystem of a solar photovoltaic system, such as a battery, is not another electrical production source.~~
Informational Note: For the purpose of this definition, an energy storage subsystem of a solar photovoltaic system, such as a battery, is not another electrical production source.
Substantiation: The NFPA Manual of Style requires definitions to be in single sentences. The information provided in the subsequent sentences is not really a part of the definition; it is further information that is best placed in an informational note.
Panel Meeting Action: Reject
Panel Statement: There is no requirement in the NEC Manual of Style that definitions be only one sentence.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-176 Log #1262 NEC-P04 **Final Action: Reject**
(690.2.Inverter)

Submitter: Marcelo M. Hirschler, GBH International
Recommendation: Revise text to read as follows:
Inverter. Equipment that is used to change voltage level or waveform, or both, of electrical energy. ~~Commonly, an inverter [also known as a power conditioning unit (PCU) or power conversion system (PCS)] is a device that changes dc input to an ac output. Inverters may also function as battery chargers that use alternating current from another source and convert it into direct current for charging batteries.~~
Informational Note: Commonly, an inverter [also known as a power conditioning unit (PCU) or power conversion system (PCS)] is a device that changes dc input to an ac output. Inverters may also function as battery chargers that use alternating current from another source and convert it into direct current for charging batteries.
Substantiation: The NFPA Manual of Style requires definitions to be in single sentences. The information provided in the subsequent sentences is not really a part of the definition; it is further information that is best placed in an informational note.
Panel Meeting Action: Reject
Panel Statement: There is no requirement in the NEC Manual of Style that definitions be only one sentence.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-177 Log #2177 NEC-P04 **Final Action: Reject**
(690.2.Inverter)

Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum
Recommendation: 690.2 Inverter. Delete this definition.
Substantiation: Three different types of inverters are in common use and each has different input output characteristics that need individual definitions. This single definition is inadequate.
See related proposals for utility-interactive inverter, stand-alone inverter and multi-mode inverter.
Panel Meeting Action: Reject
Panel Statement: The definition is correct and the term is used throughout the article. The definition needs to be retained.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-178 Log #3393 NEC-P04 **Final Action: Reject**
(690.2.Inverter Input Circuit)

Submitter: Marvin Hamon, Hamon Engineering
Recommendation: Revise text to read as follows:
Inverter Input Circuit. Conductors between the inverter and the battery in stand-alone systems or the conductors between the inverter and the photovoltaic output circuits, photovoltaic source circuits, or DC to DC converters in utility-interactive inverters. ~~for electrical production and distribution network.~~
Substantiation: The existing definition is incorrect for systems that do not have PV output circuits. This change would make it more clear what the Inverter input circuit is in contrast to the PV source and output circuits, in particular it adds DC to DC converters as a possible starting point.
Panel Meeting Action: Reject
Panel Statement: Converters are equipment and the current definition covers conductors. All PV systems do not have to have a PV output conductor. The NEC allows for proper sizing of DC PV conductors up to the inverter.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-179 Log #2178 NEC-P04 **Final Action: Reject**
(690.2.Inverter Output Circuit)

Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum
Recommendation: Delete text to read as follows:
~~**Inverter Output Circuit**. Conductors between the inverter and an ac panelboard for stand-alone systems or the conductors between the inverter and the service equipment or other electric power production source, such as a utility, for electrical production and distribution network.~~
Substantiation: This definition is to be replaced by proposals for three new definitions: utility interactive, stand-alone, and multimode inverters.
Panel Meeting Action: Reject
Panel Statement: The definition is needed to address the term used within the article.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-180 Log #1263 NEC-P04 **Final Action: Reject**
(690.2.Monopole Subarray)

Submitter: Marcelo M. Hirschler, GBH International
Recommendation: Revise text to read as follows:
Monopole Subarray. A PV subarray that has two conductors in the output circuit, one positive (+) and one negative(-). ~~Two monopole PV subarrays are used to form a bipolar PV array.~~
Informational Note: Two monopole PV subarrays are used to form a bipolar PV array.
Substantiation: The NFPA Manual of Style requires definitions to be in single sentences. The information provided in the subsequent sentences is not really a part of the definition; it is further information that is best placed in an informational note.
Panel Meeting Action: Reject
Panel Statement: There is no requirement in the NEC Manual of Style that definitions be only one sentence.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-181 Log #2179 NEC-P04 **Final Action: Accept in Part**
(690.2.Multimore Inverter)

Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum
Recommendation: Add new text to read as follows:
Multimode Inverter. Equipment having capabilities of both the utility-interactive inverter and the stand-alone inverter. The utility-interactive output is separate from the stand-alone output allowing code compliant connections for both circuits.
Substantiation: This more exact definition is needed to define how the multi-mode inverter operates in order to clarify some of the connection and critical safety requirements in this article.
This definition needs to be in both Article 690 and Article 705 because this equipment can interface with other equipment covered by requirements in both articles.
See proposals related definitions for stand-alone inverter and utility-interactive inverter.
The existing definition of inverter is deleted.
Panel Meeting Action: Accept in Part
Revise the proposed definition to read as follows:
Multimode Inverter. Equipment having capabilities of both the utility-interactive inverter and the stand-alone inverter.
Panel Statement: The second sentence is not necessary, does not add clarity and describes only one type of implementation.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-182 Log #3394 NEC-P04 **Final Action: Reject**
(690.2.Photovoltaic Source Circuit)

Submitter: Marvin Hamon, Hamon Engineering
Recommendation: Revise text to read as follows:
Photovoltaic Source Circuit. Circuits between modules and from modules to inverters, DC utilization equipment, or common connection point(s) of the dc system.
Substantiation: The current definition is vauge and not completely correct when applied to modern PV systems. The PV Source Circuit may terminate at a DC to DC converter or microinverter mounted at the module which is not a common connection point. The change to the definition makes it more clear that the PV Source Circuit ends where it connects to any type of DC utilization equipment in addition to a DC combiner.
Panel Meeting Action: Reject
Panel Statement: DC to DC converters are not utilization equipment.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-183 Log #1264 NEC-P04 **Final Action: Reject**
(690.2.Photovoltaic System Voltage)

Submitter: Marcelo M. Hirschler, GBH International
Recommendation: Revise text to read as follows:
Photovoltaic System Voltage. The direct current (dc) voltage of any photovoltaic source or photovoltaic output circuit. ~~For multiwire installations, the photovoltaic system voltage is the highest voltage between any two dc conductors.~~
Informational Note: For multiwire installations, the photovoltaic system voltage is the highest voltage between any two dc conductors.
Substantiation: The NFPA Manual of Style requires definitions to be in single sentences. The information provided in the subsequent sentences is not really a part of the definition; it is further information that is best placed in an informational note.
Panel Meeting Action: Reject
Panel Statement: There is no requirement in the NEC Manual of Style that

definitions be only one sentence.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-184 Log #2124 NEC-P04 **Final Action: Accept**
(690.2.Solar Photovoltaic System)

TCC Action: The Correlating Committee directs that the panel clarify the panel action on this proposal to correlate with the panel action on Proposal 4-8a and determine the placement of the definition, Article 100 or 690.2.
This action will be considered as a public comment.
Submitter: Chad Kennedy, Square D Company/Schneider Electric
Recommendation: Revise text to read as follows:
~~Solar~~ **Photovoltaic System.** The total components and subsystems that, in combination, convert solar energy into electric energy suitable for connection to a utilization load.
Substantiation: Article 690 is inconsistent with using the defined term "Solar Photovoltaic System" versus "Photovoltaic System". It is not necessary to include the word "Solar" since it is part of the article title. Removing would improve clarity since many of the requirements simply state "Photovoltaic System".
Panel Meeting Action: Accept
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-185 Log #2180 NEC-P04 **Final Action: Reject**
(690.2.Stand-Alone Inverter)

Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum
Recommendation: Add new text to read as follows:
Stand-Alone Inverter. Equipment that is used to change voltage level or waveform, or both, of electrical energy. Commonly, a stand-alone inverter is a device that changes dc input to an ac output and is able to change output power in response to the loads placed on the system. Stand-alone inverters may also use alternating current from another source and convert it into direct current for charging energy storage devices. Stand-alone inverters are not dependent on having an outside source, such as a utility connection, for an AC reference. The AC output terminals can be energized anytime the stand-alone inverter is in operation.
Substantiation: This more specific definition is needed to define how the stand-alone inverter operates in order to clarify some of the connection and critical safety requirements in this article.
This definition needs to be in both Article 690 and Article 705 because this equipment can interface with other equipment covered by requirements in both articles.
See proposals for related definitions for utility-interactive inverter and multimode inverter.
Panel Meeting Action: Reject
Panel Statement: The submitter has presented language that is more appropriate for a product standard or an instruction manual.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-186 Log #2181 NEC-P04 **Final Action: Reject**
(690.2.Utility-Interactive Inverter)

Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum
Recommendation: Add the new definition to 690.2
Utility-Interactive Inverter: Equipment used to change the dc input voltage and current from a PV array to an ac output current and voltage that matches the waveform, voltage and frequency of the connected utility supply system. This output has no stand-alone capabilities and must be connected to a utility supply system or other stable source of an ac reference.
Substantiation: This more exact definition is needed to define how the utility interactive inverter operates in order to clarify some of the connection and critical safety requirements in this article.
This definition needs to be in both Article 690 and Article 705 because this equipment can interface with other equipment covered by requirements in both articles.
See proposals for related definitions for stand-alone inverter and multimode inverter.
Panel Meeting Action: Reject
Panel Statement: The definition is already in Article 100.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-187 Log #2125 NEC-P04 **Final Action: Reject**
(690.3)

Submitter: Chad Kennedy, Square D Company/Schneider Electric
Recommendation: Revise text to read as follows:
690.3 Other Articles. Wherever the requirements of other articles of this *Code* and Article 690 differ, the requirements of Article 690 shall apply and, if the system is operated in parallel with a primary source(s) of electricity, the requirements in 705.10, 705.12, 705.14, 705.16, 705.32, 705.100, and 705.143 shall apply.
Substantiation: The list of references to Article 705 in this section is incomplete.
Panel Meeting Action: Reject
Panel Statement: The proposed references are already covered in 690.4(H), 690.63, and 690.64.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13
Comment on Affirmative:
STAFFORD, T.: Adding additional references to the 690.3 is unnecessary. Additionally other sections of the NEC referenced in 690.3 should also meet the same requirement. If one reference is not included for the reason provided in the panel statement, other sections should also not be referenced. Proposal should read, "Wherever the requirements of other articles of this and Article 690 differ, the requirements of Article 690 shall apply and, if the system is operated in parallel with a primary source(s) of electricity, the requirements in 705 shall apply".

4-188 Log #2920 NEC-P04 **Final Action: Reject**
(690.3)

Submitter: Robert H. Wills, Intergrid, LLC
Recommendation: Revise text to read as follows:
690.3 Other Articles
Wherever the requirements of other articles of this *Code* and Article 690 differ, the requirements of Article 690 shall apply. ~~and, I~~ If the system is operated in parallel with a primary source(s) of electricity, the requirements in 705.14, 705.16, 705.32, and 705.143 shall apply. If the system is operated as part of a direct current microgrid, 7xx.xx …[New] shall also apply.
Substantiation: This proposal was developed by a subgroup of the NEC DC Task Force of the Technical Correlating Committee. The Task Force is chaired by John R. Kovacik, Underwriters Laboratories. The subgroup members are Robert Wills, Intergrid, LLC - subgroup lead), Audie Spina (Armstrong Industries) and David Geary (Starline DC Solutions).
Solar photovoltaic systems are common sources in direct current micro-grids. A new article has been proposed by the NEC DC Working group to address dc micro-grids.
This proposal mirrors the existing requirements that Article 690 comply with the requirements of Article 705 for interconnected systems, so that the special requirements of dc micro-grids override the requirements of 690. Without this language, Article 690 would override the new dc microgrid article.
Panel Meeting Action: Reject
Panel Statement: The proposed section does not currently exist. The panel cannot take an action until the proposed section is added to the NEC.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-188a Log #CP410 NEC-P04 **Final Action: Accept**
(690.4)

TCC Action: The Correlating Committee understands that the panel action on this proposal revised 690.4 and relocated 690.4 to 690.31, as modified by the panel actions on Proposals 4-190, 4-192, 4-194, 4-195 and 4-199.
Submitter: Code-Making Panel 4,
Recommendation: Revise 690.4 to read as follows:
690.4 General Requirements
(A) Photovoltaic Systems. Photovoltaic systems shall be permitted to supply a building or other structure in addition to any other electrical supply system(s).
(B) Equipment. Inverters, motor generators, PV modules, PV panels, ac PV modules, dc combiners, dc-to-dc converters and charge controllers intended for use in PV power systems shall be listed for the PV application.
(C) Qualified Personnel. The installation of equipment and all associated wiring and interconnections shall be performed only by qualified persons. Informational Note: See Article 100 for the definition of qualified person.
(D) Multiple Inverters. A PV system shall be permitted to have multiple inverters installed in or on a single building or structure. Where the inverters are remotely located from each other, a directory in accordance with 705.10 shall be installed at each dc PV system disconnecting means, at each ac disconnecting means, and at the main service disconnecting means showing the location of all ac and dc PV system disconnecting means in the building.
Exception: A directory shall not be required where all inverters and PV dc disconnecting means are grouped at the main service disconnecting means.

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

4-189 Log #560 NEC-P04 **Final Action: Reject**
(690.4 (New))

Submitter: T. J. Woods, Wyoming Electrical JATC
Recommendation: Add new text to read as follows:
690.4 Installation. Systems covered by this article shall be installed only by qualified persons.
Informational Note: See Article 100 for the definition of *Qualified Person.*
Substantiation: I am proposing this change to substantiate that only qualified persons should be installing a solar system. I used the same language that was used for Section 694.7 for Small Wind Electric Systems.
Panel Meeting Action: Reject
Panel Statement: The requirement is already in 690.4(E).
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-190 Log #2126 NEC-P04 **Final Action: Accept**
(690.4)

TCC Action: The Correlating Committee understands that this proposal is further revised by the actions taken on Proposals 4-188a and 4-284a.
Submitter: Chad Kennedy, Square D Company/Schneider Electric
Recommendation: Revise text to read as follows:
690.4 ~~Installation~~General Requirements
(A) Photovoltaic Systems. Photovoltaic systems shall be permitted to supply a building or other structure in addition to any other electricity supply system(s).
~~**(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 690.4(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.*~~
~~**(C) 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. 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.~~
(B) ~~**(D)**~~ **Equipment.** Inverters, motor generators, photovoltaic modules, photovoltaic panels, ac photovoltaic modules, source-circuit combiners, and charge controllers intended for use in photovoltaic power systems shall be identified and listed for the application.
~~**(E) Wiring and Connections**~~**(C) Qualified Personnel.** The installation of equipment ~~and systems in 690.4(A) through (D)~~ and all associated wiring and interconnections shall be ~~installed~~ performed only by qualified persons.
Informational Note: See Article 100 for the definition of *qualified person*.
~~**(F) Circuit Routing.** Photovoltaic source and PV output conductors, in and out of conduit, and inside of a building or structure, shall be routed along building structural members such as beams, rafters, trusses, and columns where the location of those structural members can be determined by observation. Where circuits are imbedded 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.~~
~~**(G) 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.~~
~~*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.*~~
~~**(H)**~~ **(D) Multiple Inverters.** A PV system shall be permitted to have multiple utility-interactive inverters installed in or on a single building or structure. Where the inverters are remotely located from each other, a directory in accordance with 705.10 shall be installed at each dc PV system disconnecting means, at each ac disconnecting means, and at the main service disconnecting means showing the location of all ac and dc PV system disconnecting means in the building.
Exception: A directory shall not be required where all inverters and PV dc disconnecting means are grouped at the main service disconnecting means.
Substantiation: This proposal is part of a series intended to group the requirements based on the type or subject. The title for existing 690.4(E), "Wiring and Connections", was revised for clarity. Items (B) Identification and Grouping, (C) Module Connection and Arrangement, (F) Circuit Routing, and (G) Bipolar Photovoltaic Systems were removed from 690.4 but companion proposals simply move these into sections with similar content. See the summary spreadsheet I have provided which details the relocation of requirements contained in the series of proposals.
Note: Supporting material is available for review at NFPA Headquarters.
Panel Meeting Action: Accept
Panel Statement: This proposal was used as the baseline for the reorganization of 690.4 conducted under Proposal 4-188a. See the panel action on Proposal 4-188a which incorporates the submitter's proposal with additional changes.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-191 Log #2927 NEC-P04 **Final Action: Reject**
(690.4)

Submitter: Robert H. Wills, Intergrid, LLC
Recommendation: Add text to require that grounded PV source and output conductors be marked to indicate possible ungrounding. For example:
"Grounded conductors that may become ungrounded shall be specially marked yellow or white with a yellow stripe".
Substantiation: In grounded PV systems, the grounded conductor of PV source and PV output circuits is generally identified as a white conductor, or otherwise according to 210.6. However this conductor can become ungrounded and energized if a ground fault occurs. This is a dangerous situation that could harm installers or techs.
Suggest we indicate that the normally grounded conductor can become live (unlike anything else in the code) by changing wire marking.
Panel Meeting Action: Reject
Panel Statement: There already is a requirement for a sign to warn of the hazard. Establishing a color convention is unnecessary.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-192 Log #2182 NEC-P04 **Final Action: Accept**
(690.4(A))

TCC Action: The Correlating Committee understands that this proposal is further revised by the actions taken on Proposal 4-188a.
Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum
Recommendation: Revise 690.4(A) as follows:
690.4 Installation
(A) Photovoltaic Systems Photovoltaic system(s) shall be permitted to supply a building or other structure in addition to any other ~~electricity~~ electrical supply system(s).
Substantiation: Grammatical change.
Panel Meeting Action: Accept
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-193 Log #2749 NEC-P04 **Final Action: Reject**
(690.4(B))

Submitter: Bill McGovern, City of Plano
Recommendation: Revise text to read as follows:
Identification and Grouping. Photovoltaic source circuits, ~~and~~ 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-PVsystems, unless the conductors of the different systems are separated by a partion. Photvoltaic system conductors shall be identified and grouped as required by 690.4(B)(1) through (4). The means of identification shall be permitted by separate color coding, marking tape, tagging, or other approved means.

Substantiation: AC inverter output circuit conductors are specific conductors between the inverter and ac panelboard for a stand-alone system or service equipment and are a direct connection to, and are part of the photovoltaic system. Present language precludes these conductors from being in the same raceway, cable tray, cable, outlet box, junction box, or similar fitting as the PV dc system conductors without a physical partition. Common wiring practices for multiple inverters may be to bring photovoltaic output circuits into a common wireway then on into the individual inverters. The allowance to then bring the ac inverter output circuit conductors back into the common wireway would allow for a more simplified installation without the requirement to provide a physical partition or barrier. This would only allow the ac inverter output circuit conductors to be installed along with the PV dc conductors. No other conductors would be permitted to be installed without the provisions for a separate partition. Grouping and identification would still be required for all PV system conductors in the same raceway, cable tray, cable, outlet box, junction box, or similar fitting. Other separately derived systems such as UPS systems allow both dc and ac conductors in the same cable tray, and there are no restrictions for primary and secondary conductors of a transformer from occupying the same raceway.
Panel Meeting Action: Reject
Panel Statement: The revision as proposed would allow the mixing of ac inverter circuits in the same raceway as dc circuits. This will increase the chances of miswiring and crossing AC and DC circuit conductors. PV modules and PV inverters are not evaluated for mixing AC and DC power on their input and output connections and this is likely to result in significant damage to equipment and start fires.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-194 Log #3286 NEC-P04 **Final Action: Accept**
(690.4(B))

TCC Action: It was the action of the Correlating Committee that this proposal be reconsidered and correlated with the panel actions taken on Proposals 4-188a, 4-190, and 4-284a since the accepted text in this proposal is not the same as the revised text in the other proposals.
This action will be considered as a Public Comment.
Submitter: James J. Rogers, Bay State Inspectional Agency
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 Inverter Output Circuits or 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 690.4(B)(1) through (4). The means of identification shall be permitted by separate color coding, marking tape, tagging, or other approved means.
Substantiation: This section needs to be clarified as there multiple differing interpretations of these requirements on a daily basis. In the event that the insulation on a PV Output Circuit and an Inverter Output Circuit became damaged and allowed the conductors to come in contact with each other DV currents could be present on the [nverter Output Circuit conductors even with the inverter shut down due to a lack of AC power.
Panel Meeting Action: Accept
Panel Statement: See the panel action on Proposal 4-188a.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 12 Negative: 1
Explanation of Negative:
BOWER, W.: This proposal removes the option for the common practice of having dc and ac conductors from PV systems in the same gutter. No additional hazard exists by properly bundling the ac and dc conductors.

4-195 Log #2750 NEC-P04 **Final Action: Accept**
(690.4(B)(4))

TCC Action: The Correlating Committee understands that this proposal is further revised by the actions taken on Proposal 4-284a.
Submitter: Bill McGovern, City of Plano
Recommendation: Revise text to read as follows:
(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~~ cable ties or similar means at least once, and then shall be grouped at intervals not to exceed 1.8m (6 ft).
Substantiation: The tern cable ties is a more consistent term used in the NEC. Multiwire branch circuits require grouping by cable ties rather than wire ties as do many other sections in the Code. NEC 680.26 (B)(1)(a), 250.52(A)(2), and 250.52(A)(3) all use the tern steel wire ties in reference to bonding reinforcing bars together.
Panel Meeting Action: Accept
Panel Statement: See the panel action on Proposal 4-188a.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-196 Log #1869 NEC-P04 **Final Action: Reject**
(690.4(B)(5))

Submitter: Denis L. Lachance, Wareham, MA
Recommendation: Add new text to read as follows:
(5) Conductors used from photovoltaic panels to the inverter will be identified with the colors of red (positive) and black (negative).
Substantiation: With this change in the code it would stop using white or gray conductor on a grounded device. Safety is my biggest concern. As we all know the negative is a ungrounded conductor on a D.C. system.
Panel Meeting Action: Reject
Panel Statement: Circuit identification is critically important in the installation of a PV system. However, there are multiple marking schemes that will accomplish this. The proposed wiring method is too prescriptive and may disallow other legitimate marking methods. In some systems the ungrounded conductor may not be negative.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-197 Log #2915 NEC-P04 **Final Action: Reject**
(690.4(B)(5))

Submitter: Robert H. Wills, Intergrid, LLC
Recommendation: Revise text to read as follows:
690.4(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 690.4(B)(1) through ~~(4)~~ (5), as applicable. The means of identification for PV source ~~or output~~ circuits shall be permitted by separate color coding, marking tape, tagging, or other approved means. Photovoltaic output circuit conductors shall be identified as required in 690.4(B)(5).
[No changes to (B)(1) through (B)(4).]
(5) Identification for PV Output Circuit Conductors. Photovoltaic output circuit conductors shall be color coded as required by 690.4(B)(5)(a) through (B)(5)(c).
(a) Grounded Conductor. The grounded conductor of a photovoltaic output circuit shall be identified in accordance with 200.6,
(b) Equipment Grounding Conductor. The equipment grounding conductor of a photovoltaic output circuit shall be identified in accordance with 250.119.
(c) Identification of Ungrounded Conductors. Ungrounded conductors of a photovoltaic output circuit shall be identified in accordance 690.5(B)(5)(c)(1), (2), or (3).
(1) Application. Each ungrounded conductor shall be permitted to be identified by polarity at all terminations, connections, and splice points for conductors 6 AWG or smaller as follows:
(a) Durably marked by printing +/–, pos/neg, or positive/negative on the insulation or the jacket over the single insulated conductors, where applicable, at a maximum of 610 mm (24 in) interval in accordance with 310.120(B); or
(b) a solid color (red shall be used for positive, black shall be used for negative) for the insulation or the jacket over single-insulated conductors, where applicable; or
(c) a continuous colored stripe of black for negative, red for positive for the entire length of the conductor colored other than green, white or gray, over the outermost layer of single-insulated conductors, where applicable.
Where a colored stripe or printing is used on the insulation or jacket, the stripe or printing shall be weather (sunlight) resistant.
(2) Means of Identification. The means of identification for single conductors larger than 6 AWG or single conductors of any size where part of a multiconductor cable shall be permitted by marking tape, tagging, or other approved means at the time of installation.
(3) Posting of Identification Means. The method utilized for conductors originating at the combiner box shall be documented in a manner that is readily available or shall be permanently posted at the inverter.
Substantiation: This proposal was developed by a Subtask Group of the NEC TCC Task Group on DC Applications within the NEC. The Subtask Group members are Christel Hunter with Alcan Cable, Rob Wills with Intergrid, Brian Rock with Hubbell, Chairman of the Subtask Group Mark Ode with Underwriters Laboratories, Suzanne Borek Childers with the State of New Jersey, Chairman of the TCC DC Task Group John Kovacik with Underwriters Laboratories, Inc.
Note that a similar proposal has been submitted by Mark Ode (chair of this sub-group). This revision is based on discussion during the final TCC-DC Task Group meeting on Nov 3, 2011, and discussions with Mark. The main differences are typographical and removing the exemption for stand-alone systems, which Mark thinks might be required per 210.5, and so remains in his version. This version also incorporates new suggestions from Brian Rock to simplify and clarify the marking requirements.
This new text provides specific color coding requirements for direct current photovoltaic output circuits (usually installed from the combiner box to the dc side of the inverter) similar to the color coding requirements in 210.5 for branch circuits and 215.12 for feeders, where the premises has more than one

voltage system. The addition of a PV system to utility-supplied premises constitutes more than one voltage system so this text now ensures compliance with the general rule for branch circuit and feeders. Ensuring the proper color coding for these PV output conductors will also promote safety during hookup and troubleshooting. This text is also similar to text that has been accepted for the Canadian Electrical Code (CEC) and will help provide consistency between the NEC and the CEC.

This new requirement applies to photovoltaic output circuits and not to PV source circuits. The reason is that source circuits are a/ generally wired with single-conductor sunlight resistant (typically black type PV / USE-2) conductors, and b/ source circuit conductors run both from module-to-module and from string-end modules to combiner or inverter. The module-to-module conductors connect (+) to (-) and so cannot be marked with polarity.

Panel Meeting Action: Reject

Panel Statement: Circuit identification is critically important in the installation of a PV system. However, there are multiple marking schemes that will accomplish this. The proposed wiring method is too prescriptive and may disallow other legitimate marking methods. The references back to Article 250 are not necessary as they already apply.

Number Eligible to Vote: 13

Ballot Results: Affirmative: 13

4-198 Log #3221 NEC-P04 **Final Action: Reject (690.4(B)(5))**

Submitter: Mark C. Ode, Underwriters Laboratories Inc.

Recommendation: Revise text to read as follows:

690.4(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 690.4(B)(1) through ~~(4)~~ (5), as applicable. The means of identification for PV source ~~or output~~ circuits shall be permitted by separate color coding, marking tape, tagging, or other approved means. Photovoltaic output circuit conductors shall be identified as required in 690.4(B)(5).

[No changes to (B)(1) through (B)(4).]

(5) Identification for PV Output Circuit Conductors. Photovoltaic output circuit conductors shall be color coded as required by 690.4(B)(5)(a) through (B)(5)(c).

(a) Grounded Conductor. The grounded conductor of a photovoltaic output circuit shall be identified in accordance with 200.6.

(b) Equipment Grounding Conductor. The equipment grounding conductor of a photovoltaic output circuit shall be identified in accordance with 250.119.

(c) Identification of Ungrounded Conductors. Ungrounded conductors of a photovoltaic output circuit shall be identified in accordance with 690.5(B)(5)(c)(1), (2), or (3).

(1) Application. Where the PV wiring system is installed as other than a stand-alone system and single conductors are used, each ungrounded conductor of the PV system shall be permitted to be identified by polarity at all terminations, connections, and splice points for conductors 6 AWG or smaller as follows:

(a) Durably marked by printing +/–, pos/neg, or positive/negative on the insulation or the jacket over the single insulated conductors, where applicable, at a maximum of 610 mm (24 in) interval in accordance with 310.120(B);

(b) a solid color (red for positive, black for negative) for the insulation or the jacket over single-insulated conductors, where applicable; or

(c) a continuous colored stripe of black for negative, red for positive for the entire length of the conductor colored other than green, white or gray, over the outermost layer of single-insulated conductors, where applicable.

Where a colored stripe or printing is used on the insulation or jacket, the stripe or printing shall be weather (sunlight) resistant.

(2) Means of Identification. The means of identification for single conductors larger than 6 AWG or single conductors of any size where part of a multiconductor cable shall be permitted by marking tape, tagging, or other approved means at the time of installation.

(3) Posting of Identification Means. The method utilized for conductors originating at the combiner box shall be documented in a manner that is readily available or shall be permanently posted at the inverter.

Substantiation: This new text provides specific color coding requirements for direct current photovoltaic output circuits (usually installed from the combiner box to the dc side of the inverter) similar to the color coding requirements in 210.5 for branch circuits and 215.12 for feeders, where the premises has more than one voltage system. The addition of a PV system to utility-supplied premises constitutes more than one voltage system so this text now ensures compliance with the general rule for branch circuit and feeders. Ensuring the proper color coding for these PV output conductors will also promote safety during hookup and troubleshooting. This text is also similar to text that has been accepted for the Canadian Electrical Code (CEC) and will help provide consistency between the NEC and the CEC. The color coding requirements are not required for standalone PV systems since the premises only has one source of power with a standalone systems versus an interactive system which has branch circuits and feeders supplied from utility source of power.

This proposal is as a part of a larger effort to provide clear and specific requirements in NFPA 70 regarding the use of dc power. There is a growing interest in the use of alternative energy sources (e.g. photovoltaics, wind turbines, batteries, fuel cells, etc.) this coupled with the reality that many of the loads installed ultimately use electricity in its dc form has renewed an interest in dc power and its distribution in buildings. While many parts of the Code cover dc power with specific requirements, other portions are not as clear.

This proposal was developed by a subgroup of the NEC DC Task Force of the Technical Correlating Committee. The Task Force is chaired by John R. Kovacik, Underwriters Laboratories, the Subtask Group that developed this proposal consisted of the following people: Christel Hunter with Alcan Cable, Rob Wills with Intergrid, Brian Rock with Hubbell, Chairman of the Subtask Group Mark Ode with Underwriters Laboratories, Suzanne Borek Childers with the State of New Jersey, Chairman of the TCC DC Task Group John Kovacik with Underwriters Laboratories, Inc.

Panel Meeting Action: Reject

Panel Statement: Circuit identification is critically important in the installation of a PV system. However, there are multiple marking schemes that will accomplish this. The proposed wiring method is too prescriptive and may disallow other legitimate marking methods. The references back to Article 250 are not necessary as they already apply.

Number Eligible to Vote: 13

Ballot Results: Affirmative: 13

Comment on Affirmative:

STAFFORD, T.: Positive grounded arrays and negative grounded, bi-polar arrays all present different wiring labeling and marking and utilizing color codes may increase the application of incorrect wiring applications. Being too prescriptive in identification methods or means may actually increase the chance for incorrect installation.

4-199 Log #2183 NEC-P04 **Final Action: Accept in Principle in Part (690.4(D))**

TCC Action: The Correlating Committee understands that the panel action on this proposal applies to 690.4(B) as contained in Proposal 4-188a.

Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum

Recommendation: Revise as follows

(D) Equipment. Inverters, motor generators, ~~photovoltaic~~ PV modules, ~~photovoltaic~~ PV panels, AC ~~ac~~ PV modules, ~~source-circuit combiners~~, DC combiners, dc-to-dc module power converters, and charge controllers intended for use in ~~photovoltaic~~ PV power systems shall be indentified and listed for the application.

Substantiation: The term "photovoltaic" is replaced with PV for brevity and compliance with the NEC Style Manual.

DC Combiners are added and defined in a proposal in 690.2 as a general term to replace all types of PV dc combiners.

New technology products like AC PV Modules, microinverters and dc-to-dc module power converters that are complex and must be listed are added to keep the list current with these highly active, complex devices that must be listed to ensure the safety of the public.

Panel Meeting Action: Accept in Principle in Part

1) Reject the words "module power"

2) Accept the remainder of the proposal

Panel Statement: The defined term is dc-to-dc converter.

Number Eligible to Vote: 13

Ballot Results: Affirmative: 13

4-200 Log #3148 NEC-P04 **Final Action: Reject (690.4(D))**

Submitter: Timothy P. Zgonena, Underwriters Laboratories Inc.

Recommendation: Revise 690.4(D) as follows;

(D) Equipment. Inverters, motor generators, photovoltaic modules, photovoltaic panels, ac photovoltaic modules, source-circuit combiners, and charge controllers intended for use in photovoltaic power systems shall be identified and listed for the application. PV source output control and converter equipment that interrupt, equalize or otherwise modify the dc output power of a PV module(s) or array shall be specifically listed and rated for the functions that it performs. This includes any specific protective functions defined within the applicable portions of this code when the PV output control device is used to meet the requirements in this code, such as but not limited to; overcurrent protection, disconnect, ground fault or arc fault protection.

Substantiation: There are many new PV output control devices on the market today that are claimed to perform numerous functions including but not limited to power equalization, optimization, wireless semiconductor based on / off output control, reduction of output power to "safe" levels, output isolation, arc fault protection, overcurrent protection, etc.

Some of these products can increase PV output current or voltage to levels well above the PV module rating to which it is connected. Some certification organizations, do not evaluate these new features and functions as they are not specifically addressed in the published safety standards. The NEC and safety standards are written to establish safe system installation based upon the known normal and abnormal operating conditions of PV modules and inverters. Under normal and abnormal operating conditions some of these new output devices can negatively impact system safety if they allow the system to exceed ratings

of other system components. Single fault, fail safe operation is commonly addressed in functional safety evaluations and should be required for critical features and functions such as overcurrent and output disconnect functions if they are to be used in place of traditional components that perform those functions.
Panel Meeting Action: Reject
Panel Statement: This proposed language is instructional in nature. The proposed language is better suited for an instruction manual or product standard.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 12 Negative: 1
Explanation of Negative:
ZGONENA, T.: It is important that protective functions that are part of the equipment be included in the listing of the product. There are products currently on the market where these functions are not part of the Listing, and the AHJ or user might unknowlingly rely on those functions that haven't been investigated.

4-201 Log #9 NEC-P04 **Final Action: Accept in Principle**
(690.4(E))

Note: This Proposal appeared as Comment 4-70 (Log #2670) which was held from the A2010 ROC on Proposal 4-187. The Recommendation on Proposal 4-187 was: Add the new Section 690.4(E) as follows:
690.4(E) Circuit Routing. Photovoltaic source and PV output conductors, in and out of conduit, and inside of a building or structure, shall be routed along building structural members such as beams, rafters, trusses, and columns where the location of those structural members can be determined by observation. Where circuits are imbedded 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.
Submitter: Technical Correlating Committee on National Electrical Code®,
Recommendation: The Technical Correlating Committee directs that the panel action on Comment 4-70 be reported as "Hold" in compliance with the NFPA Regulations Governing Committee Projects, Section 4.4.6.2.2.
Substantiation: This is a direction from the Technical Correlating Committee on National Electrical Code Correlating Committee in accordance with 3.4.2 and 3.4.3 of the Regulations Governing Committee Projects.
Panel Meeting Action: Accept in Principle
Panel Statement: This proposed text is currently in the NEC. See panel action on Proposal 4-284a for the direction taken by the panel on the reorganization of 690.4.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-202 Log #248 NEC-P04 **Final Action: Reject**
(690.4(E))

Submitter: Gerald Newton, electrician2.com (National Electrical Resource Center)
Recommendation: Revise to read as follows:
(E) Wiring and Connections. The equipment and systems in 690.4(A) through (D) and all associated wiring and interconnections shall be installed only by qualified persons or by persons working under the onsite direct supervision of qualified persons.
Substantiation: The present wording of this section does not permit trainees or apprentices to conduct work on photovoltaic systems. This is not consistent with many licensing laws as enforced in various jurisdictions.
Panel Meeting Action: Reject
Panel Statement: A trainee or apprentice could be considered a qualified person with respect to the definition in Article 100.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-203 Log #561 NEC-P04 **Final Action: Reject**
(690.4(E))

Submitter: T. J. Woods, Wyoming Electrical JATC
Recommendation: Delete text as follows:
~~**(E) Wiring and Connections.** The equipment and systems in 690.4(A) through (D) and all associated wiring and interconnections shall be installed only by qualified persons.~~
~~Informational Note: See Article 100 for the definition of *qualified person*.~~
Substantiation: In a previous proposal I wanted to see this language moved to directly after Section 690.4 before the subdivisions, so it will apply to all installation provisions of a solar photovoltaic system. I would like to see the requirements be like the provisions of Section 694.7.
Panel Meeting Action: Reject
Panel Statement: A requirement for qualified personnel is necessary within Article 690.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-204 Log #3111 NEC-P04 **Final Action: Accept**
(690.4(E))

TCC Action: The correlating committee understands that the panel action on this proposal correlates with the panel action taken on Proposal 4-284a in 690.31(G)(1).
Submitter: Frederic P. Hartwell, Hartwell Electrical Services, Inc.
Recommendation: Revise as follows:
(E) Circuit Routing. ~~Photovoltaic source and PV output conductors. in and out of conduit, and inside of a building or structure, shall be routed along building structural members such as beams, rafters, trusses, and columns where the location of those structural members can be determined by observation.~~ Where circuits are ~~imbedded~~ 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..
Substantiation: The first sentence covers the same ground as 690.31(E)(1), but far less clearly and in a manner that is almost in direct conflict with the later section. As written, 690.4(E) makes it a violation of the literal text to conceal any wiring from a rooftop array because it must, without qualification, have its location (which must be along structural members) verifiable by observation, and most buildings other than some with post-and-beam construction do not expose their structural members to observation. The requirements in 690.31 have been much more comprehensively developed over many code cycles on these topics. Rooftop markings, on the other hand, can stay where they are. It should be noted that they present a real challenge as far as durability in the presence of UV radiation and precipitation; since there is no current listing category the only possible acceptance criterion at this time would appear to be approval by the AHJ. The change from "imbedded" to "embedded" reflects the clear preference in current dictionaries that only show "imbed" as a variant.
Panel Meeting Action: Accept
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-205 Log #249 NEC-P04 **Final Action: Accept in Part**
(690.4(F))

Submitter: Gerald Newton, electrician2.com (National Electrical Resource Center)
Recommendation: Delete text as follows:
~~**(F) Circuit Routing.** Photovoltaic source and PV output conductors, in and out of conduit, and inside of a building or structure, shall be routed along building structural embers such as beams, rafters, trusses, and columns where the location of those structural members can be determined by observation. Where circuits are imbedded 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.~~
Substantiation: The routing of raceways is covered in the raceway articles and in Chapter 3. If there is a problem with energized circuits during fire fighting then a labeled disconnect should be required near the service on the outside of a building or structure. Limiting where an installer can run his raceways in order to protect fire fighters from energized circuits is not practical. Also the instructions for clearly marking where raceways are run under a roof do not delineate how the marking is to be accomplished. Does this mean that a painted line on the roof is sufficient, or should little signs on pedestals be mounted on the roof, and if so, how many, how far apart, and what should the signs say? Furthermore, mounting such signs would require screws that would penetrate the roof and cause leaks. The statement "where the location of those structural members can be determined by observation" is not clear at all. Does this observation have to occur while one is in the attic, on the ground, on the roof, or in some other location?
Panel Meeting Action: Accept in Part
1) Accept the deletion of the first sentence.
2) Reject the deletion of the second sentence.
Panel Statement: The second sentence is necessary to protect personnel from hazards that could arise from accidental contact with PV conductors embedded in roofs. See panel action on Proposal 4-204.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-206 Log #1380 NEC-P04 **Final Action: Reject**
(690.4(F))

Submitter: John Powell, JPETC
Recommendation: Revise text to read as follows:
(F) Circuit Routing. Photovoltaic source and PV output conductors, in and out of conduit, and inside of a building or structure, shall be routed along building structural members such as beams, rafters, trusses, and columns where the location of those structural members can be determined by observation. ~~Where circuits are imbedded 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~~. Photovoltaic source and PV output conductors shall not be imbedded in built-up, laminate or membrane roofing materials.

Substantiation: Fire-fighters face enough hazard on a day-to-day basis without worrying about cutting a vent hole in a roof and hitting an energized dc conductor that is imbedded in a roof. The existing code language does not provide any specific methods of marking the roof that would provide a clear observation of the conductors on roofs that may be covered with snow.
Panel Meeting Action: Reject
Panel Statement: The second sentence is necessary to protect personnel from hazards that could arise from accidental contact with PV conductors embedded in roofs. Certain building integrated PV modules installation techniques require embedding in the roof.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-207 Log #3285 NEC-P04 **Final Action: Accept in Principle**
(690.4(F))

Submitter: James J. Rogers, Bay State Inspectional Agency
Recommendation: Revise text to read as follows:
(F) Circuit Routing. Photovoltaic source and PV output conductors, in ~~and out of~~ conduit, or as a permitted cable wiring method, installed inside of a building or structure, shall be ~~routed along building structural members such as beams, rafters, trusses, and columns where the location of those structural members can be determined by observation.~~ installed in accordance with the installation requirements for the applicable wiring method located elsewhere in this code. ~~Where circuits are imbedded 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.~~
Substantiation: This section as written is non-descript and unenforceable. The proper installation of wiring methods is covered in the various articles of the NEC that cover each wiring method or in general in Article 300. Type Me cable is now accepted for these conductors and as such could be fished in wall or ceiling cavities, this section as written would prohibit that. The blanket requirement for conductors in roof membrane areas does not provide any marking method and is vague as to which conductors of a PV system are being considered.
Panel Meeting Action: Accept in Principle
Panel Statement: See panel action on Proposal 4-204 which addresses the submitter's concern.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-208 Log #3183 NEC-P04 **Final Action: Accept in Part**
(690.4(G))

Submitter: Christel K. Hunter, Alcan Cable
Recommendation: Revise text to read as follows:
(G) 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 photovoltaic systems shall be clearly marked in a with a permanent, legible warning notice indicating that the disconnection of the grounded conductor(s) may result in overvoltage on the equipment.
Substantiation: The additional text in this proposal is intended to recognize the higher voltage available to equipment when overcurrent devices or switches are opened in bipolar photovoltaic PV systems and to provide a warning to that effect.
Panel Meeting Action: Accept in Part
1) Reject the "in a"
2) Accept the remainder of the proposal
Panel Statement: The words "in a" are deleted as editorial.
See panel action on Proposal 4-284a for the direction taken by the panel on the reorganization of 690.31.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 12 Negative: 1
Explanation of Negative:
STAFFORD, T.: This panel member does not agree with the additional requirement of extra signage or permanent legible warning notices as required by the proposal. Article 690 has multiple requirements for signs to be placed in and around the installation to comply with the NEC. Signs are only effective if the person walking up to the sign actually reads the sign, understands the sign, and weighs the consequences of their actions in relation to what the sign is warning them about. While properly placed effective signage can increase safety, having so many signs in close proximity actually can have the opposite effect.
The concern for overvoltage on the equipment could be addressed by proper engineering that could place the array in a safe condition if an overvoltage is detected. This panel member feels that a sign is just a Band-Aid to try to cover-up the real concern.

4-209 Log #407 NEC-P04 **Final Action: Reject**
(690.4(G) Exception)

Submitter: Joel A. Rencsok, Scottsdale, AZ
Recommendation: Revise text to read as follows:
(G) 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 sub array output shall be in separate enclosures. All conductors from each separate monopole subarray shall be routed in the same raceway.
Exception: Listed ~~switchgear~~ equipment 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.
Substantiation: It appears that the word "switchgear" is not defined in the NEC. See also Article 100 definitions. The main paragraph refers to equipment and not switchgear.
Panel Meeting Action: Reject
Panel Statement: Listed switchgear is by definition provided with physical barriers that separate disconnecting means for separate circuits. Other listed equipment is not required to have this characteristic.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-210 Log #3438 NEC-P04 **Final Action: Reject**
(690.4(I) (New))

Submitter: Ron B. Chilton, Raleigh, NC
Recommendation: Add new text to read as follows:
690.4(I) Arc-Flash Hazard Warning. Photovoltaic systems equipment shall be field marked to warn qualified persons of potential electrical arc flash hazards in accordance with 110.16.
Substantiation: The arc-flash hazards of PV systems must be considered as any energy source to a building should be. PV installations arrays have been growing in size, voltage, and output steadily as they rise in popularity.
Panel Meeting Action: Reject
Panel Statement: The recommendation does not state what equipment should be marked and how it should be marked. The requirements of 110.16 do not apply to dwelling units.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-211 Log #3439 NEC-P04 **Final Action: Reject**
(690.4(J) (New))

Submitter: Ron B. Chilton, Raleigh, NC
Recommendation: Add new text to read as follows:
690.4(J) Available Fault Current Photovoltaic Systems Sources shall be legibly marked in the field with the maximum available fault current in accordance with 110.24(A).
Substantiation: The available fault currents of PV systems must be considered as any energy source to a building should be. PV installations arrays have been growing in size, voltage, and output steadily as they rise in popularity.
Panel Meeting Action: Reject
Panel Statement: Section 690.53 requires maximum circuit current marking which is the available fault current.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-212 Log #2184 NEC-P04 **Final Action: Accept in Part**
(690.5)

Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum
Recommendation: 690.5 Ground-Fault Protection. Grounded dc photovoltaic arrays shall be provided with dc ground-fault protection meeting the requirements of 690.5(A) through (C) to reduce fire hazards. Ungrounded dc photovoltaic arrays shall comply with 690.35.
Exception ~~No. 1~~: Ground-mounted or pole-mounted photovoltaic arrays with not more than two paralleled source circuits and with all dc source and dc output circuits isolated from buildings shall be permitted without ground fault protection.
~~Exception No. 2: PV arrays installed at other than dwelling units shall be permitted without ground-fault protection where the equipment grounding conductors are sized in accordance with 690.45.~~
(A) Ground-Fault Detection and Interruption. The ground-fault protection device or system shall be capable of detecting a ground-fault current, interrupting the flow of fault current, and providing an indication of the fault. Automatically opening the grounded conductor of the faulted circuit to interrupt the ground-fault current path shall be permitted. If a grounded

conductor is opened to interrupt the ground-fault current path, all conductors of the faulted circuit shall be automatically and simultaneously opened.

Manual operation of the main PV dc disconnect shall not activate the ground-fault protection device or result in grounded conductors becoming ungrounded. The ground fault protection device shall be permitted to automatically isolate the PV source and output circuits before allowing the inverter or charge controller to export power.

Informational Note: Ground fault currents can originate from an ungrounded conductor to ground connection (as defined in Art 100) and also from a grounded conductor to ground connection. Ground fault currents from either source can cause fires and pose shock hazards.

(B) ~~Isolating~~ Indentifying Faulted Circuits. The faulted circuits shall be ~~isolated~~ identified by one of the two following methods:

(1) The ungrounded conductors of the faulted circuit shall be automatically disconnected.

(2) The inverter or charge controller fed by the faulted circuit shall automatically cease to supply power to output circuits.

(C) Labels and Markings. A warning label shall appear on the utility-interactive inverter or be applied by the installer near the ground-fault indicator at a visible location, stating the following:

WARNING
ELECTRIC SHOCK HAZARD
IF A GROUND FAULT IS INDICATED,
NORMALLY GROUNDED CONDUCTORS
MAY BE UNGROUNDED AND ENERGIZED

When the photovoltaic system also has batteries, the same warning shall also be applied by the installer in a visible location at the batteries.

Substantiation: In (A), the added text permits the ground fault protection device to isolate (disconnect and/or unground) the dc PV array circuits to perform an insulation/ground fault test automatically before allowing the inverter or charge controller to export power. Recent analysis of fires has determined that this test can identify ground fault problems that are not easily identified by other means. This test would normally be preformed automatically at system start up and possibly any time the inverter or charge controller restarted during the day.

Existing code language did not allow this isolation function that can involve ungrounding the PV array when no ground fault action is indicated.

UL 1741 is being modified to address grounded conductor ground faults and to address a morning wake up insulation test for ground faults.

The Informational Note is necessary because the new definition of "Ground Fault" Art 100 in the 2011 NEC only defines a ground fault between an ungrounded conductor and ground. It does not include the grounded conductor ground fault that can cause objectionable and hazardous currents into the equipment-grounding systems.

Exception 2 is deleted because research and actual fires due to ground faults indicate that over sizing the equipment-grounding conductors would not reduce the potential fire hazard.

A related proposal is being submitted for 690.45

In B, the words "Isolating" and "isolated" are replaced with the words "Identifying" and "identified" because the required actions are aimed at additional alerting that a ground fault has occurred and identifying the area where the fault has occurred. These actions do not necessarily isolate the faulted circuit.

Panel Meeting Action: Accept in Part

1) Accept the deletion of exception No. 2
2) Reject the remainder of the changes

Panel Statement: The proposed text in 690.5(A) adds material that is better suited to a product standard. The proposed language to 690.5(B) is a misleading statement.

Number Eligible to Vote: 13

Ballot Results: Affirmative: 13

4-213 Log #1400 NEC-P04 **Final Action: Reject**
(690.5(A))

Submitter: Abel Lampa, Innovative Engineering Inc.

Recommendation: Please revise Art. 690.5(A).

Art. 690.S(A) Ground Fault Detection & interruption. Add to the last paragraph.

The ground fault detection device shall be installed in the combiner & recombiner boxes also, so that if there is a fault in between these (2) boxes & inverters, they can disconnect the ungrounded faulted wire. All combiners & re-combiner boxes shall be equipped with built in shunt circuit breakers & contactors so that when fault occurs, it can disconnect the faulted wires thru them.

Substantiation: Back in May of2011, one of my projects in Freehold NJ, (About 1 Meg PV system) creates a massive fire on the roof of the bldg. because the main cable
between re-combiner box & the inverter had a ground fault during our commissioning.

The inverter is not even engage yet at the time of the fire. Our investigation reveals that the cable was nicked during installation, thereby creates a high impedance contact with
the EMT conduit which is grounded. The fuses did not activate because the short circuit current available is way below the ratings of the fuses. Per Art. 690.8(B) Overcurrent
Device.(a) Overcurrent protection device= FLA X 1.25X1.25.

The only way to protect the system is have arc fault or ground fault protection installed in every temination box, like in the combiner & re-combiner boxes.

Panel Meeting Action: Reject

Panel Statement: The existing NEC and product standards do not dictate a specific location and method as long as the performance requirements are met. There should not be a prescription on the location of these devices as it may remove other viable methods.

See panel action on Proposal 4-214 for the panel direction on ground fault detection.

Number Eligible to Vote: 13

Ballot Results: Affirmative: 13

4-214 Log #3149 NEC-P04 **Final Action: Accept in Part**
(690.5(A))

Submitter: Timothy P. Zgonena, Underwriters Laboratories Inc.

Recommendation: Revise text to read as follows:

(A) Ground-Fault Detection and Interruption. The ground-fault protection device or system shall:

1) determine the pv input circuit has a minimum acceptable level of isolation prior to export of current,
2) be capable of detecting a ground-fault ~~current~~ ,
3) interrupt~~ing~~ the flow of fault current, and
4) provide ~~providing~~ an indication of the fault.

Automatically opening the grounded conductor for measurement purposes or ~~of the faulted circuit~~ to interrupt the ground-fault current path shall be permitted. If a grounded conductor is opened to interrupt the ground-fault current path, all conductors of …..

Substantiation: This proposal is intended to revise the ground fault protection requirements and add an additional array isolation measurement prior to export of current. This proposal also revises the format of required functions into a list.

Recent information on existing ground fault protection techniques has indicated that additional protection is necessary to provide protection against high impedance and multiple ground faults on PV systems.
Ground faults that occur in the grounded conductors of traditional grounded PV arrays can pose detection challenges for existing Ground Fault Detector Interrupters (GFDIs). Ground faults in the grounded conductors do not result in significant fault currents and the fault current they do cause can bypass the GFDI sensing and protection circuitry. Per the existing requirements, faults in the grounded conductors do not result in a ground fault current above the required trip limit and as such do not trip the GFDI circuit protection.
In the event that a high impedance ground fault occurs in the grounded leg of a PV array and the resulting fault current does not exceed the trip limit of the GFDI circuit protection, the GFDI will not identify the fault and it will allow the system to continue operation.

If a subsequent ground fault occurs within the array or if it occurs in the ungrounded conductor,

a) the first fault can provide a parallel current path for the subsequent fault current and reduce the current measured by the GFDI circuit either causing it not to trip or trip at a fault current level above its required trip limit and

b) once the GFDI protection does trip it will open the intended PV array ground bond which will then allow the full ground fault current to flow between the first fault in the circuit and the subsequent ground fault elsewhere in the array.

The resulting fault current between these two faults is not likely to be interrupted until the sun goes down or other measures are taken.

On May 27, 2010, UL introduced a CRD and a UL 1741 proposal for non-isolated PV inverters that is similar to draft IEC 62109-2 PV inverter requirements for non-isolated PV inverters. These requirements include a measurement of the PV array isolation prior to initiating connection to the array and power export. Implementation of a similar protection scheme for all ground fault protection circuits would result in daily verification of PV array isolation and drastically reduce the potential for ground faults going unnoticed. The proposed text also allows for interruption of the grounded conductor to make the isolation measurement.

Panel Meeting Action: Accept in Part

1) Reject the words "a minimum acceptable level of"
2) Accept the remainder of the proposal.

Panel Statement: The proposed text "a minimum acceptable level of" is not an enforceable requirement.

Number Eligible to Vote: 13

Ballot Results: Affirmative: 13

Comment on Affirmative:

BOWER, W.: The term "pv" should be "PV"

4-215 Log #885 NEC-P04 **Final Action: Accept**
(690.5(C))

Submitter: Michael J. Johnston, National Electrical Contractors Association
Recommendation: Add a new last sentence as follows:
"…When the photovoltaic system also has batteries, the same warning shall also be applied by the installer in a visible location at the batteries. The warning sign(s) or label(s) shall comply with 110.21(B).
Substantiation: This proposal is one of several coordinated companion proposals to provide consistency of danger, caution, and warning sign or markings as required in the NEC. The proposed revision will correlate this warning marking requirement with proposed 110.21(B) and the requirements in ANSI Z 535.4.
Panel Meeting Action: Accept
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-216 Log #3150 NEC-P04 **Final Action: Reject**
(690.6(A) and (C))

Submitter: Timothy P. Zgonena, Underwriters Laboratories Inc.
Recommendation: Revise paragraph 690.6(A) as follows:
(A) Photovoltaic Source Circuits. The requirements of Article 690 pertaining to photovoltaic source circuits shall
not apply to ac modules. The photovoltaic source circuit, conductors, connectors and inverters shall be considered as ~~internal~~ wiring of an ac module and shall comply with the requirements as specified in this section .
Revise paragraph 690.6(C) as follows:
(C) Disconnecting Means. A single disconnecting means, in accordance with 690.15 and 690.17, shall be permitted
for the DC connections between a PV module and inverter as well as the combined ac output of one or more ac modules. Additionally, each ac module in a multiple ac module system shall be provided with a connector, bolted, or terminal type disconnecting means.
Substantiation: Some new AC module designs have included open and accessible DC wiring with PV connectors. While PV connectors are typically not rated for disconnect under load for their full rated voltage and current, they can be evaluated to perform the disconnect function for the voltage and current of an AC module's specific single PV module and inverter input circuit combination. These connectors are likely to be used as a disconnect during the troubleshooting and replacement of a damaged PV module or inverter in the AC module.
Panel Meeting Action: Reject
Panel Statement: There is conflict between the proposed text and the existing text regarding a single disconnecting means. The recommendation would mix ac and dc circuits within a single disconnect.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13
Comment on Affirmative:
ZGONENA, T.: The panel is correct in that the proposal is confusing. Revised text will be submitted during the comment stage.

4-217 Log #2294 NEC-P04 **Final Action: Reject**
(690.6(B))

Submitter: Mark T. Rochon, Peabody, MA
Recommendation: Revise text to read as follows:
(B) Inverter output circuit. The output of an AC module shall be considered an inverter output circuit. Those circuits shall be installed by all the installation requirements and wiring methods of 690.31.
Substantiation: The AC module output has the same shock potential and is capable of the same fire hazards as the dc module outputs. Both types of outputs should be treated the same.
Panel Meeting Action: Reject
Panel Statement: These circuits are standard ac circuits and are protected by both the branch circuit overcurrent protective device that they connect to and the inverter if there is any interruption in the ac power source to these conductors the inverter will turn off and the conductors will be totally deenergized unlike those of a dc supply to an inverter.
This proposal is not required as 690 Part IV stands on its own.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-218 Log #2185 NEC-P04 **Final Action: Accept**
(690.6(D))

Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum
Recommendation: Delete this section and renumber remaining sections.
~~Alternating-current module systems shall be permitted to use a single detection device to detect only ac ground faults and to disable the array by removing ac power to the ac module(s).~~
Substantiation: The existing text is deleted because there is no readily available equipment that can perform the function. The ac output of these ac PV modules is connected to a circuit that is in fact a branch circuit. There are no exposed receptacles and the circuit usually terminates in a non-accessible area like the roof. There is no current requirement for an ac ground fault protector on this circuit. Uninformed PV installers are attempting to install standard GFCIs to meet this requirement and such devices can be damaged when backfed.
Panel Meeting Action: Accept
Number Eligible to Vote: 13
Ballot Results: Affirmative: 12 Negative: 1
Explanation of Negative:
BOWER, W.: The language in 690.6(D) should not be removed from the article. Although permissive at this time there is a need for protection of the ac conductors as devices are made available.

4-219 Log #3151 NEC-P04 **Final Action: Reject**
(690.6(D))

Submitter: Timothy P. Zgonena, Underwriters Laboratories Inc.
Recommendation: Revise paragraph 690.6(D) as follows:
(D) Ground-Fault Protection ~~Detection~~. Alternating-current module systems shall provide ~~be permitted to use a single detection device to detect only ac~~ ground faults protection for the PV DC input circuit. ~~and to disable the array by removing ac power to the ac module(s)~~.
Substantiation: DC ground faults in AC modules can occur as a result of delamination or other damage to the PV module's DC circuit. Some new AC module designs have included open and accessible DC wiring that can be subjected to damage during or after installation that can create a ground fault condition. Since ground faults are possible in the DC circuit of an AC module, these products should also provide GFDI protection.
Panel Meeting Action: Reject
Panel Statement: The panel action on Proposal 4-218 accomplishes the same thing through deletion of the text. Ground fault protection is covered in 690.5.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-220 Log #3395 NEC-P04 **Final Action: Reject**
(690.7)

Submitter: Marvin Hamon, Hamon Engineering
Recommendation: Add new text to read as follows:
(F) DC to DC Converter. The maximum system voltage on the output of one or more DC to DC Converters in series shall be determined in accordance with the manufacturer's instructions.
Substantiation: There are currently no references in NEC 690 that discuss how to safely integrate DC to DC converters into the PV system design.
When a DC to DC converter is inserted into the DC circuit there is no guidance on how to determine the voltage and current limits between the DC to DC converter and the inverter input. This proposal along with companion proposals tries to address this issue.
The manufacturers of the DC to DC converters provide direction on the maximum and minimum number of devices in series and that number generally has no relation to either the Voc of the PV module or the maximum voltage that the DC to DC Converter is capable of producing.
Panel Meeting Action: Reject
Panel Statement: This should be covered in marking requirements as part of the listing. The proposal is unenforceable as written.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13
Comment on Affirmative:
BOWER, W.: Having a definition for the voltage output of a dc-dc converter circuit will help clarify the difference between a PV Output Circuit and a DC-DC converter output circuit. It is new technology and the definition may need clarification during the comment period so the NEC 690 can remain current with technology advances.

4-221 Log #3034 NEC-P04 **Final Action: Reject**
(690.7, Informational Note)

Submitter: D. Jerry Flaherty, Electrical Inspection Service, Inc.
Recommendation: Delete text as follows:
~~Informational Note: One source for statistically valid, lowest-expected ambient temperature design data for various locations is the Extreme Annual Mean Minimum Design Dry Bulb Temperature found in the ASHRAE Handbook Fundamentals. These temperature data can be used to calculate maximum voltage using the manufacturer's temperature coefficient relative to the rating temperature of 25°C.~~
Substantiation: 690.7(A) states "corrected for the lowest expected ambient temperature". The ASHRAE handbook table is for the "Mean Minimum Design Dry Bulb Temperature". The mean temperature is the midway between two extreme temperatures; this is not the "lowest expected ambient temperature". Perhaps another source can be cited the correct information and that can be referred to with buying a $100 manual.
Panel Meeting Action: Reject

Panel Statement: This informational note is correct and necessary. Data is available for free at www.solarabcs.org/permitting. The ASHRAE mean temperature is in fact a statistically valid estimate of the lowest expected ambient temperature.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-222 Log #3033 NEC-P04 **Final Action: Reject**
(690.7(A))

Submitter: D. Jerry Flaherty, Electrical Inspection Service, Inc.
Recommendation: Revise text to read as follows:

(A) Maximum Photovoltaic ~~System~~ Source Circuit Voltage. In a dc photovoltaic source circuit or output circuit, the maximum photovoltaic ~~system~~ source circuit voltage for the circuit for the circuit shall be calculated as the sum of the rated open-circuit voltage of the series-connected photovoltaic module corrected for the lowest expected ambient temperature. For crystalline and multicrystalline silicon modules, the rated open-circuit voltage shall be multiplied by the correction factor provided in Table 690.7. This voltage shall be used to determine the voltage rating of cables, disconnects, overcurrent devices, and other equipment. Where the lowest expected ambient temperature is below -40C (-40F), or where other than crystalline or multicrystalline silicon photovoltaic modules are used, the ~~system~~ source circuit voltage adjustment shall be made in accordance with the manufacturer's instructions.

When open-circuit voltage temperature coefficients are supplied in the instructions for listed PV modules, they ~~shall~~ can be used to calculate the maximum photovoltaic ~~system~~ source circuit voltage as required by 110.3(B) instead of using Table 690.7.

Substantiation: (Changing "Photovoltaic System" to "Source Circuit") Very confusing between "Photovoltaic System" and "Solar Photovoltaic System"; "Photovoltaic System" meaning the source circuit (dc) voltage and "Solar Photovoltaic System" meaning both the source circuit (dc) and output circuit (ac). To help in understanding which system applies to this section, change the terms to "photovoltaic source circuit", a term that is very easily understood.

(Changing "shall" to "can") Calculations using Table 690.7 will yield a higher source circuit voltage then the coefficient calculation and calculations using the coefficient are very difficult for trade's people. Allowing a choice will not jeopardize the PV system but will make this requirement easier for trades people.
Panel Meeting Action: Reject
Panel Statement: The substantiation that calculations are difficult is not sufficient. Maximum system voltage is a critical parameter. The source circuit voltage is only one part of the photovoltaic system voltage and does not necessarily represent the maximum system voltage.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-223 Log #1006 NEC-P04 **Final Action: Accept in Part**
(690.7(C))

Submitter: James T. Dollard, Jr., IBEW Local 98
Recommendation: Replace 600V with 1000V.
Substantiation: This proposal is the work of the "High Voltage Task Group" appointed by the Technical Correlating Committee. The task group consisted of the following members: Alan Peterson, Paul Barnhart, Lanny Floyd, Alan Manche, Donny Cook, Vince Saporita, Roger McDaniel, Stan Folz, Eddie Guidry, Tom Adams, Jim Rogers and Jim Dollard.

The Task Group identified the demand for increasing voltage levels used in wind generation and photovoltaic systems as an area for consideration to enhance existing NEC requirements to address these new common voltage levels. The task group recognized that general requirements in Chapters 1 through 4 need to be modified before identifying and generating proposals to articles such as 690 specific for PV systems. These systems have moved above 600V and are reaching 1000V due to standard configurations and increases in efficiency and performance. The committee reviewed Chapters 1 through 8 and identified areas where the task group agreed that the increase in voltage was of minimal or no impact to the system installation. Additionally, there were requirements that would have had a serious impact and the task group chose not to submit a proposal for changing the voltage. See table (supporting material) that summarizes all sections considered by the TG.

Note: Supporting material is available for review at NFPA Headquarters.
Panel Meeting Action: Accept in Part

Revise current text as follows:

(C) Photovoltaic Source and Output Circuits. In one and two-family dwellings, photovoltaic source circuits andphotovoltaic output circuits that do not include lampholders, fixtures, or receptacles shall be permitted to have a maximum photovoltaic system voltage up to 600 volts. Other installations with a maximum photovoltaic system voltage over ~~600~~ 1000 volts shall comply with Article 690, Part IX.

Panel Statement: One and Two family dwellings should not be dealing with AC voltages above 600 Volts. The change is acceptable for the "other installations" clause in the section.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 11 Negative: 2
Explanation of Negative:

MCDANIEL, R.: It is recognized that increasing voltage from 600 to 1,000 Volts may be applicable to specific installations. However, adequate technical substantiation has not been provided to support the change in this Article.

STAFFORD, T.: This panel member agrees with the panel statement upon residential limitations for voltage levels. This panel member does not agree with acceptance upon "other" areas of use of 1000 volts.

It is recognized that the distributed generation sources covered by the NEC such as wind and photovoltaics are demanding increased voltage levels to improve performance and efficiency, but this panel member feels that extensive training and equipment research is needed before implementing a "new" voltage threshold to which electricians may be exposed.

Meters and other testing equipment need to be evaluated and tested for 1000 volts as compared to some existing 600 volt limitations. Proper PPE also needs to be evaluated and determined for increased level of arc /blast hazards that may occur. Conductor insulation(s), equipment and terminal spacing, termination points, overcurrent protection devices, work space clearances, etc.- all will be affected by proposed change. Increasing existing voltage levels to 1000 volts from 600 volts immediately renders existing equipment today that is rated for 600 volts unsafe. There is a concern of this panel member as to what is going to be available to present clarity in the proper selection of meters and tools to identify 1000 volt use as compared to 600 volts. Concern is also raised as to making sure specification's for all equipment also meets new voltage levels, even existing equipment being supplied today. This panel member does not believe that all equipment, tools, meters, etc. will immediately become available for use by the electrician upon the issue of the 2014 NEC. The electrical worker is the one exposed to such hazards immediately upon issue of 2014 NEC if this proposal is accepted.

The task group submitted in their substantiation that, "minimal or no impact to the system installation" would be a result of increasing the voltage level to 1000 volts. This panel member agrees with that statement but the impact upon the worker in the specific industries will be affected. Time for implementation of the new voltage levels needs to be outlined and detailed as to when such a voltage increase may be placed into the NEC. Proper timing and opportunities for training, and new equipment needs to be provided before allowing a voltage increase to be implemented.

This panel member is in favor of increasing the voltage level to 1000 volts as outlined in this proposal and companion proposals outlining the same change- But, this panel member cannot support the industry changing voltage level increase without sufficient reporting upon the effects of such a change will have upon the electrical worker. Perhaps a timeline for implementation is also needed to prepare workers for the change rather than allowing such a change to occur upon issue of the 2014 NEC.
Comment on Affirmative:

BOWER, W.: The proposal should use the term "PV" instead of "photovoltiac".

4-224 Log #2186 NEC-P04 **Final Action: Accept in Part**
(690.7(C))

Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum
Recommendation: Revise 690.7(C) as follows:

(C) Photovoltaic Source and Output Circuits. In one and two family dwellings, PV source and PV output circuits that do not include lamp holders, fixtures, or receptacles shall be permitted to have a maximum systems voltage up to 600 volts. Other installations with a maximum systems voltage over ~~600~~ 1000 volts shall comply with Article 690, Part IX.
Systems with a maximum systems voltage of 1000 volts or less shall use the circuit sizing and current calculations of Section 690.8.

Substantiation: There are numerous large (megawatt size) 1000 volt dc PV systems being installed throughout the country. Although these Power Purchase Systems (PPA) usually are fenced and accessed only by qualified people, they are not owned and operated by a utility on utility property and therefore come under the requirements of the NEC.

There is a gap in the requirements for systems below the 600-volt limit in the NEC and the requirements for 2001 volt and higher medium voltage systems.

The cable ampacities (and cable types) given for cables rated from 0 to 2000 volts in Table 310.15(B)(16) differ significantly from the ampacities for cables rated from 2001 to 35 KV given in tables in the 310.60(C) series.

As an example, engineers are arguing that Article 240.101 (overcurrent devices above 600 volts) should be used for sizing overcurrent devices on 1000-volt PV systems rather than article 240.4. Article 240.101 allows overcurrent protection to be used at three (3) to six (6) times the conductor ampacity. PV modules and inverters listed at 1000 volts are not tested and evaluated during the listing process for use with overcurrent devices of this magnitude. Using such large overcurrent protective devices with this PV equipment could result in significant equipment damage and personnel hazards.

This proposal requires that systems operating at 1000 volts use 690.7 and 690.8 to size the conductors and overcurrent devices rather than go to the parts of the code that applies to the more specialized over 600 volt devices. And equipment

A related proposal is being submitted for Section 690.80
Panel Meeting Action: Accept in Part

Panel Statement: The addition of last sentence is rejected. Maximum system voltage is not defined in Article 690. See panel action on Proposal 4-223.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 12 Negative: 1
Explanation of Negative:

STAFFORD, T.: This panel member agrees with the panel statement upon residential limitations for voltage levels. This panel member does not agree with acceptance upon "other" areas of use of 1000 volts.

It is recognized that the distributed generation sources covered by the NEC such as wind and photovoltaics are demanding increased voltage levels to improve performance and efficiency, but this panel member feels that extensive training and equipment research is needed before implementing a "new" voltage threshold to which electricians may be exposed.

Meters and other testing equipment need to be evaluated and tested for 1000 volts as compared to some existing 600 volt limitations. Proper PPE also needs to be evaluated and determined for increased level of arc /blast hazards that may occur. Conductor insulation(s), equipment and terminal spacing, termination points, overcurrent protection devices, work space clearances, etc.- all will be affected by proposed change. Increasing existing voltage levels to 1000 volts from 600 volts immediately renders existing equipment today that is rated for 600 volts unsafe. There is a concern of this panel member as to what is going to be available to present clarity in the proper selection of meters and tools to identify 1000 volt use as compared to 600 volts. Concern is also raised as to making sure specification's for all equipment also meets new voltage levels, even existing equipment being supplied today. This panel member does not believe that all equipment, tools, meters, etc. will immediately become available for use by the electrician upon the issue of the 2014 NEC. The electrical worker is the one exposed to such hazards immediately upon issue of 2014 NEC if this proposal is accepted.

The task group submitted in their substantiation that, "minimal or no impact to the system installation" would be a result of increasing the voltage level to 1000 volts. This panel member agrees with that statement but the impact upon the worker in the specific industries will be affected. Time for implementation of the new voltage levels needs to be outlined and detailed as to when such a voltage increase may be placed into the NEC. Proper timing and opportunities for training, and new equipment needs to be provided before allowing a voltage increase to be implemented.

This panel member is in favor of increasing the voltage level to 1000 volts as outlined in this proposal and companion proposals outlining the same change- But, this panel member cannot support the industry changing voltage level increase without sufficient reporting upon the effects of such a change will have upon the electrical worker. Perhaps a timeline for implementation is also needed to prepare workers for the change rather than allowing such a change to occur upon issue of the 2014 NEC.

Comment on Affirmative:

ROGERS, J.: The allowances found in 240.101 would not generally apply to the DC circuits that are part of PV Source and Output circuits, they may apply to inverter output circuits. In any event 110.3 B would mandate that listing requirements be followed for either the PV system components or the over-current devices thus not allowing over-current devices that are sized in excess of the maximum allowed in product standards or instruction manuals.

4-225 Log #886 NEC-P04 **Final Action: Accept**
(690.7(E))

Submitter: Michael J. Johnston, National Electrical Contractors Association
Recommendation: Add a new last sentence after the warning text as follows:
The warning sign(s) or label(s) shall comply with 110.21(B).
Substantiation: This proposal is one of several coordinated companion proposals to provide consistency of danger, caution, and warning sign or markings as required in the NEC. The proposed revision will correlate this warning marking requirement with proposed 110.21(B) and the requirements in ANSI Z 535.4.
Panel Meeting Action: Accept
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-225a Log #CP409 NEC-P04 **Final Action: Accept**
(690.8)

Submitter: Code-Making Panel 4,
Recommendation: Revised 690.8 to read as follows:

690.8 Circuit Sizing and Current.

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

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

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

(2) Photovoltaic Output Circuit Currents. The maximum current shall be the sum of parallel source circuit maximum currents as calculated in 690.8(A)(1).

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

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

(5) DC to DC Converter Output Current. The maximum current shall be the dc- to-dc converter continuous output current rating.

(B) Conductor Ampacity. PV system currents shall be considered to be continuous. Circuit conductors shall be sized to carry not less than the larger of 690.8(B)(1) or (2).

(1) One hundred and twenty-five percent of the maximum currents calculated in 690.8(A) before the application of adjustment and correction factors.

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

(2) The maximum currents calculated in 690.8(A) after the application of adjustment and correction factors.

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

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

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

BOWER, W.: There appears to be a tendency to use just the word "module" for "PV module". Since PV systems are becoming modular in nature it would be wise to begin using language that is very clear. Also, the new changes are using a mix of dc, DC and direct current to indicate a direct current situation. I believe the code should be consistent. I have no objections to beginning a sentence with Direct Current or Using Direct Current in Titles. There now needs to be a guidance in the style manual as dc systems become more prevalent.

4-226 Log #2129 NEC-P04 **Final Action: Accept in Principle**
(690.8)

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

690.8 Circuit Sizing and Current.

(A) Calculation of Maximum Circuit Current. The maximum current for the specific circuit shall be calculated in accordance with 690.8(A)(1) through (A)(4).

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

(1) Photovoltaic Source Circuit Currents. The maximum current shall be the sum of parallel module rated shortcircuit currents multiplied by 125 percent.

(2) Photovoltaic Output Circuit Currents. The maximum current shall be the sum of parallel source circuit maximum currents as calculated in 690.8(A)(1).

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

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

(B) Conductor Ampacity ~~and Overcurrent Device Ratings~~. Photovoltaic system currents shall be considered to be continuous.

~~**(1) Overcurrent Devices.** Overcurrent devices, where required, shall be rated as required by 690.8(B)(1)(a) through (1)(d).~~

~~(a) To carry not less than 125 percent of the maximum currents calculated in 690.8(A).~~

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

~~(b) Terminal temperature limits shall be in accordance with 110.3(B) and 110.14(C).~~

~~(c) Where operated at temperatures greater than 40°C (104°F), the manufacturer's temperature correction factors shall apply.~~

~~(d) The rating or setting of overcurrent devices shall be permitted in accordance with 240.4(B), (C), and (D).~~

(2) Conductor Ampacity. Circuit conductors shall be sized to carry not less than the larger of 690.8(B)(1) ~~(2)(a)~~ or (2) ~~(b)~~.

(1) ~~(a)~~ One hundred and twenty-five percent of the maximum currents calculated in 690.8(A) without any additional correction factors for conditions of use.

(2) ~~(b)~~ The maximum currents calculated in 690.8(A) after conditions of use have been applied.

(3) ~~(c)~~ The conductor selected, after application of conditions of use, shall be protected by the overcurrent protective device, where required.

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

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

Substantiation: This proposal is part of a series of proposals intended to group the requirements based on the type or subject. This proposal removes overcurrent device sizing in order to group like requirements together within the article. A companion proposal inserts the overcurrent device requirements into 690.9 Overcurrent Protection section. See the summary spreadsheet which details the relocation of requirements contained in the series of proposals.

Note: Supporting material is available for review at NFPA Headquarters.

Panel Meeting Action: Accept in Principle

Panel Statement: This proposal was used as the baseline for the reorganization of 690.8 conducted under Proposal 4-225a. See panel action on Proposal 4-225a which incorporates the submitter's proposal with additional changes.

Number Eligible to Vote: 13

Ballot Results: Affirmative: 13

4-227 Log #3165 NEC-P04 **Final Action: Reject**

(690.8x (New))

TCC Action: It was the action of the Correlating Committee that further consideration be given to the comments expressed in the voting since the PV cable is a special use cable listed for use in Article 690 and not covered in Article 310.

Section 300.50 and the accompanying Table 300.50 require over 600 volt cable to comply with the requirements in 310.10(F), which may not apply to PV cable.

This action will be considered a public comment.

Submitter: Christel K. Hunter, Alcan Cable

Recommendation: Revise text to read as follows:

IX. Systems over 600 Volts

690.8x **Listing** Products listed for photovoltaic systems shall be permitted to be used and installed in accordance with their listing. Photovoltaic wire that is listed for direct burial at voltages above 600 volts but not exceeding 2000 volts shall be installed in accordance with Table 300.50, Column 1.

Substantiation: It is common practice in large utility-scale solar installations to direct bury 2000V rated conductors used to carry power from combiner boxes to the inverter. Since these installations are not accessible to the public and maintenance is controlled by the facility owner, direct buried single conductor installations are appropriate. There are Listed PV wire products rated at 2000 volts and listed for direct burial that are now available. New standards are being developed for above 600 volt equipment and other electrical systems components, and this language would allow those products to be used where available.

(A companion proposal was submitted to similarly revise 300.50 just for listed direct burial single conductors above 600 volts.)

Panel Meeting Action: Reject

Panel Statement: It is not required to tell people that products can be used in accordance with their listing. The requirements for burial depths at voltages above 600 volts are already covered in 300.50.

Number Eligible to Vote: 13

Ballot Results: Affirmative: 12 Negative: 1

Explanation of Negative:

ALLISON, M.: The panel action should have been to accept. Although normally the NEC and product listings work together, in this case they do not. PV wire is a listed conductor type, but does not yet have a full product standard and is not included as a Chapter 3 wiring method. The requirements in 690.80 and 300.50 are likely to be interpreted as being in conflict with the listed use of 2000V direct burial listed PV wire. Chapters 1-4 are applied in general and since this is a wiring method specific to PV it is necessary to recognize it in order to ensure appropriate installation methods are followed.

4-228 Log #3396 NEC-P04 **Final Action: Accept**

(690.8(A)(5) (New))

TCC Action: The Correlating Committee understands that this proposal is further revised by the actions taken on Proposal 4-225a.

Submitter: Marvin Hamon, Hamon Engineering

Recommendation: Revise text to read as follows:

(A) Calculation of Maximum Circuit Current. The maximum current for the specific circuit shall be calculated in accordance with 690.8(A)(1) through (A)(5~~4~~).

(5) DC to DC Converter Output Current. The maximum current shall be the DC to DC Converter continous output current rating.

Substantiation: There are currently no references in NEC 690 that discuss how to safely integrate DC to DC converters into the PV system design. When a DC to DC converter is inserted into the DC circuit there is no guidance on how to determine the voltage and current limits between the DC to DC converter and the inverter input. This proposal along with companion proposals tries to address this issue.

DC to DC converters have listed maximum output current limits and maximum overcurrent protection requirements if the outputs are combined.

Panel Meeting Action: Accept

Number Eligible to Vote: 13

Ballot Results: Affirmative: 13

4-229 Log #1889 NEC-P04 **Final Action: Accept in Principle**

(690.8(B)(2))

Submitter: Brian Mehalic, Solar Energy International

Recommendation: Add new text to read as follows:

Exception: When protected by an overcurrent device which, along with its assembly, is listed for continuous duty, conductors may be sized to carry the larger of:

(1) The maximum currents calculated in 690.8(A), or

(2) The rated current after conditions of use have been applied.

Substantiation: The exception to 690.8(B)(1)(a) allows "Circuits containing an assembly, together with its overcurrent device(s), that is listed for continuous operation at 100 percent of its rating…to be utilized at 100 percent of its rating," rather than requiring it to be sized for 125% of the maximum current as calculated in 690.8(A). 690.8(B)(2) states that conductors must be sized to carry either 125% of the maximum current (as calculated in 690.8(A)) or the maximum current after conditions of use factors have been applied. PV system currents are considered continuous per 690.8(B) and conductors are already rated for continuous duty, however they do need to be protected by the overcurrent device per 690.8(B)(2)(c). Adding the proposed Exception to the conductor sizing requirements in 690.8(B)(2) will prevent conductors from being needlessly oversized when overcurrent devices listed for continuous operation at 100 percent of their rating are used in a circuit.

Panel Meeting Action: Accept in Principle

Panel Statement: See panel action on Proposal 4-232a which addresses the submitter's concerns.

Number Eligible to Vote: 13

Ballot Results: Affirmative: 13

4-230 Log #2187 NEC-P04 **Final Action: Reject**

(690.8(B)(2))

Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum

Recommendation: Revise to add terminal temperature conductor size adjustment to (2):

(2) Conductor Ampacity. Circuit conductors shall be sized to meet the most restrictive requirement ~~carry not less than the larger~~ of 690.8(B)(2)(a) through (2)(d)., ~~or (2)(b)~~

(a) Shall carry one hundred and twenty-five percent of the maximum current~~s~~ calculated in 690.8(A) without any additional correction factors for conditions of use.

(b) Shall carry the maximum current~~s~~ calculated in 690.8(A) after conditions of use have been applied.

(c) Shall meet the terminal temperature requirements of 110.14(C) where the conductor terminates at a terminal with a temperature rating. One hundred and twenty-five percent of the maximum current calculated in 690.8(A) shall be used in the terminal temperature estimation.

(ed) ~~The conductor selected, after application of conditions of use~~, Shall be protected by the overcurrent protective device, where required, after application of conditions of use.

Substantiation: The terminal temperature limitations of 110.14(C) are often not applied during design or checked during the AHJ plan review. It is common to use 90°C rated conductor in PV systems with overcurrent protection devices with 60 °C or 75°C terminals. The elevated temperatures experienced in dc combiner boxes mounted in exposed locations on roofs makes this check even more important. Adding this requirement here will make this requirement more visible to people using 690.

Changes were also made to correct grammar.

Panel Meeting Action: Reject

Panel Statement: PV installations are already required to comply with the requirements of 110.14(C). It is not necessary to add the requirements here as well. Wire size and temperature rating specified by UL 1741 listing is based upon actual test data for the equipment and will supersede the calculation. See panel action on 4-225a for the panel direction on minor edits.

Number Eligible to Vote: 13

Ballot Results: Affirmative: 13

4-231 Log #1979 NEC-P04 **Final Action: Accept in Principle**
(690.8(B)(2), Informational Note (New))

Submitter: Jonathan R. Althouse, Michigan State University
Recommendation: Add a new informational note after paragraph (c) to read as follows:
Informational Note: Conditions of use can include installation in a location where the operating temperature significantly differs from rated test temperature conditions necessitating the use of output adjustment factors provided by the manufacturer.
Substantiation: The words "conditions of use" is meaningless to installers without some explanation as to what they include. Solar photovoltaic panels installed in northern climates may have an output greater than rated values in cold sunlight conditions. The manufacturer will provide adjustment factors that can be applied to increase the short circuit current ratings to be used in determining minimum conductor size.
Panel Meeting Action: Accept in Principle
Panel Statement: See panel taken on Proposal 4-225a which addresses the submitter's concerns.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-232 Log #2651 NEC-P04 **Final Action: Reject**
(690.8(B)(2), Informational Note (New))

Submitter: William F. Brooks, Brooks Engineering
Recommendation: Add text to read as follows:
(2) Conductor Ampacity. Circuit conductors shall be sized to carry not less than the larger of 690.8(B)(2)(a) or (2)(b).
(a) One hundred and twenty-five percent of the maximum currents calculated in 690.8(A) without any additional correction factors for conditions of use.
(b) The maximum currents calculated in 690.8(A) after conditions of use have been applied.
(c) The conductor selected, after application of conditions of use, shall be protected by the overcurrent protective device, where required.
Informational Note: One source for the highest expected 3-hour ambient temperatures in various locations is the average of the June through August 2% Monthly Design Dry Bulb Temperature from the ASHRAE Handbook — Fundamentals.
Substantiation: The 2011 NEC Handbook refers to these data as the basis for the examples when calculating ampacity of conductors in outdoor conditions. These data are also recommended by the Copper Development Association, of which many conductor manufacturers are members. There is a similar informational note proposal submitted to clean up the current ambiguous note in 310.15(B)(3)(c). Since all rooftop PV systems must consider ambient temperature adjustment factors as required in 690.8(B)(2), it is important that the accurate informational note be placed in this section whether or not 310.15 proposal is accepted.
Panel Meeting Action: Reject
Panel Statement: Conductor sizing is addressed in 310.15.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 12 Negative: 1
Explanation of Negative:
BOWER, W.: The NEC is vague in article 310 about the appropriate data to use as the starting point for ambient temperature. A proposal was submitted to fix the note in 310.15, but this proposal was rejected. Since PV systems must routinely perform correction factors for ambient temperature, it is a disservice to AHJs and engineers not to provide the correct ambient temperature reference.

4-232a Log #CP411 NEC-P04 **Final Action: Accept**
(690.9)

TCC Action: The Correlating Committee directs that the panel clarify the panel action on this proposal by providing a complete sentence in (B)(1) in accordance with 3.3.5 of the NEC Style Manual.
The Correlating Committee further directs that the panel reconsider general references to Articles in Chapters 1 through 4 since they apply to the remainder of the code, unless supplemented or modified in Chapters 5, 6 or 7. See 90.3.
This action will be considered as a public comment.
Submitter: Code-Making Panel 4,
Recommendation: Revised 690.9 to read as follows:
690.9 Overcurrent Protection.
(A) Circuits and Equipment. PV source circuit, PV output circuit, inverter output circuit, and storage battery circuit conductors and equipment shall be protected in accordance with the requirements of Article 240. Protection devices for PV source circuits and PV output circuits shall be listed for use in PV systems. Circuits, either ac or dc, connected to current limited supplies (e.g. PV modules, ac output of utility-interactive inverters) and also connected to sources having significantly higher current availability (e.g. parallel strings of modules, utility power) shall be protected at the source from overcurrent.
Exception: An overcurrent device shall not be required for PV modules or PV source circuit conductors sized in accordance with 690.8(B) where one of the following applies:
(a) There are no external sources such as parallel connected source circuits, batteries, or backfeed from inverters.
(b) The short-circuit currents from all sources do not exceed the ampacity of the conductors and do not exceed the maximum overcurrent protective device rating specified on the PV module nameplate.
(B) Overcurrent Devices. Overcurrent devices, where required, shall be rated as required by 690.9(B)(1) through (4).
(1) To carry not less than 125 percent of the maximum currents calculated in 690.8(A).
Exception: Circuits containing an assembly, together with its overcurrent device(s), that is listed for continuous operation at 100 percent of its rating shall be permitted to be used at 100 percent of its rating.
(2) Terminal temperature limits shall be in accordance with 110.3(B) and 110.14(C).
(3) Where operated at temperatures greater than 40°C (104°F), the manufacturer's temperature correction factors shall apply.
(4) The rating or setting of overcurrent devices shall be permitted in accordance with 240.4(B), (C), and (D).
(C) Direct-Current Rating. Overcurrent devices, either fuses or circuit breakers, used in any dc portion of a PV power system shall be listed for use in PV systems and shall have the appropriate voltage, current, and interrupt ratings.
(D) Photovoltaic Source and Output Circuits. Listed PV overcurrent devices shall be required to provide overcurrent protection in photovoltaic source and output circuits. The overcurrent devices shall be accessible but shall not be required to be readily accessible.
(E) Series Overcurrent Protection. In grounded PV source circuits, a single overcurrent protection device, where required, shall be permitted to protect the PV modules and the interconnecting conductors. In ungrounded PV source circuits complying with 690.35, an overcurrent protection device, where required, shall be installed in each ungrounded circuit conductor and shall be permitted to protect the PV modules and the interconnecting cables.
(F) Power Transformers. Overcurrent protection for a transformer with a source(s) on each side shall be provided in accordance with 450.3 by considering first one side of the transformer, then the other side of the transformer, as the primary.
Exception: A power transformer with a current rating on the side connected toward the utility-interactive inverter output, not less than the rated continuous output current of the inverter, shall be permitted without overcurrent protection from the inverter.
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.
Panel Meeting Action: Accept
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13
Comment on Affirmative:
BOWER, W.: This is another instance where the use of the term PV for photovoltaic and the term DC for direct current should be consistent.

4-233 Log #2132 NEC-P04 **Final Action: Accept in Principle**
(690.9)

Submitter: Chad Kennedy, Square D Company/Schneider Electric
Recommendation: Revise text to read as follows:
690.9 Overcurrent Protection.
(A) Circuits and Equipment. Photovoltaic source circuit, photovoltaic output circuit, inverter output circuit, and storage battery circuit conductors and equipment shall be protected protected in accordance with the requirements of Article 240. Circuits connected to more than one electrical source shall have overcurrent devices located so as to provide overcurrent protection from all sources.
Exception: An overcurrent device shall not be required for PV modules or PV source circuit conductors sized in accordance with 690.8(B) where one of the following applies:
(a) There are no external sources such as parallelconnected source circuits, batteries, or backfeed from inverters.
(b) The short-circuit currents from all sources do not exceed the ampacity of the conductors or the maximum overcurrent protective device size specified on the PV module nameplate..
(B) Overcurrent Devices. Overcurrent devices, where required, shall be rated as required by 690.9(B)(1) through (4).
(1) To carry not less than 125 percent of the maximum currents calculated in 690.8(A).
Exception: Circuits containing an assembly, together with its overcurrent device(s), that is listed for continuous operation at 100 percent of its rating shall be permitted to be used at 100 percent of its rating.
(2) Terminal temperature limits shall be in accordance with 110.3(B) and 110.14(C).
(3) Where operated at temperatures greater than 40°C (104°F), the manufacturer's temperature correction factors shall apply.
(4) The rating or setting of overcurrent devices shall be permitted in accordance

with 240.4(B), (C), and (D).
~~(D)~~ (C) Direct-Current Rating. Overcurrent devices, either fuses or circuit breakers, used in any dc portion of a photovoltaic power system shall be listed for use in dc circuits and shall have the appropriate voltage, current, and interrupt ratings.
~~(C)~~ (D) Photovoltaic Source Circuits. Branch-circuit or supplementary-type overcurrent devices shall be permitted to provide overcurrent protection in photovoltaic source circuits. The overcurrent devices shall be accessible but shall not be required to be readily accessible. Standard values of supplementary overcurrent devices allowed by this section shall be in one ampere size increments, starting at one ampere up to and including 15 amperes. Higher standard values above 15 amperes for supplementary overcurrent devices shall be based on the standard sizes provided in 240.6(A).
(E) Series Overcurrent Protection. In PV source circuits, a single overcurrent protection device shall be permitted to protect the PV modules and the interconnecting conductors.
~~(B)~~ (F) Power Transformers. Overcurrent protection for a transformer with a source(s) on each side shall be provided in accordance with 450.3 by considering first one side of the transformer, then the other side of the transformer, as the primary.
Exception: A power transformer with a current rating on the side connected toward the utility-interactive inverter output, not less than the rated continuous output current of the inverter, shall be permitted without overcurrent protection from the inverter.
Substantiation: This proposal is part of a series of proposals which group similar requirements for PV systems together in order to make the article easier to use. Overcurrent device requirements from existing 690.8(B)(1) are moved to 690.9 to group them with other overcurrent protection requirements. See the summary spreadsheet which details the relocation of requirements contained in the series of proposals.
Note: Supporting material is available for review at NFPA Headquarters.
Panel Meeting Action: Accept in Principle
Panel Statement: This proposal was used as the baseline for the reorganization of 690.9 conducted under Proposal 4-232a. See panel action on Proposal 4-232a which incorporates the submitter's proposal with additional changes.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13
Comment on Affirmative:
BOWER, W.: In 690.9(B)(3) The sentence "Where operated at temperatures greater than 40°C (104°F)," is inaccurate and would be more accurate if it read "(3) Where operated in ambient temperatures greater than 40°C (104°F)". Nobody will be measuring the temperate at which the device is operating. Again the term photovoltaic is creeping back into the body of sentences.

4-234 Log #598 NEC-P04 **Final Action: Accept in Principle**
(690.9(A) (New))

Submitter: John Foster, Advanced Energy
Recommendation: Add new text to read as follows:
Exception No. 2: An over current device shall not be required on the inverter side of inverter output circuits for utility interactive inverters provided the following apply:
(1) Fault current from the inverter is limited in magnitude and duration
(2) The conductors are protected by an over current device on the utility side of the inverter output circuit.
Informational Note: Utility interactive inverters are inherently limited in the fault current they can provide. Even if an over current device is provided, the inverter fault current is typically insufficient to activate it.
Substantiation: The peak inverter fault current is typically less than 3x operating current. Fault duration from an inverter is limited. The time an inverter can feed into a fault is typically under 0.05 second. This magnitude and duration is insufficient to trip a circuit breaker or fuse. The utility is the source of current which can cause damage during a fault on the inverter output circuit. Fault current contribution from the utility is typically greater than 10 kA, far in excess of what the inverter can provide. The utility supply is capable of feeding into a fault indefinitely unless interrupted by an appropriate over current device. Therefore, while over current protection on the utility side is critical; over current protection on the inverter side should not be required. The contribution of the inverter into a fault on the AC output conductors will be trivial compared to the contribution from the utility. A circuit breaker or fuse on the inverter side of the inverter output conductors will do nothing to protect those conductors.
Additional supporting information is provided by the explanatory text following Section 705.65(B) in the 2011 NEC Handbook.
Note: Supporting material is available for review at NFPA Headquarters.
Panel Meeting Action: Accept in Principle
Panel Statement: See panel action on Proposal 4-235 which addresses the submitter's concerns through positive text. Also see panel action on Proposal 4-232a.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-235 Log #2188 NEC-P04 **Final Action: Accept in Principle**
(690.9(A))

Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum
Recommendation: Add the following paragraph to 690.9(A) before the Exceptions.
Circuits, either ac or dc, connected to current limited supplies (e.g. PV modules, ac output of utility-interactive inverters) and also connected to sources having significantly higher current availability (e.g. parallel strings of modules, utility power) shall be protected from overcurrents at the source of overcurrents that can damage the circuit.
Substantiation: For circuits supplied by current limited sources, Section 240. gives misleading requirements with respect to the location of overcurrent protection for the circuit. The overcurrent protection must be located where the overcurrents can originate that might damage the circuit, not at the supply for the circuit which may be a current limited PV source or the ac output of a utility-interactive inverter. These circuits are sized at 125% of the continuous currents the supplies can generate and are not affected by currents from the obvious supply for the circuit. However, they can be damaged by external sources that may be connected such as parallel-connected PV source circuits or utility-power sources.
Sample diagrams have been provided.
Note: Supporting material is available for review at NFPA Headquarters.
Panel Meeting Action: Accept in Principle
Panel Statement: See panel action on Proposal 4-232a, which addresses the submitter's concern.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-236 Log #3181 NEC-P04 **Final Action: Accept**
(690.9(A))

Submitter: Christel K. Hunter, Alcan Cable
Recommendation: Revise text to read as follows:
690.9 Overcurrent Protection
(A) Circuits and Equipment
Photovoltaic source circuit, photovoltaic output circuit, inverter output circuit, and storage battery circuit conductors and equipment shall be protected in accordance with the requirements of Article 240. Protection devices for photovoltaic source circuits and photovoltaic output circuits shall be listed for use in photovoltaic systems. Circuits connected to more than one electrical source shall have overcurrent devices located so as to provide overcurrent protection from all sources.
Substantiation: This proposal was developed by a subgroup of the NEC DC Task Force of the Technical Correlating Committee. The Task Force is chaired by John R. Kovacik, Underwriters Laboratories, and the subgroup members are Christel Hunter with Alcan Cable (subgroup lead), Mike Stelts with Panasonic, Mark Ode with Underwriters Laboratories, Randy Hunter with Cooper Bussmann, Vince Saporita with Cooper Bussmann, Audie Spina with Armstrong, Edward Byaliy with Rockwell Automation, and Brian Patterson with Armstrong.
Overcurrent protection devices in photovoltaic source and output circuits are subject to wide operating current and temperature cycling, high ambient temperatures, low clearing currents and high open-circuit voltages. Standards have been created specifically for photovoltaic dc system protection (both fuses and circuit breakers). The added language in this proposal will make it clear to the inspector and installer that devices specifically designed for these systems are required.
Panel Meeting Action: Accept
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13
Comment on Affirmative:
BOWER, W.: The term PV should be substituted for photovoltaic except for when it is the first word in a sentence.

4-237 Log #3152 NEC-P04 **Final Action: Accept in Principle in Part**
(690.9(A)(b))

TCC Action: It was the action of the Correlating Committee that this proposal be reconsidered and correlated with the action on proposal 4-232a.
This action will be considered as a public comment.
Submitter: Timothy P. Zgonena, Underwriters Laboratories Inc.
Recommendation: Revise paragraph 690.9(A)b as follows:
(b) The short-circuit currents from all sources do not exceed the ampacity of the conductors ~~or~~ and do not exceed the maximum overcurrent protective device ~~size~~ rating specified on the PV module nameplate.
Substantiation: This proposal is intended to clarify the requirement's intent that both criteria are required to be met.
Panel Meeting Action: Accept in Principle in Part
Panel Statement: The additional "and do not exceed" is not necessary. See panel action on Proposal 4-232a which addresses the submitter's concerns.

Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-238 Log #2189 NEC-P04 **Final Action: Reject**
(690.9(C))

Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum
Recommendation: Revise the second paragraph of 690.9(C) as follows
Standard values of supplementary overcurrent devices allowed by this section shall be in one ampere size increments, starting at one ampere up to and including 10 amperes, 12 amperes and 15 amperes. Higher standard values above 15 amperes for supplementary overcurrent devices shall be based on then standard sizes provided in 240.6(A).
Substantiation: Section is revised to reflect commonly available overcurrent device rating sizes of 1-10 amps in one amp increments and 12 amps. There are no commonly available sizes rated at 11, 13, or 14 amps.
Panel Meeting Action: Reject
Panel Statement: Reorganization of 690.9 has made the proposed language unnecessary. See panel action on Proposal 4-232a.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-239 Log #3153 NEC-P04 **Final Action: Accept in Principle in Part**
(690.9(C) and (D))

Submitter: Timothy P. Zgonena, Underwriters Laboratories Inc.
Recommendation: Revise paragraph 690.9(C) and (D) as follows:
(C) Photovoltaic Source Circuits. Listed branch ~~Branch~~-circuit ~~or supplementary~~-type overcurrent devices shall be ~~permitted~~ required to provide overcurrent protection in photovoltaic source circuits. The overcurrent devices shall be accessible but shall not be required to be readily accessible.
~~Standard values of supplementary overcurrent devices allowed by this section shall be in one ampere size increments, starting at one ampere up to and including 15 amperes.~~
~~Higher standard values above 15 amperes for supplementary overcurrent devices shall be based on the standard sizes provided in 240.6(A).~~
(D) Direct-Current Rating. Overcurrent devices, either fuses or circuit breakers, used in any dc portion of a photovoltaic power system shall be listed for use in PV systems in dc circuits and shall have the appropriate voltage, current, and interrupt ratings.
Substantiation: Unlike the US power grid and traditional rotating machine power sources with high levels of potential fault current, PV arrays are a high impedance power source with much lower fault current capability. Considerable research and development work has yielded published national and international requirements for overcurrent protective devices (OCPD) that address the specific needs of PV circuits. There are presently UL requirements for the certification of both fuses (Subject 2579 Outline for Low-Voltage Fuses - Fuses for Photovoltaic Systems) and circuit breakers (Subject 489B Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures For Use With Photovoltaic (PV) Systems) specifically for DC PV systems. Only these devices should be used as branch circuit protection in PV systems.
At present, UL has hundreds of PV OCPD's Listed and others in the process of certification to the published PV OCPD requirements. This proposal is intended to update paragraph 690.9 (C) to require the use of these Listed PV overcurrent protective devices in PV circuits.
Additionally, this proposal removes the allowance for supplementary over current devices, which are not considered branch circuit protection in accordance with 240.10. Supplementary OCPDs in contrast provide no protection against interchangeability with devices of lower voltage and/or higher current ratings or devices that are not rated for DC at all potentially causing a problem far worse than what they are intended to address. In accordance with clause 690.9 (A), overcurrent protective devices shall comply with article 240. Article 240.60(B) requires that:
"Fuseholders shall be designed so that it will be difficult to put a fuse of any given class into a fuseholder that is designed for a current lower, or voltage higher, than that of the class to which the fuse belongs. Fuseholders for current-limiting fuses shall not permit insertion of fuses that are not current-limiting". This is an added benefit for fuses and much less of an issue for circuit breakers.
Branch circuit overcurrent protective devices already include requirements for standard values so that portion of the 690.9 can be removed from the paragraph.
Panel Meeting Action: Accept in Principle in Part
Panel Statement: See panel action on Proposal 4-232a for the direction taken by the panel on the reorganization of 690.9.
The word "branch" was rejected as listed PV type branch overcurrent devices are not available.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-240 Log #3154 NEC-P04 **Final Action: Reject**
(690.9(D))

Submitter: Timothy P. Zgonena, Underwriters Laboratories Inc.
Recommendation: Revise paragraph 690.9 (D) as follows:
(D) Direct-Current Rating. Overcurrent devices, either fuses or circuit breakers, used in any dc portion of a photovoltaic power system shall be listed for use in PV systems in dc circuits and shall have the appropriate voltage, current, and interrupt ratings.
The interrupting rating of the overcurrent device shall be suitable for the available short circuit current for all installed sources.
The available short circuit current shall be calculated as the sum of the available DC sources as follows:
1. Photovoltaic source circuits - The maximum short circuit current of the photovoltaic as determined by 690.8 (A) (1).
2. Energy Storage - The available short circuit current from all DC energy storage equipment including battery banks, capacitors, etc.
3. Inverter – The rated short circuit backfeed current on the inverter.
4. Other DC sources - The rated short circuit current rating.
Substantiation: The new PV OCPD component standards include short circuit interrupting ratings and this proposal provides guidance on how to calculate what OCPD is suitable for a specific installation. The inverter backfeed current rating is planned to be revised/enhanced to account for capacitive discharge and total backfed energy to better correlate to OCPD ratings and functionality.
Panel Meeting Action: Reject
Panel Statement: The proposed material is explanatory and better suited to a product standard or instruction manual.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-241 Log #3180 NEC-P04 **Final Action: Accept in Principle**
(690.9(D))

Submitter: Christel K. Hunter, Alcan Cable
Recommendation: Revise text to read as follows:
690.9 Overcurrent Protection
(D) Direct-Current Rating
Overcurrent devices, either fuses or circuit breakers, used in any portion of a photovoltaic power system shall be listed for use in PV dc circuits and shall have the appropriate voltage, current, and interrupt rating.
Substantiation: This proposal was developed by a subgroup of the NEC DC Task Force of the Technical Correlating Committee. The Task Force is chaired by John R. Kovacik, Underwriters Laboratories, and the subgroup members are Christel Hunter with Alcan Cable (subgroup lead), Mike Stelts with Panasonic, Mark Ode with Underwriters Laboratories, Randy Hunter with Cooper Bussmann, Vince Saporita with Cooper Bussmann, Audie Spina with Armstrong, Edward Byaliy with Rockwell Automation, and Brian Patterson with
Armstrong.
This proposal is developed in concert with the companion proposal submitted by this subgroup for article 690.9(A).
Overcurrent protection devices in photovoltaic source and output circuits are subject to wide operating current and temperature cycling, high ambient temperatures, low clearing currents and high open-circuit voltages. Standards have been created specifically for photovoltaic dc system protection (both fuses and circuit breakers). The added language in this proposal will make it clear to the inspector and installer that devices specifically designed for these systems are required.
Panel Meeting Action: Accept in Principle
Panel Statement: See panel action on Proposal 4-232a which addresses the submitter's concerns.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-242 Log #2190 NEC-P04 **Final Action: Accept**
(690.9(E))

TCC Action: The Correlating Committee understands that the panel action on this proposal applies to 690.9(B) as contained in Proposal 4-232a.
Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum
Recommendation: Revise the section as follows.
690.9(E) Series Overcurrent Protection. In grounded PV source circuits, a single overcurrent protection device, where required, shall be permitted to protect the PV modules and the interconnecting cables. In ungrounded PV source circuits complying with 690.35, an overcurrent protection device, where required, shall be installed in each ungrounded circuit conductor and shall be permitted to protect the PV modules and the interconnecting cables.
Substantiation: As written, the 2011 NEC gives misleading overcurrent requirements for PV arrays. Ungrounded PV arrays are being installed in increasing numbers to permit the use of the newer transformerless utility-interactive inverters. These ungrounded PV source circuits require overcurrent devices in each of the ungrounded conductors, whereas the grounded PV source circuit requires an overcurrent device in only the single ungrounded

conductor.

In some cases, overcurrent protection is not required in either grounded or ungrounded PV source circuits (see 690.9(A) EX).

The addition of the word "grounded" and the reference to 690.35 and the ungrounded PV source circuit clarifies these differing requirements.

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

4-243 Log #60 NEC-P04 **Final Action: Reject**
(690.10 (New))

TCC Action: The Correlating Committee advises that Article Scope statements are the responsibility of the Correlating Committee and the Correlating Committee "Rejects" the panel action.

The Correlating Committee notes that the proposed new Article is assigned to Code-Making Panel 13, therefore, this proposal is forwarded to Code-Making Panel 13 for action. See the action of Code-Making Panel 13 on Proposal 13-152.

This action will be considered as a public comment by Code-Making Panel 13.

NOTE: This Proposal appeared as Comment 4-74 (Log #2469) on Proposal 4-201 in the 2010 Annual Meeting National Electrical Code Committee Report on Proposals. This comment was held for further study during the processing of the 2011 NATIONAL ELECTRICAL CODE. The Recommendation in Proposal 4-201 was: Revise text to read as follows:

690.10 Stand-Alone Systems.

The premises wiring system shall be adequate to meet the requirements of this Code for a similar installation connected to a service. The wiring on the supply side of the building or structure disconnecting means shall comply with the requirements of Article xxx. ~~this Code except as modified by 690.10(A) through (D).~~

~~(A) Inverter Output. The ac output from a stand-alone inverter(s) shall be permitted to supply ac power to the building or structure disconnecting means at current levels less than the calculated load connected to that disconnect. The inverter output rating or the rating of an alternate energy source 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.~~

~~A stand-alone residential or commercial PV installation may have an ac output and be connected to a building wired in full compliance with all articles of this Code. Even though such an installation may have service-entrance equipment rated at 100 or 200 amperes at 120/240 volts, there is no requirement that the PV source provide either the rated full current or the dual voltages of the service equipment. While safety requirements dictate full compliance with the ac wiring sections of the Code, a PV installation is usually designed so that the actual ac demands on the system are sized to the output rating of the PV system. The inverter output is required to have sufficient capacity to power the largest single piece of utilization equipment to be supplied by the PV system, but the inverter output does not have to be sized for the potential multiple loads to be simultaneously connected to it. Lighting loads are managed by the user based on the available energy from the PV system.~~

~~(B) Sizing and Protection. The circuit conductors between the inverter output and the building or structure disconnecting means shall be sized based on the output rating of the inverter. These conductors shall be protected from overcurrents in accordance with Article 240. The overcurrent protection shall be located at the output of the inverter.~~

~~(C) Single 120-Volt Supply. The inverter output of a stand-alone solar photovoltaic system 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 rating of the overcurrent device connected to the output of the inverter 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!~~

~~Multiwire branch circuits are common in one- and two-family dwelling units. When connected to a normal 120/240-volt ac service, the currents in the neutral conductors of these multiwire branch circuits (typically 14-3 AWG) subtract or are, at most, no larger than the rating of the branch-circuit overcurrent device. When these electrical systems are connected to a single 120-volt PV power system inverter by paralleling the two ungrounded conductors in the service entrance load center, the currents in the neutral conductor for each multiwire branch circuit add rather than subtract. The currents in the neutral conductor may be as high as twice the rating of the branch-circuit overcurrent device. With this configuration, neutral conductor overloading is possible.~~

~~(D) Energy Storage or Backup Power System Requirements. Energy storage or backup power supplies are not required.~~

Article 70X – Stand-Alone Electric Systems

Scope: This Article covers electric systems that supply power independently of the electric production and distribution network.

70X.1 Stand-Alone Systems.

The premises wiring system shall be adequate to meet the requirements of this Code for a similar installation connected to a service. The wiring on the supply side of the building or structure disconnecting means shall comply with this Code except as modified by 690.10(A) through (D).

(A) Inverter Output. The ac output from a stand-alone inverter(s) shall be permitted to supply ac power to the building or structure disconnecting means at current levels less than the calculated load connected to that disconnect. The inverter output rating or the rating of an alternate energy source 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.

A stand-alone residential or commercial PV installation may have an ac output and be connected to a building wired in full compliance with all articles of this Code. Even though such an installation may have service-entrance equipment rated at 100 or 200 amperes at 120/240 volts, there is no requirement that the PV source provide either the rated full current or the dual voltages of the service equipment. While safety requirements dictate full compliance with the ac wiring sections of the Code, a PV installation is usually designed so that the actual ac demands on the system are sized to the output rating of the PV system. The inverter output is required to have sufficient capacity to power the largest single piece of utilization equipment to be supplied by the PV system, but the inverter output does not have to be sized for the potential multiple loads to be simultaneously connected to it. Lighting loads are managed by the user based on the available energy from the PV system.

(B) Sizing and Protection. The circuit conductors between the inverter output and the building or structure disconnecting means shall be sized based on the output rating of the inverter. These conductors shall be protected from overcurrents in accordance with Article 240. The overcurrent protection shall be located at the output of the inverter.

(C) Single 120-Volt Supply. The inverter output of a stand-alone solar photovoltaic system 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 rating of the overcurrent device connected to the output of the inverter 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!

Multiwire branch circuits are common in one- and two-family dwelling units. When connected to a normal 120/240-volt ac service, the currents in the neutral conductors of these multiwire branch circuits (typically 14-3 AWG) subtract or are, at most, no larger than the rating of the branch-circuit overcurrent device. When these electrical systems are connected to a single 120-volt PV power system inverter by paralleling the two ungrounded conductors in the service entrance load center, the currents in the neutral conductor for each multiwire branch circuit add rather than subtract. The currents in the neutral conductor may be as high as twice the rating of the branch-circuit overcurrent device. With this configuration, neutral conductor overloading is possible.

(D) Energy Storage or Backup Power System Requirements. Energy storage or backup power supplies are not required.

Submitter: Robert H. Wills, Intergrid, LLC / Rep. American Wind Energy Association

Recommendation: Move common language in Articles 690, 692 & 694 to a new common Article 70X:

Article 70X – Stand-Alone Electric Systems

70X.1 Scope. The provisions of this article apply to electric systems that supply power independent of the electric production and distribution network (utility). Stand-alone electric systems can be supplied by sources including engine generators, inverters, fuel cells, and renewable energy sources such as wind and solar-electric systems.

70X.3 Other Articles. Whenever the requirements of other articles of this *Code* and Article 70X differ, the requirements of Article 70X shall apply.

70X.2 Premises Wiring

When used to supply a building or other structure, a stand-alone electric system shall be adequate to meet the requirements of this *Code* for a similar installation connected to a service. The wiring on the supply side of the building or structure disconnecting means shall comply with this *Code* except, as modified by 690.10(A) through (D).

(A) Inverter Output. The ac output from an electrical source such as a generator or stand-alone inverter shall be permitted to supply ac power to the building or structure disconnecting means at current levels less than the calculated load connected to that disconnect. The electrical source output rating shall be not less 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.

(B) Sizing and Protection. The circuit conductors between the inverter output and the building or structure disconnecting means shall be sized based on the output rating of the inverter. These conductors shall be protected from overcurrent in accordance with Article 240. The overcurrent protection shall be located at the output of the inverter.

(C) Single 120-Volt Supply. The inverter output of a stand-alone solar photovoltaic system 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 multi-wire branch circuits. In all installations, the rating of the overcurrent device connected to the output of the inverter 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!

(D) Energy Storage or Backup Power System Requirements. Energy storage or backup power supplies shall not be required.
Substantiation: The same language for stand-alone systems is included in the three renewable energy Articles (690, 692 and 694).
It makes sense to eliminate redundancy and to move it to a general Article so that common language can serve all three.

In addition, the permissions and safety issues resolved by this language are not solely applicable to PV, fuel cells and wind energy.
In particular, there are many houses that are powered "off-grid" by prime-power generators that are not capable of the full 100 or 200A capacity of a conventional service. Experience with the approximately 100,000 off-grid PV systems in the USA has shown the need to clarification the requirements for stand-alone systems in the *Code*. This should be extended to the general case.

There is no existing article that covers the general area of stand-alone systems:
- Article 705 covers the opposite (interconnected systems).
- These systems are not for standby use, and so do not belong in Article 702 (Optional Standby Systems).

It makes sense then to create a new article in Chapter 7 to complement Article 705. (covering essentially "non-interconnected power production sources").

The language above is based on that of Article 690.10, but with the specific references to PV power sources changed to the generic term "stand-alone electric system source". The language was also changed to make it compliant with the NEC Style Manual.

This proposal was originally rejected for not being presented as a complete article. I trust that this revision meets the panel's requirements.
Panel Meeting Action: Accept
Panel Statement: The panel recognizes that this recommendation is under the purview of the Technical Correlating Committee. The panel requests the that Technical Correlating Committee consider the inclusion of this new article into the NEC.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-244 Log #887 NEC-P04 **Final Action: Accept**
(690.10(C))

Submitter: Michael J. Johnston, National Electrical Contractors Association
Recommendation: Add a new last sentence after the warning text as follows:
The warning sign(s) or label(s) shall comply with 110.21(B).
Substantiation: This proposal is one of several coordinated companion proposals to provide consistency of danger, caution, and warning sign or markings as required in the NEC. The proposed revision will correlate this warning marking requirement with proposed 110.21(B) and the requirements in ANSI Z 535.4.
Panel Meeting Action: Accept
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-245 Log #2063 NEC-P04 **Final Action: Accept**
(690.10(E))

TCC Action: The Correlating Committee directs that the panel clarify the panel action on this proposal and correlate with the action taken on Proposal 4-246.
This action will be considered as a public comment.
Submitter: Robert J. Walsh, City of Hayward
Recommendation: Revise text to read as follows:

690.10(E) Back-fed Circuit Breakers. Plug-in type back-fed circuit breakers connected to a stand-alone inverter output in ~~either~~ stand-alone ~~or utility interactive~~ systems shall be secured in accordance with 408.36(D). Circuit breakers that are marked "line" and "load" shall not be back-fed.
Substantiation: The inclusion of "or utility interactive" in 690.10(E) conflicts with the permissive rule in 705.12(D)(6) (i.e., "to omit the additional fastener normally required by 408.36(D) for such applications").
Panel Meeting Action: Accept
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13
Comment on Affirmative:

STAFFORD, T.: While this panel member will vote to accept the proposal as written as it does increase the safety of the installation. However, this panel member feels this proposal does not go far enough. It does not matter if a circuit breaker connects a stand alone or a utility interactive inverter it must maintain the same requirements. This panel member suggests that the operation of a circuit breaker does not change if a circuit breaker is installed for back-feed in a stand alone or interactive mode. The requirements of 408.36 (D) should be maintained for stand alone systems.

4-246 Log #2191 NEC-P04 **Final Action: Accept**
(690.10(E))

TCC Action: The Correlating Committee directs that the panel clarify the panel action on this proposal and correlate with the action taken on Proposal 4-245.
This action will be considered as a public comment.
Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum
Recommendation: Revise text to read as follows:

Plug-in type back-fed circuit breakers connected to a stand-alone inverter output in either stand-alone or ~~utility-interactive~~ multimode inverter systems shall be secured in accordance with 408.46(D). Circuit breakers ~~that are~~ marked "line" and "load" shall not be backfed.
Substantiation: Clarifies the intent that the breakers that are to be secured are the ones on the stand-alone output of a multimode inverter (defined in a separate proposals for 690.2), not a utility-interactive inverter. Remove "that are" for grammatical reasons.
Panel Meeting Action: Accept
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13
Comment on Affirmative:

ROGERS, J.: The reference in the proposal should be 408.36 not 408.46.

STAFFORD, T.: While this panel member will vote to accept the proposal as written as it does increase the safety of the installation. The inclusion of "multimode inverter" does require additional safety measures. The requirements of 408.36 (D) should be maintained for stand alone systems, multimode and utility interactive.

4-246a Log #CP416 NEC-P04 **Final Action: Accept**
(690.11)

Submitter: Code-Making Panel 4,
Recommendation: Revise the subsections of 690.11 to read as follows:
(1) The system shall detect and interrupt arcing faults in dc PV source and output circuits.
(2) The system shall require that the disabled or disconnected equipment be manually restarted.
(3) The system shall have an annunciator that provides a visual indication that the circuit interrupter has operated. This indication shall not reset automatically.
Substantiation: Language is revised from current text to make arc fault detection a requirement for both series and parallel arc faults. Additionally prescribed methods and equipment are removed from current text to allow alternate implementation.
Panel Meeting Action: Accept
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-247 Log #232 NEC-P04 **Final Action: Reject**
(690.11)

Submitter: Gregory P. Bierals, Samaritan's Purse World Medical Mission
Recommendation: Revise text to read as follows:

The readily accessible requirement for overcurrent devices in 240.24 shall not apply to the arc-fault circuit protection required by this section.
Substantiation: These devices typically will be elevated and, therefore, not in a readily accessible location.
Panel Meeting Action: Reject
Panel Statement: The recommendation does not follow Section 4.3.3(c) of the Regulations Governing Committee Projects. Revisions to the current text are not indicated.

The devices that are being described in 690.11 are not overcurrent devices they are protective techniques thus 240.24 does not apply.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-248 Log #233 NEC-P04 **Final Action: Reject**
(690.11)

Submitter: Gregory P. Bierals, Samaritan's Purse World Medical Mission
Recommendation: Revise text to read as follows:

The readily accessible requirement for overcurrent protective devices in 240.24 shall not apply to the arc-fault circuit protection required by this section.
Substantiation: These devices will typically be elevated at the PV Panel location and, most likely, will not be readily accessible.
Panel Meeting Action: Reject

Panel Statement: The recommendation does not follow Section 4.3.3(c) of the Regulations Governing Committee Projects. Revisions to the current text are not indicated.

The devices that are being described in 690.11 are not overcurrent devices they are protective techniques thus 240.24 does not apply.

Number Eligible to Vote: 13

Ballot Results: Affirmative: 13

4-249 Log #2265 NEC-P04 **Final Action: Accept in Principle**

(690.11)

Submitter: Lee Charles Martin, Sensata Technologies

Recommendation: Revise text to read as follows:

(1) The system shall detect and interrupt arcing faults resulting from a failure in the intended continuity (Series arc-faults) and from a failure in the intended insulation (Parallel arc-faults) of a conductor, connection, module, or other system component in the dc PV source or output circuits.

(2) The system shall disable or disconnect ~~one or the following:~~ system components within the arcing circuit to remove power that sustains the arcing fault.

~~a. Inverters or charge controllers connected to fault circuit when fault is detected~~

~~b. System components within the arcing circuit~~

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

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

Substantiation: Several fires have occurred as a result of parallel arc faults. Removal of the load (Opening the inverter) will not extinguish a parallel arc and may in fact make the situation worse. The present technology for detecting arcing may not 100% distinguish between a series and parallel arc, thus the best system response would be to isolate the arc as close as possible to its location in the circuit.

Panel Meeting Action: Accept in Principle

Panel Statement: See panel action on Proposal 4-246a which addresses the submitter's concern.

Number Eligible to Vote: 13

Ballot Results: Affirmative: 13

4-250 Log #2266 NEC-P04 **Final Action: Accept in Principle**

(690.11)

Submitter: Lee Charles Martin, Sensata Technologies

Recommendation: Revise text to read as follows:

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

(1) The system shall detect and interrupt arcing faults resulting from a failure in the intended continuity of a conductor, connection, module, or other system component in the dc PV source or output circuits.

(2) The system shall disable or disconnect ~~one or the following:~~ system components within the arcing circuit to remove power that sustains the arcing fault.

~~a. Inverters or charge controllers connected to fault circuit when fault is detected~~

~~b. System components within the arcing circuit~~

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

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

Substantiation: Present Arc detection technology cannot reliably distinguish between series and parallel arc faults. Fires have occurred in the real world as a result of parallel arc faults. In the event of misidentification of a parallel arc as a series arc, removal of the load (Opening the Inverter) could result in more power to be delivered to the arc.

Panel Meeting Action: Accept in Principle

Panel Statement: See panel action on Proposal 4-246a which addresses the submitter's concern.

Number Eligible to Vote: 13

Ballot Results: Affirmative: 13

4-251 Log #3155 NEC-P04 **Final Action: Accept**

(690.11)

Submitter: Timothy P. Zgonena, Underwriters Laboratories Inc.

Recommendation: Revise 690.11 as follows:

690.11 Arc-Fault Circuit Protection (Direct Current).

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

(1) The system shall detect and interrupt arcing faults resulting from a failure in the intended continuity of a conductor, connection, module, or other system component in the dc PV source and output circuits.

(2) The system shall disable or disconnect one of the following: a. Inverters or charge controllers connected to the fault circuit when the fault is detected b. System components within the arcing circuit (3) The system shall require that the disabled or disconnected equipment be manually restarted. (4) The system shall have an annunciator that provides a visual indication that the circuit interrupter has operated. This indication shall not reset automatically.

Substantiation: Arc faults in PV systems can occur in all PV systems regardless of where they are located. PV arc faults in ground mounted PV arrays can result in grass and brush fires. Such fires can result in deaths and significant property damage, which can be prevented with PV arc fault protection. This proposal expands the coverage of this requirement to all PV arrays.

Since this requirement was proposed for addition to the 2011 code, some independent research has indicated the 80V limit may be higher than appropriate. As a new limit has not yet been determined, a change in this limit is not being proposed at this time, but ongoing research may determine a new limit for this requirement.

Panel Meeting Action: Accept

Number Eligible to Vote: 13

Ballot Results: Affirmative: 13

Comment on Affirmative:

BOWER, W.: In light of the acceptance of 4-250, this would require all PV systems to have both series and parallel arc fault detection. Parallel arc fault detection on buildings is not difficult to add as a requirement since it requires the modules to be shut down as now required in the accepted proposal 4-253. This proposal incorrectly requires ground mounted PV systems to have module-level shutdown and is beyond what is necessary for safety.

4-252 Log #1314 NEC-P04 **Final Action: Reject**

(690.11(5))

Submitter: Abel Lampa, Innovative Engineering Inc.

Recommendation: Please add 690.11(5) to read as follows:

690.11 Arc-Fault Circuit Protection (Direct Current). (5) addition to (4). (5) The Arc fault circuit protection device shall installed to all combiner & recombiner boxes. All combiners & re-combiner boxes shall be equip with a main circuit breaker & Contactors or equivalent so that it will be activated & disconnect all ungrounded conductors affected, when the arc-flash devise was activated.

Substantiation: Explanation. Back in May of 2011, one of my projects in Freehold NJ, (About 1 Meg PV system) creates a massive fire on the roof of the bldg. because the main cable between re-combiner box & the inverter had a ground fault during our commissioning. The inverter is not even engage yet at the time of the fire. Our investigation reveals that the cable was nicked during installation, thereby creates a high impedance contact with the EMT conduit which is grounded. This contact creates spark between the cable & the grounded conduit. The fuses did not activate because the short circuit current available is way below the ratings of the fuses, Per Art. 690.8 & 690.9, indicates that the wiring shall be protected with fuses with the rating not less than (125%X125%) of the short circuit current of the strings.

The only way to protect the system is have arc fault or ground fault protection devices installed in every termination like in the combiner & re-combiner boxes.

Panel Meeting Action: Reject

Panel Statement: The requirements located in 690.11 already mandate that the arc-fault protection system provides protection for all conductors and equipment in PV source circuit and output circuit of any PV system. This protection would extended to combiner boxes as well.

Number Eligible to Vote: 13

Ballot Results: Affirmative: 13

4-253 Log #2646 NEC-P04 **Final Action: Accept in Principle**

(690.12)

Submitter: William F. Brooks, Brooks Engineering

Recommendation: Add text to read as follows:

690.12 PV Arrays on Buildings Response to Emergency Shutdown.

For PV Systems installed on roofs of buildings, photovoltaic source circuits shall be deenergized from all sources within 10 seconds of when the utility supply is deenergized or when the PV power source disconnecting means is opened. When the source circuits are deenergized, the maximum voltage at the module and module conductors shall be 80 volts.

Substantiation: In order to increase the electrical and fire safety of PV systems on buildings, this provision is proposed. This will implement a significant improvement in safety for rooftop PV systems based on the safety concerns of the Fire Service during emergency operations on a PV-equipped

structure. The recent DHS/AFG funded research project by UL provides further evidence of the need for the ability to deenergize this generator in the event of an emergency.

The proposal addresses the deenergization of rooftop wiring leaving only the module wiring and internal conductors of the module still energized. PV source circuit conductors include all wiring between modules or modular electronic devices up to the combining point. In order to meet this requirement, some electronic means will be necessary to shut off the module at the source circuit level. This shutdown must coincide with a utility outage, or manual inverter shutdown. A PV module-level dc-dc converter, single-module micro-inverter, and ac module would all meet this requirement at the module end of the circuit. Simple remotely controlled electronic switches can also meet this requirement. The 80 volts at the module and module conductors is to allow typical modules, up to 72 cells, to be used on rooftop PV systems without modifying the internal wiring of the module. The inverter, or utilization load would also have to have some method to deenergize the input conductors should the product have internal storage such as capacitance or a battery.

Panel Meeting Action: Accept in Principle

Add new text to read as follows:

690.12 PV Arrays on Buildings Response to Emergency Shutdown.

For PV Systems installed on roofs of buildings, photovoltaic source circuits shall be deenergized from all sources within 10 seconds of when emergency shutdown is initiated or when the PV power source disconnecting means is opened. When the source circuits are deenergized, the maximum voltage at the module and module conductors shall be 80 volts.

Panel Statement: The proposed text was revised from "the utility supply is deenergized" to "emergency shutdown is initiated" to address proper shutdown procedures for optional standby systems.

Number Eligible to Vote: 13

Ballot Results: Affirmative: 13

Comment on Affirmative:

BOWER, W.: In tracing the path for this change, I believe that 4-253 wording is still deficient in that it does not properly allow for conversion from the utility interactive mode to an intentional stand-alone (aka UPS) mode. I suggest the language be edited to say "...within 10 seconds of when emergency shutdown is initiated, when the PV power source disconnecting means is opened, or in accordance with utility requirements for interconnection. When the PV source circuits are deenergized, the maximum voltage with respect to ground potential at the PV module and exposed module conductors shall be 80 volts. This is a comment only but should be addressed during the comment period.

STAFFORD, T.: While this panel member agrees that the PV industry should move in this direction, the panel's action to add the new text raises some confusion as to where the voltages are measured from during an ESD trip and for that matter what constitutes an ESD trip. I think if we want the source circuits to be less than 80 volts in an emergency, we should state that clearly. If I measure voltage on a string, depending on how many modules are on a string I could measure up to 600 volts on the string at the same time each module is only supplying 44 volts to the string. I think the first sentence of the proposer's second paragraph sums up the concern. We need to find a way to state that the concern is with the combined voltage output of the string (rooftop wiring) versus the module conductors and internal wiring of the module.

An ESD trip is something that has to be further defined in order for it not to mean a multitude of things to many different interest groups.

ZGONENA, T.: The text needs to clarify the combined string voltage shall be 80 V or less.

4-254 Log #3329 NEC-P04 **Final Action: Reject**
(690.12 (New))

Submitter: Steven Goble, Olathe, KS

Recommendation: Insert the following new requirement.

690.12 Surge Protection. A listed SPD shall be installed in or on all solar photovoltaic (PV) combiner boxes, recombiner boxes, and inverters.

Substantiation: Throughout its history, the NEC® has mandated the practical safeguarding of persons and property from hazards arising from the use of electricity. However, one of the hazards that is often overlooked is damage to property, such as fire, or the destruction of appliances and electronic equipment, due to surges caused by (1) the starting and stopping of power electronic equipment, (2) direct or indirect lightning strikes, and (3) imposition of a higher voltage on a lower voltage system. While NFPA 70 has long recognized the practical application of surge protective devices as evidenced by several NEC®

Articles, including but not limited to, 285, 694 and 708, the vast majority of equipment is not required to be protected from damage by surges. This lack of required protection results in, as the State Farm Insurance Company notes on their web site, "... power surges are responsible for hundreds of millions of dollars of property damage every year... Over time, surges can also cause cumulative damage to your property, incrementally decreasing the lifespan of televisions, computers, stereo equipment, and anything else plugged into the wall."

This proposal is intended to expand protection against damaging surges through the use of listed surge protective devices. While progress has been made in this area, it is evident that expanded use oflisted surge protective devices will be a step function improvement to the practical safeguarding of persons and property.

Some very recent specific examples of events that call attention to this need include the documented destruction of a house due to electrical surge as a result of a transformer fire. This occurred in Kings County California in October of 2011.

In the UK in 2010, 71 incidents were caused by electrical power surges according to the fire inspector. In fact, the cause of the surge was related to the theft of a copper component in a substation. Of the 71incidents, 48 resulted in damage to electrical equipment, including 36 panelboards, a number of Throughout its history, the NEC® has mandated the practical safeguarding of persons and property from hazards arising from the use of electricity. However, one of the hazards that is often overlooked
is damage to property, such as fire, or the destruction of appliances and electronic equipment, due to surges caused by (1) the starting and stopping of power electronic equipment, (2) direct or indirect lightning strikes, and (3) imposition of a higher voltage on a lower voltage system. While NFPA 70 has long recognized the practical application of surge protective devices as evidenced by several NEC®

Articles, including but not limited to, 285, 694 and 708, the vast majority of equipment is not required to be protected from damage by surges. This lack of required protection results in, as the State Farm Insurance Company notes on their web site, "... power surges are responsible for hundreds of millions of dollars of property damage every year... Over time, surges can also cause cumulative damage to your property, incrementally decreasing the lifespan of televisions, computers, stereo equipment, and
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In Dallas, Texas, a utility electric crew repairing a transformer in front of a residence caused a significant surge. The transformer was seen to be arcing with the subsequent destruction of equipment in nearby homes. This included Central Heat and Air units, refrigerators, washers, dryers.... and the like. Another recent event in Carthage, MO, occurred in October of 2011. Lightning hit the Jasper County Jail and the resultant surge knocked out the security system as well as fire alarms, locks and other key systems. The same event also resulted in a small fire at a Carthage home. Only because of an alert homeowner and quick response by the local fire department was extensive damage and possible loss of life prevented.

Studies by recognized authorities including NEMA, IEEE, and UL, all substantiate the fact that surges can and do cause significant damage. Nationwide Insurance recognizes the need for effective surge protection as well and has published recommendations that include point-of-use surge protectors and installation of main service panel suppressors.

Unprotected surges do cause catastrophic damage to industrial, commercial and residential electronic equipment and residential appliances, sometimes resulting in fire and loss of life. Surge protective devices are readily available to protect against these common surges, but have simply not been required in most applications. This Code Making Panel has the opportunity to take a significant step toward better protection of persons and property by accepting this proposal. televisions, washing machines and other electrical appliances.

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Panel Meeting Action: Reject
Panel Statement: Surge protection is permitted to be installed and should not be required, as surge probabilities vary by locality, and different types of electrical loads have differing surge protection requirements. Surge protection must also be periodically maintained or replaced. The user should make the decision to install this protection.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-254a Log #CP412 NEC-P04 **Final Action: Accept**
(690.13)

TCC Action: It was the action of the Correlating Committee that further consideration be given to the comments expressed in the voting and Section 3.2.3 of the NEC Style Manual suggesting use of the acronym (PV) throughout Article 690.

This action will be considered as a public comment.

Submitter: Code-Making Panel 4,
Recommendation: Revise 690.13 to read as follows:

690.13 Building or Other Structure Supplied by a Photovoltaic System. Means shall be provided to disconnect all ungrounded dc conductors of a photovoltaic system from all other conductors in a building or other structure.

(A) Location. The photovoltaic disconnecting means shall be installed at a readily accessible location either on the outside of a building or structure or inside nearest the point of entrance of the system conductors.

Exception: Installations that comply with 690.31(F) shall be permitted to have the disconnecting means located remote from the point of entry of the system conductors.

The photovoltaic system disconnecting means shall not be installed in bathrooms.

(B) Marking. Each photovoltaic system disconnecting means shall be permanently marked to identify it as a photovoltaic system disconnect.

(C) Suitable for Use. Each photovoltaic system disconnecting means shall not be required to be suitable as service equipment.

(D) Maximum Number of Disconnects. The photovoltaic system disconnecting means shall consist of not more than six switches or six circuit breakers mounted in a single enclosure, or in a group of separate enclosures.

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

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.: This is revised language that did not correct the use of the term photovoltaic, which is used throughout. Replace photovoltaic with PV except in the title. Also there are inconsistencies in the punctuation and the new language should be rewritten according to the style manual.

4-255 Log #2133 NEC-P04 **Final Action: Accept in Principle**
(690.13)

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

690.13 ~~All Conductors~~ Building or Other Structure Supplied by a Photovoltaic System. Means shall be provided to disconnect all ~~current-carrying~~ ungrounded dc conductors of a photovoltaic system from all other conductors in a building or other structure.

~~A switch, circuit breaker, or other device shall not be installed in a grounded conductor if operation of that switch, circuit breaker, or other device leaves the marked, grounded conductor in an ungrounded and energized state.~~

~~*Exception No. 1: A switch or circuit breaker that is part of a ground-fault detection system required by 690.5, or that is part of an arc-fault detection/ interruption system required by 690.11, shall be permitted to open the grounded conductor when that switch or circuit breaker is automatically opened as a normal function of the device in responding to ground faults.*~~

~~*Exception No. 2: A disconnecting switch shall be permitted in a grounded conductor if all of the following conditions are met:*~~

~~*(1) The switch is used only for PV array maintenance.*~~

~~*(2) The switch is accessible only by qualified persons.*~~

~~*(3) The switch is rated for the maximum dc voltage and current that could be present during any operation, including ground-fault conditions.*~~

~~Informational Note: The grounded conductor may have a bolted or terminal disconnecting means to allow maintenance or troubleshooting by qualified personnel.~~

(A) Location. The photovoltaic disconnecting means shall be installed at a readily accessible location either on the outside of a building or structure or inside nearest the point of entrance of the system conductors.

Exception: Installations that comply with 690.31(F) shall be permitted to have the disconnecting means located remote from the point of entry of the system conductors.

The photovoltaic system disconnecting means shall not be installed in bathrooms.

(B) Marking. Each photovoltaic system disconnecting means shall be permanently marked to identify it as a photovoltaic system disconnect.

(C) Suitable for Use. Each photovoltaic system disconnecting means shall not be required to be suitable as service equipment but shall be suitable for the prevailing conditions and comply with 690.17. Equipment installed in hazardous (classified) locations shall comply with the requirements of Articles 500 through 517.

(D) Maximum Number of Disconnects. The photovoltaic system disconnecting means shall consist of not more than six switches or six circuit breakers mounted in a single enclosure, in a group of separate enclosures, or in or on a switchboard.

(E) Grouping. The photovoltaic system disconnecting means shall be grouped with other disconnecting means for the system to comply with 690.13(D). A photovoltaic disconnecting means shall not be required at the photovoltaic module or array location.

Substantiation: This proposal is part of a series of proposals which group similar requirements for PV systems together in order to make the article easier to use. The revisions clarify that the requirements apply to all ungrounded conductors similar to NEC 225.31. Disconnect construction requirements were moved to 690.17(D) to group similar to NEC 225.38. See the summary spreadsheet which details the relocation of requirements contained in the series of proposals.

Note: Supporting material is available for review at NFPA Headquarters.
Panel Meeting Action: Accept in Principle
Panel Statement: This proposal was used as the baseline for the reorganization of 690.13 conducted under Proposal 4-254a. See panel action on Proposal 4-254a which incorporates the submitter's proposal with additional changes.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-256 Log #3032 NEC-P04 **Final Action: Accept in Principle**
(690.13)

Submitter: D. Jerry Flaherty, Electrical Inspection Service, Inc.
Recommendation: Rearrange and reword 690.13, 690.14 and 690.15 to conform to definitions in 690.2.

690.13 Photovoltaic (PV) System Requirements. Photovoltaic (PV) System disconnecting means shall comply with 690.13(A), through (C).

(A) Requirements for Disconnecting Means. Means shall be provided to disconnect all conductors in a building or structure from the photovoltaic (PV) system conductors**.**

(B) Maximum Number of Disconnects. The photovoltaic (PV) system disconnecting means shall consist of not more than six switched or six circuit breakers mounted in a single enclosure, in a group of separate enclosures, or in or on a switchboard.

(C) Grouping. The photovoltaic (PV) system disconnecting means shall be grouped with other disconnecting means for the system to comply with 690.13(B). ~~A photovoltaic disconnecting means is not be required at the photovoltaic modules or array location.~~

690.14 Photovoltaic (PV) Power Circuit Requirements. Photovoltaic (PV) Power Circuit disconnecting means shall comply with 690.13(A), through (C).

(A) All conductors. Means shall be provided to disconnect all current-carrying dc conductors of a photovoltaic system from all other conductors in a building or other structure. A switch, circuit breaker, or other listed device shall not be installed in a grounded conductor if operation of that switch, circuit breaker, or other listed device leaves the marked, grounded conductor in an ungrounded and energized state.

Exception No. 1; Same as 2011 NEC
Exception No. 2:Same as 201 NEC
Informational Note: Same as 2011 NEC

(B) Equipment. Equipment such as photovoltaic source circuit isolation switches, overcurrent devices, and blocking diodes shall be permitted on the photovoltaic side of the photovoltaic (PV) power circuit disconnect.

(C) Location. The photovoltaic (PV) power circuit disconnecting means shall be installed at a readily accessible location either on the outside of a building or structure or inside nearest the point of entrance of the photovoltaic (PV) power circuit conductors.

Exception: Installations that comply with 690.31(E) shall be permitted to have the disconnect means located remote from the point of entry of the photovoltaic (PV) power circuit(s) conductors.

Photovoltaic (PV) power circuit disconnecting means shall not be installed in bathrooms.

A photovoltaic disconnecting means is not be required at the photovoltaic modules, panels, or array location.

690.15 Additional Provisions. Photovoltaic disconnecting means shall comply with 690.15 (A) through (C).

(A) Disconnecting Means. Photovoltaic (PV) disconnecting means shall not be required to be suitable as service equipment and shall comply with 690.17.

(1) Marking. Each photovoltaic (PV) disconnecting means shall be permanently marked to identify it is a photovoltaic disconnect.
(2) Suitable for Use. ~~Each~~ All photovoltaic (PV) disconnect means shall be suitable for the prevailing conditions. Equipment installed in hazardous (classified) locations shall comply with the requirements of Article 500 through 517.
(B) Disconnection of Photovoltaic Equipment. Means shall be provided to disconnect equipment, such as inverters, batteries, charge controllers, and the like, from all ungrounded conductors of all sources. If the equipment is energized from more than one source, the disconnecting means shall be grouped and identified.
A single disconnecting means in accordance with 690.17 shall be permitted for the combined ac output of one or more micro-inverters or ac modules in an interactive system.
(C) Utility-Interactive Inverters Mounted in Not-Readily-Accessible Locations. Utility-interactive inverters shall be permitted to be mounted on roofs or other exterior areas that are not readily accessible. These installations shall comply with (1) through (4)
(1) A ~~direct-current~~ dc photovoltaic (PV) power circuit disconnecting means shall be mounted within sight of or in the inverter.
(2) An ~~alternating-current~~ ac photovoltaic (PV) system disconnects means shall be mounted within sight of or in the inverter.
(3) ~~The alternating-current~~ ac ~~output conductors from the inverter and~~ An additional ~~alternating-current~~ ac photovoltaic (PV) system disconnect means for the ~~inverter~~ photovoltaic PV system shall comply with 690.13(B) and (C).
(4) A plaque shall be installed in accordance with 705.10.
Substantiation: Part III. Disconnecting 690.13, 690.14 and 690.15 are very confusing requirements. 690.13 is titled "All Conductors" yet this article only refers to dc conductors. 690.14 is titled "Additional Provisions" and is a combination of photovoltaic (PV) system requirements and photovoltaic (PV) power source requirements. 690.15 is titled "Disconnection of Photovoltaic Equipment" which logically should be under "Additional Provisions".
Photovoltaic system (usually) requires two disconnects, one on the PV source power (dc) and one on the whole PV system after the inverter, charge controller or before the load. It seems logical to separate these disconnect into two articles and the common requirements into a third article.
Article 690.2 define PV terms, these terms should be used as defined in all the articles.
Panel Meeting Action: Accept in Principle
Panel Statement: See panel action on Proposal 4-254a for the direction taken by the panel on the reorganization of 690.13. See panel action on Proposal 4-254a which addresses the submitter's concerns.

Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-257 Log #2192 NEC-P04 **Final Action: Reject**
(690.13 Exception No. 2 (4) (New))

Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum
Recommendation: Revise the 690.13 Exception 2 as follows. Add a number (4).
(4) The switch shall be separate and marked as a maintenance disconnect to distinguish it from any disconnecting means used in the normal operation of the PV system.
Substantiation: This maintenance-only switch must not be confused with the required DC PV disconnecting means and needs to be separated and distinctly marked from that disconnecting means to prevent any confusion. Accidentally opening this switch will unground the array and create a hazard for unsuspecting people.
Panel Meeting Action: Reject
Panel Statement: Additional marking of a maintenance switch is unnecessary as this disconnecting means is required to be rated appropriately and will not create a hazard if opened. Current text prohibits unqualified personnel from accessing the switch.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-258 Log #2134 NEC-P04 **Final Action: Accept**
(690.14)

Submitter: Chad Kennedy, Square D Company/Schneider Electric
Recommendation: Delete the following text:
~~**690.14 Additional Provisions.** Photovoltaic disconnecting means shall comply with 690.14(A) through (D).~~
~~**(A) Disconnecting Means.** The disconnecting means shall not be required to be suitable as service equipment and shall comply with 690.17.~~
~~**(B) Equipment.** Equipment such as photovoltaic source circuit isolating switches, overcurrent devices, and blocking diodes shall be permitted on the photovoltaic side of the photovoltaic disconnecting means.~~
~~**(C) Requirements for Disconnecting Means.** Means shall be provided to disconnect all conductors in a building or other structure from the photovoltaic system conductors.~~
~~**(1) Location.** The photovoltaic disconnecting means shall be installed at a readily accessible location either on the outside of a building or structure or inside nearest the point of entrance of the system conductors.~~
~~*Exception: Installations that comply with 690.31(E) shall be permitted to have the disconnecting means located remote from the point of entry of the system conductors.*~~
~~The photovoltaic system disconnecting means shall not be installed in bathrooms.~~
~~**(2) Marking.** Each photovoltaic system disconnecting means shall be permanently marked to identify it as a photovoltaic system disconnect.~~
~~**(3) Suitable for Use.** Each photovoltaic system disconnecting means shall be suitable for the prevailing conditions.~~
~~Equipment installed in hazardous (classified) locations shall comply with the requirements of Articles 500 through 517.~~
~~**(4) Maximum Number of Disconnects.** The photovoltaic system disconnecting means shall consist of not more than six switches or six circuit breakers mounted in a single enclosure, in a group of separate enclosures, or in or on a switchboard.~~
~~**(5) Grouping.** The photovoltaic system disconnecting means shall be grouped with other disconnecting means for the system to comply with 690.14(C)(4). A photovoltaic disconnecting means shall not be required at the photovoltaic module or array location.~~
~~**(D) Utility-Interactive Inverters Mounted in Not-Readily-Accessible Locations.** Utility-interactive inverters shall be permitted to be mounted on roofs or other exterior areas that are not readily accessible. These installations shall comply with (1) through (4):~~
~~(1) A direct-current photovoltaic disconnecting means shall be mounted within sight of or in the inverter.~~
~~(2) An alternating-current disconnecting means shall be mounted within sight of or in the inverter.~~
~~(3) The alternating-current output conductors from the inverter and an additional alternating-current disconnecting means for the inverter shall comply with 690.14(C)(1).~~
~~(4) A plaque shall be installed in accordance with 705.10.~~
Substantiation: This proposal is part of a series of proposals which group similar requirements for PV systems together in order to make the article easier to use. Since all of the requirements found in "690.14 Additional Provisions." have been moved this section can be deleted. See the summary spreadsheet which details the relocation of requirements contained in the series of proposals.
Note: Supporting material is available for review at NFPA Headquarters.
Panel Meeting Action: Accept
Panel Statement: Reorganization of 690.14 has moved the text to other sections. See the panel actions on Proposals 4-254a and 4-274a.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-259 Log #2195 NEC-P04 **Final Action: Reject**
(690.14)

Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum
Recommendation: It is proposed that Section 690.14 be restructured and revised to improve clarity and intent. This proposal is for 690.14(C). 690.14(C) contains information duplicated in 690.13 and is modified as shown below. The original *2011 NEC* 690.14 and an overview of the entire 690.14 revision have been attached in the substantiation. Additional proposals are provided on a subsection-by-subsection basis to allow comparisons with proposals submitted by others.
(C) ~~Requirements for Disconnecting Means.~~ ~~Means shall be provided to disconnect all conductors in a building or other structure from the photovoltaic system conductors.~~
~~(1)~~ Location. The dc photovoltaic disconnecting means shall be installed at a readily accessible location either ~~on the~~ outside of a building or structure or inside nearest the point of entrance of the system conductors. The disconnecting means shall comply with 690.17.
Exception: The location of the PV system disconnecting means for the dc PV source and output circuits ~~Installations~~ *that comply with 690.31(E) shall be permitted to be in a location that is* ~~*have the disconnecting means located remote from the point of entry of the system conductors.*~~
The ~~photovoltaic~~ PV system disconnecting means shall not be installed in bathrooms.
Informational Note #1: The readily accessible location requirement for the dc PV system disconnecting means and the requirement that it be at the point of entry of the conductors implies that the PV system conductors remain outside the building until the first disconnect is reached. The exception, when met, allows these conductors to be routed through the building to the dc disconnecting means location that is still required to be readily accessible, but no longer is required to be at the point of penetration.
Informational Note #2: The interior of a locked building is considered readily accessible by first responders in emergency situations.
~~(2)~~ (D) Marking. Each dc photovoltaic system disconnecting means shall be permanently marked to identify it as a dc photovoltaic system disconnect.

~~(3)~~ (E) **Suitable for Use.** Each dc photovoltaic system disconnecting means shall be suitable for the prevailing conditions. Equipment installed in hazardous (classified) locations shall comply with the requirements of Articles 500 through 517.

~~(4)~~ (F) **Maximum Number of Disconnects.** The dc photovoltaic system disconnecting means shall consist of not more than six switches or six circuit breakers mounted in a single enclosure, in a group of separate enclosures, or in or on a switchboard.

~~(5)~~ (G) **Grouping.** The ~~photovoltaic~~ dc PV system disconnecting means shall be grouped with the ~~other~~ disconnecting means for other services connected to the building or structure to comply with 690.14(C). A ~~photovoltaic~~ dc PV disconnecting means shall not be required at the photovoltaic module or array location. A dc PV disconnecting means shall be permitted at the array location if that location complies with 690.14 (C) or 690.14(H).

Exception: The disconnecting means for multiple PV systems on a single building or structure shall not be required to be grouped together where the requirements of 705.10 are met.

Substantiation: The introductory information in 690.14(C) is deleted since it duplicates 690.13 and the information in subsection (1) is elevated to (C) with revisions.

Subsections (2) through (5) are renumbered as (D) through (G) with revisions.

690.14(C) Removed old 690.14(C) since the requirement is addressed in 690.13. The introduction used to be 690.14(C)1. No change in language; just location.

Exception: The exception was modified so that it pertains only to the dc outputs for modules and arrays. See related proposal for 690.31(E).

Informational Note #1 has been added because of the continuing inability of PV installers to realize that these disconnecting means requirements (added to the 2002 NEC at the request of the Technical Correlating Committee) affect the routing of the conductors from the PV array to the inverter. This FPN gives information to improve understanding of the requirement and the exception.

Informational Note #2. Normally a locked house does not permit ready access as defined in Article 100. However first responders have ready access to disconnecting means inside a locked house by using master keys and fire axes.

690.14(D). Previously 690.14(C)(2). Used the abbreviation PV

690.14(E). Previously 690.14(C)(3). Used the abbreviation PV

690.14(F). Previously 690.14(C)(4). Used the abbreviation PV

690.14(G). Previously 690.14(C)(5). Revised to be consistent with 690.14(F) and to indicate that PV disconnecting means may be required in areas normally considered not readily accessible in some situations (e.g. flat roofed buildings with ready access).

The Exception is needed for installations where there are multiple, widely-spaced PV systems on a large commercial building and it is not feasible to group either the dc or ac disconnects from all systems in a single location. Examples include warehouses, malls, and apartment complexes.

Note: Supporting material is available for review at NFPA Headquarters.

Panel Meeting Action: Reject

Panel Statement: The proposed informational notes specify requirements and are erroneous. See panel action on Proposal 4-254a for the direction taken by the panel on the reorganization of 690.14.

Number Eligible to Vote: 13

Ballot Results: Affirmative: 13

4-260 Log #2198 NEC-P04 **Final Action: Reject**

(690.14)

Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum

Recommendation: Revise 690.14 as shown below. This is the first revision of all of 690.14 and individual submissions are made each section in the existing 2011 NEC 690.14.. A copy of the original 690.14 from the *2011 NEC* may be found in the substantiation as well as a copy of the entire new revision.

690.14 ~~Additional Provisions~~. AC and DC Photovoltaic Disconnecting Means. The direct current (dc) PV system disconnecting means shall comply with (A) through (G). The alternating current (ac) PV disconnecting means for PV systems or AC PV modules shall comply with (H) and (I).

Substantiation: This revision of 690.14 is required to clarify and define the numerous requirements for both the ac and dc disconnecting means of a PV system. PV systems are becoming increasingly complex internally and in the numbers of components in each system as well as the numbers of systems on any single building.

Note: Supporting material is available for review at NFPA Headquarters.

Panel Meeting Action: Reject

Panel Statement: See panel action on Proposal 4-254a for the direction taken by the panel on the reorganization of 690.14. The action taken removed the need for the proposed text.

Number Eligible to Vote: 13

Ballot Results: Affirmative: 13

4-261 Log #2503 NEC-P04 **Final Action: Reject**

(690.14)

Submitter: Mark T. Rochon, Peabody, MA

Recommendation: Revise text to read as follows:

A photovoltaic disconnecting means shall not be required at the service location, photovoltaic module or array locations.

Substantiation: The PV system may be a line side tap and not near the service disconnect, 230.2(A)(5) uses parallel power production systems, 230.71 lists the maximum number of disconnects and 705.10 requests a plaque or directory for service equipment location for interconnected PV systems.

Panel Meeting Action: Reject

Panel Statement: The submitter has not stated any purpose for this requirement. Article 690 already covers what disconnects are required for a PV system and their location. Section 230.2 addresses the number of services that can be brought to a building not the number the of additional supplies other than a service. Line side connections to services have been addressed by action on Proposal 4-410a.

Number Eligible to Vote: 13

Ballot Results: Affirmative: 13

4-262 Log #3179 NEC-P04 **Final Action: Reject**

(690.14 and 690.14(E) (New))

Submitter: Christel K. Hunter, Alcan Cable

Recommendation: Revise text to read as follows:

690.14 Additional Provisions. Photovoltaic disconnecting means shall comply with 690.14(A) through (~~D~~E).

690.14(E) Guarding.

In combiner boxes with circuits operating above 60 volts, all normally current-carrying components shall be constructed and installed so as to guard against inadvertent contact with live parts by persons.

Substantiation: This proposal was developed by a subgroup of the NEC DC Task Force of the Technical Correlating Committee. The Task Force is chaired by John R. Kovacik, Underwriters Laboratories, and the subgroup members are Christel Hunter with Alcan Cable (subgroup lead), Mike Stelts with Panasonic, Mark Ode with Underwriters Laboratories, Randy Hunter with Cooper Bussmann, Vince Saporita with Cooper Bussmann, Audie Spina with Armstrong, Edward Byaliy with Rockwell Automation, and Brian Patterson with
Armstrong.

Combiner boxes in photovoltaic systems typically cannot be completely disconnected from the dc circuit inputs without manually separating each dc circuit coming into the combiner box. To increase safety, any live parts in the combiner box should be protected in order to avoid accidental contact by personnel working in the combiner box. The language proposed is similar to that presently in 690.33(B). The requirement is limited to circuits operating above 60 volts since voltages below that are not considered shock hazards.

Although the term "combiner box" is not defined in the NEC, it is used in 690.35(F). This term is used by electrical equipment manufacturers as a general term that includes string combiners, array combiners, etc.

Panel Meeting Action: Reject

Panel Statement: The proposed text is not necessary as equipment standards (UL 1741, Certification requirements decision dated 2011 06 10) already require guarding live parts.

Number Eligible to Vote: 13

Ballot Results: Affirmative: 13

4-263 Log #2193 NEC-P04 **Final Action: Accept in Principle**

(690.14(A))

Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum

Recommendation: It is proposed that Section 690.14 be restructured and revised to improve clarity and intent. This proposal is for 690.14(A). The original *2011 NEC* 690.14 and an overview of the entire 690.14 revision have been provided. Additional proposals are provided on a subsection-by-subsection basis to allow comparisons with proposals submitted by others.

Revise 690.14(A) as follows:

(A) Disconnecting Means. The dc disconnecting means shall not be required to be suitable as service equipment and shall comply with 690.17.

Substantiation: The designation "dc" is added for clarity.

Note: Supporting material is available for review at NFPA Headquarters.

Panel Meeting Action: Accept in Principle

Panel Statement: See panel action on Proposal 4-254a for the direction taken by the panel on the reorganization of 690.14. The action taken addresses the submitter's concerns.

Number Eligible to Vote: 13

Ballot Results: Affirmative: 13

4-264 Log #3147 NEC-P04 **Final Action: Accept**
(690.14(A))

TCC Action: The Correlating Committee directs that the panel clarify the action on this proposal to correlate with the panel action taken on Proposal 4-278a.
This action will be considered as a public comment.
Submitter: Timothy P. Zgonena, Underwriters Laboratories Inc.
Recommendation: Revise paragraph 690.14 (A) as follows:
(A) Disconnecting Means. The disconnecting means shall:
1) not be required to be suitable as service equipment,
2) ~~shall~~ comply with 690.17 and,
3) be one of the following devices:
a) PV Industrial Control Switch. A listed industrial control switch marked for use in PV systems.
b) PV Molded Case Circuit Breaker. A listed molded case circuit breaker marked for use in PV systems
c) PV Molded Case Switch. A listed molded case switch marked for use in PV systems.
d) PV Enclosed Switch. A listed, enclosed switch marked for use in PV systems.
e) PV Open Type Switch. A listed, open type switch marked for use in PV systems.
f) Molded Case Circuit Breaker. A listed, dc rated molded case circuit breaker suitable for backfeed operation.
g) Molded Case Switch. A listed, dc rated, molded case switch suitable for backfeed operation.
h) Enclosed Switch. A listed, dc rated enclosed switch.
i) Open Type Switch. A listed, dc rated open type switch.
Devices marked with "line" and "load" are not suitable for backfeed.
Substantiation: UL has developed 489B, Outline of Investigation of Molded Case Circuit Breakers and Molded Case Switches for use in PV systems; Subject 98B, Outline of Investigation of Enclosed Switches for use in PV Systems; and 508I, Outline of Investigation for Manual Disconnect Switches Intended for Use in Photovoltaic Systems to address the specific needs for circuit breakers, disconnect switches for use in PV systems. In addition, traditional listed circuit breakers, molded case switches and safety switches are also suitable for use in PV systems. Switches with line and load ratings are not suitable for to break backfed current.
Panel Meeting Action: Accept
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13
Comment on Affirmative:
ZGONENA, T.: The last line of text should read:
Devices marked with "line" and "load" shall not be subjected to reverse current.

4-265 Log #3156 NEC-P04 **Final Action: Accept in Principle**
(690.14(A))

Submitter: Timothy P. Zgonena, Underwriters Laboratories Inc.
Recommendation: Revise paragraph 690.14 (A) as follows:
(A) Disconnecting Means. The disconnecting means shall:
1) not be required to be suitable as service equipment,
2) be listed for use in PV systems, and
3) ~~shall~~ comply with 690.17.
4)marked line and load shall not be used where they may be exposed to reverse currents.
Substantiation: UL has developed UL Subject 489B and UL Subject 98B to address the specific needs for disconnects and switches used in PV circuits. PV rated disconnect switches are specifically evaluated for PV reverse fault current, up to 1000Vdc, operation in a 50C ambient, and also accept larger wires sized for use in a 50C ambient, These documents are being transitioned into ANSI /UL standards. Traditional DC switches and disconnects are commonly evaluated for current flow in a single direction as indicated by line and load markings. Ground faults in PV arrays often result in reverse current flow. Use of a traditional DC rated disconnect with line and load markings can result in premature failure of the disconnect and a potential inability to clear the ground fault current flow.
Panel Meeting Action: Accept in Principle
Panel Statement: See panel action on Proposals 4-254a and 4-278a for the direction taken by the panel on the reorganization of 690.14. The actions taken address the submitter's concerns.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-266 Log #2194 NEC-P04 **Final Action: Accept in Principle**
(690.14(B))

Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum
Recommendation: It is proposed that Section 690.14 be restructured and revised to improve clarity and intent. This proposal covers 690.14(B). The original 2011 NEC 690.14 and an overview of the entire proposed section have been provided. Additional proposals are provided on a subsection-by-subsection basis to allow comparisons with proposals submitted by others.
Revise 690.14(B) as follows.
(B) Equipment. Equipment such as photovoltaic source circuit isolating switches, overcurrent devices and blocking diodes shall be permitted on the PV side of the dc PV ~~photovoltaic~~ disconnecting means.
Substantiation: "PV" added for clarity. Added direct-current (dc) to clarify that these device requirements do not apply to ac circuits. Some PV designers and AHJs have expressed confusion in this area.
Note: Supporting material is available for review at NFPA Headquarters.
Panel Meeting Action: Accept in Principle
Panel Statement: See panel action on Proposal 4-274a for the direction taken by the panel on the reorganization of 690.14. The action taken addresses the submitter's concerns.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-267 Log #1376 NEC-P04 **Final Action: Reject**
(690.14(C))

Submitter: Tom Scholtens, City of Charleston / Rep. NFPA Building Code Development Committee (BCDC)
Recommendation: Revise 690.14 C as follows:
C Requirements for Disconnecting Means. Means shall be provided to disconnect all conductors in a building or other structure from the photovoltaic system conductors.
1 Location. The photovoltaic disconnecting means shall be installed at a readily accessible location ~~either~~ on the outside of a building or structure ~~or inside nearest the point of entrance of the system conductors. It shall be clearly~~ adjacent to the meter on the exterior of the building or structure and clearly labeled as a "Photo Voltaic Building Disconnect-panel disconnect is upstream".
Substantiation: Note: This proposal was developed by the proponent as a member of NFPA's Building Code Development Committee (BCDC) with the committee's endorsement.
When an emergency occurs, it may be impossible for an emergency responder to disconnect the PV system from the electrical system by hunting around inside a building or the roof for a switch. The switch should be readily accessible and labeled on the outside of the building. Having a live PV Circuit running through a building in an emergent dangerous situation could prove deadly. See justification for proposal to 230.70.
Note that this will only shut service to the system "downstream", and the system from the disconnect to the PV on the roof may still be live. This is why this proposal identifies there may also be a disconnect "upstream".
Panel Meeting Action: Reject
Panel Statement: This requirement is far too restrictive as proposed and does not necessarily enhance safety. If one were to comply with this requirement based on the physical construction and location of the PV system and the electric service meter, this may actually require that a longer run of unprotected conductors be made to reach the service meter locations.
See panel action on Proposal 4-253 for the direction taken by the panel.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-268 Log #1379 NEC-P04 **Final Action: Reject**
(690.14(C)(1) Exception)

Submitter: John Powell, JPETC
Recommendation: Revise text to read as follows:
(1) Location. The photovoltaic disconnecting means shall be installed at a readily accessible location either on the outside of a building or structure or inside nearest the point of entrance of the system conductors.
~~*Exception: Installations that comply with 690.31(E) shall be permitted to have the disconnecting means located remote from the point of entry of the system conductors.*~~ **A placard shall be placed at the main electrical service or disconnect for the structure denoting the location of the PV disconnects. The placard shall be permanently mounted and suitable for the environment.**
Substantiation: Throughout the code sources of power such as service-entrance and outside branch-circuits and feeders to a structure require a disconnecting means at nearest point of entry, yet an exception is created for PV systems that may be sized at several hundred volts and amps. The exception creates a hazard to fire fighters as simply shutting off the inverter does not de-energize the dc conductors from the array. A firefighter could accidently cut into a dc conductor that is installed in a raceway that is buried in insulation or in a wall thus exposing the firefighter to an electrical shock or arcing hazard. The placard would provide firefighters with information that

could help alleviate other fire and shock hazards.
Panel Meeting Action: Reject
Panel Statement: Signs are addressed in 705.10 and 690.56. See panel action on Proposal 4-253 for the direction taken by the panel.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-269 Log #2502 NEC-P04 **Final Action: Reject**
(690.14(C)(2))

Submitter: Mark T. Rochon, Peabody, MA
Recommendation: Revise text to read as follows:
Permanently marked to identify it as a photovoltaic system disconnect and denoting all locations of other services supplying that building or structure.
Substantiation: The PV disconnects are misleading the disconnecting of the service disconnects with the added parallel power production systems in 230.2(A)(5).
Panel Meeting Action: Reject
Panel Statement: A PV system is not a service. A service is provided by a utility company and their characteristics are inherently different than on site power production sources. Signs are addressed in 705.10 and 690.56. See panel action on Proposal 4-253 for the direction taken by the panel.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

9-181b Log #CP933 NEC-P09 **Final Action: Accept**
(690.14(C)(4))

TCC Action: It was the action of the Correlating Committee that this proposal be referred to Code-Making Panel 4 for action in Article 690.
This action will be considered as a public comment by Code-Making 4.
Submitter: Code-Making Panel 9,
Recommendation: Revise text to read as follows:
The photovoltaic system disconnecting means shall consist of not more than six switches or six circuit breakers mounted in a single enclosure, in a group of separate enclosures, or in or on a switchboard or switchgear.
Substantiation: This proposal correlates this provision with action taken by CMP 9 to place a revised definition of what used to be "Metal-Enclosed Power Switchgear" in Article 100. The change will rename the defined term as "Switchgear" and make editorial changes to the content accordingly, including adding an informational note. CMP 9 requests the Correlating Committee refer this proposal to CMP 4 for action in Article 690.
Panel Meeting Action: Accept
Number Eligible to Vote: 12
Ballot Results: Affirmative: 12

4-270 Log #3416 NEC-P04 **Final Action: Reject**
(690.14(C)(4))

Submitter: Thomas Hattert, SMA Solar Technology AG
Recommendation: Add text to read as follows:
(4) Maximum Number of Disconnects The photovoltaic system disconnecting means shall consist of not more than six switches or six circuit breakers mounted in a single enclosure, in a group of separate enclosures, or in a switchboard.
If more than six switches or six circuit breakers are mounted in a single enclosure, in a group of separate enclosures, or in a switchboard this requirement can be met by using power operated disconnecting means operated by not more than six control switches.
Substantiation: The six handle restriction of clause 690.14 (C)(4) influences cable routing of large scale PV systems with a single inverter essentially and leads to the problem that PV cables have to be combined to maximum six large bundles. Power operable switches create more flexibility for system designers, can lower system costs and still satisfy the same purpose as manual ones. To be in compliance with the AC section 230.71 power operable switches shall not be counted among the number of six.
Panel Meeting Action: Reject
Panel Statement: The existing disconnect rule has been used as the acceptable standard for safety for many decades in the NEC. The submitter has not presented any documented technically substantiation to make this change in basic safety.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-271 Log #2196 NEC-P04 **Final Action: Accept in Principle**
(690.14(D))

Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum
Recommendation: It is proposed that Section 690.14 be restructured and revised to improve clarity and intent. This new proposal revises 690.14(D), which is renumbered to (H). The original *2011 NEC* 690.14 and an overview of the revised 690.14 are attached below. Additional proposals are provided on a subsection-by-subsection basis to allow comparisons with proposals submitted by others.

(D H) Utility-interactive Inverters Mounted in Not Readily-Accessible Locations,
Utility-interactive inverters shall be permitted to be mounted on roofs or other exterior areas that are not readily accessible. These installations shall comply with 690.14(H) (1) through (5):
(1) A dc PV disconnecting means shall be mounted within sight of or in each inverter.
(2) An ac disconnecting means shall be mounted within sight of or in each inverter.
(3) An additional disconnecting means complying with 690.14 (I) shall be installed on the ac output circuit of the inverter(s).
(4) A plaque shall be installed in accordance with 705.10.
Substantiation: 690.14(H) Previously (D) with revisions: Clarified to be consistent with definitions, Style Manual, and revised numbering requirements.
Note: Supporting material is available for review at NFPA Headquarters.
Panel Meeting Action: Accept in Principle
Panel Statement: See panel action on Proposals 4-275 and 4-274a for the direction taken by the panel on the reorganization of 690.14.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-272 Log #1653 NEC-P04 **Final Action: Reject**
(690.14(D)(1))

Submitter: Teri Dwyer, Wells Fargo
Recommendation: Add new text to read as follows:
690.14 Additional Provisions.
Photovoltaic disconnecting means shall comply with 690.14(A) through (D).
(D) Utility-Interactive Inverters Mounted in Not-Readily-Accessible Locations. Utility-interactive inverters shall be permitted to be mounted on roofs or other exterior areas that are not readily accessible. These installations shall comply with (1) through (4):
(1) A direct-current photovoltaic disconnecting means shall be mounted within sight of or in the inverter.
Exception: Where micro-inverters are installed, a direct-current disconnect shall not be required where the dc conductor is 12 in. or less in length and the ac required disconnect is mounted within 10 ft or the array. Where more than one array is present, the ac disconnect shall be identified to the corresponding array.
Substantiation: 690.14(D)(1) as currently written is practically impossible to comply with when micro-inverters are installed. Currently micro-inverters are being installed and the only dc disconnecting means are the connectors required by 690.33. They type of connector is a recognized component covered by UL category QIJQ2 which requires them to be marked "Do Not Disconnect Under Load." Therefore the need to have the ac disconnect located in close proximity (10 ft) of the associated PV array. These connectors are single-pole latching and locking type connectors which will not permit quick disconnecting without the use of a tool or special knowledge.
Note: Supporting material is available for review at NFPA Headquarters.
Panel Meeting Action: Reject
Panel Statement: Current code allows ac disconnect to be remote from the PV array-at ground level-much more than 10'. The NEC permits the use of connectors to meet the disconnect requirements of 690.17 exception.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-273 Log #3422 NEC-P04 **Final Action: Reject**
(690.14(D)(2))

Submitter: Nicholas P. Carter, Enecsys LLC
Recommendation: Revise text to read as follows:
A load break-rated alternating-current disconnecting means shall be mounted within sight of or in each inverter.
Substantiation: The alternating-current connector can be used as a disconnecting means, so it needs to be load break-rated. Once the alternating-current disconnecting means is opened, it will be safer to open the direct-current disconnecting means because the inverter will already have shut down due to anti-islanding.
Panel Meeting Action: Reject
Panel Statement: AC disconnects already have to be load break rated since they have to be rated for voltage and current. Connectors are not required to be load break rated.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-274 Log #2197 NEC-P04 **Final Action: Reject**
(690.14(I))

Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum
Recommendation: It is proposed that Section 690.14 be restructured and revised to improve clarity and intent. This proposal covers a new section 690.14(I). The original *2011 NEC* 690.14 and an overview of the revised section are attached below the substantiation. Additional proposals are provided on a subsection-by-subsection basis to allow comparisons with proposals

submitted by others.
(I) AC PV Disconnect. The main service disconnect(s) on a building or structure shall be permitted to serve as the single ac PV disconnect for utility-interactive inverters or ac PV modules connected to the load side of the service disconnect.
Where connections, as permitted by 705.12(A), are made on the supply side of the service disconnect, the PV systems shall be considered parallel power production systems as permitted by 230.2 and shall be permitted an additional six ac PV disconnects per PV system as allowed by 230.71. These ac disconnecting means shall comply with the location requirements of 690.14(C).
Disconnecting means in the ac output circuit of each utility-interactive inverter shall be required where the individual inverter does not have an internal ac output disconnect and where the inverter is not within sight of the main service disconnect.
AC disconnecting means shall be permitted at each inverter.
The disconnecting means shall comply with 690.17.
Substantiation: Utility-interactive inverters and ac PV modules shut down when the utility voltage is not present at their output terminals. Opening the main service disconnect will disable or turn off all utility-interactive inverters and ac PV modules connected to the load side of that disconnect.

Many PV systems, because of their size, are connected on the supply side of the service disconnect. The main service disconnect cannot serve as a disconnect for the supply-side systems and they must have individual disconnects. This is consistent with 230.2(A)(5) and each of these PV systems as parallel power production systems is allowed six disconnects per 230.71.

In order for the main service disconnect to also serve as the required maintenance disconnect, the inverter must be within sight of the main service disconnect. If the inverter and main service disconnect are not in sight, then a maintenance disconnect must be installed at each inverter to allow safe servicing. Optional, permitted disconnects may be installed at each inverter for system segregation or other purposes.

Note: Supporting material is available for review at NFPA Headquarters.
Panel Meeting Action: Reject
Panel Statement: Reorganization of 690.14 has made the proposal language unnecessary. See panel actions on Proposal 4-274a for disconnecting means and Proposal 4-410a for supply side connections.

The allowance for additional services located in Section 230.2 as referred to by the submitter is intended to allow additional services to be brought to a building to allow a parallel power production system to be connected into the serving utility system. A parallel power production system is not a service and cannot be treated as such for many reasons. Using the service disconnecting means as the AC disconnect for a PV system is not practical and in some cases may introduce additional hazards when all that is required id to isolate the PV system and not remove all power from a building.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-274a Log #CP413 NEC-P04 **Final Action: Accept**
(690.15)

Submitter: Code-Making Panel 4,
Recommendation: Revise 690.15 to read as follows:

690.15 Disconnection of Photovoltaic Equipment. Means shall be provided to disconnect equipment, such as inverters, batteries, and charge controllers, from all ungrounded conductors of all sources. If the equipment is energized from more than one source, the disconnecting means shall be grouped and identified. A single disconnecting means in accordance with 690.17 shall be permitted for the combined ac output of one or more inverters or ac modules in an interactive system.

(A) Utility Interactive Inverters Mounted in Not Readily Accessible Locations. Utility interactive inverters shall be permitted to be mounted on roofs or other exterior areas that are not readily accessible and shall comply with (1) through (4):

(1) A direct-current PV disconnecting means shall be mounted within sight of or in each inverter.

(2) An alternating-current disconnecting means shall be mounted within sight of or in each inverter.

(3) The alternating-current output conductors from the inverter and an additional alternating-current disconnecting means for the inverter shall comply with 690.13(A).

(4) A plaque shall be installed in accordance with 705.10.

(B) Equipment. Equipment such as PV source circuit isolating switches, overcurrent devices, dc–to–dc converters, and blocking diodes shall be permitted on the PV side of the PV disconnecting means.

(C) DC Combiner Disconnects. The direct current (dc) output of dc combiners mounted on roofs of dwellings or other buildings shall have a load break disconnecting means located in the combiner or within 1.8 m (6ft) of the combiner. The disconnecting means shall be permitted to be remotely controlled, but shall be manually operable locally when control power is not available.
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.: Please note the inconsistent use of dc, direct-current.
(1) A direct-current PV disconnecting means shall be mounted within sight of or in each inverter.
(2) An alternating-current disconnecting means shall be mounted within sight of or in each inverter.
(3) The alternating-current output conductors from the inverter and an additional alternating-current disconnecting means for the inverter shall comply with 690.13(A).
(4) A plaque shall be installed in accordance with 705.10.
(B) Equipment. Equipment such as PV source circuit isolating switches, overcurrent devices, dc–to–dc converters, and blocking diodes shall be permitted on the PV side of the PV disconnecting means.
(C) DC Combiner Disconnects. The direct current (dc) output of dc combiners

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4-275 Log #2127 NEC-P04 **Final Action: Accept in Principle**
(690.15)

TCC Action: It was the action of the Correlating Committee that this proposal be reconsidered and correlated with the action on proposal 4-274a.

This action will be considered as a public comment.
Submitter: Chad Kennedy, Square D Company/Schneider Electric
Recommendation: Add text to read as follows:

690.15 Disconnection of Photovoltaic Equipment. Means shall be provided to disconnect equipment, such as inverters, batteries, charge controllers, and the like, from all ungrounded conductors of all sources. If the equipment is energized from more than one source, the disconnecting means shall be grouped and identified.
A single disconnecting means in accordance with 690.17 shall be permitted for the combined ac output of one or more inverters or ac modules in an interactive system.
(A) Utility-Interactive Inverters Mounted in Not-Readily-Accessible Locations. Utility-interactive inverters shall be permitted to be mounted on roofs or other exterior areas that are not readily accessible. These installations shall comply with (1) through (4):
(1) A direct-current photovoltaic disconnecting means shall be mounted within sight of or in the inverter.
(2) An alternating-current disconnecting means shall be mounted within sight of or in the inverter.
(3) The alternating-current output conductors from the inverter and an additional alternating-current disconnecting means for the inverter shall comply with 690.13(A).
(4) A plaque shall be installed in accordance with 705.10.
(B) Equipment. Equipment such as photovoltaic source circuit isolating switches, overcurrent devices, and blocking diodes shall be permitted on the photovoltaic side of the photovoltaic disconnecting means.
Substantiation: This proposal is part of a series of proposals which group similar requirements for PV systems together in order to make the article easier to use. The revisions clarify that the requirements apply to all ungrounded conductors similar to NEC 225.31. Disconnect construction requirements were moved to 690.17(D) to group similar to NEC 225.38. See the summary spreadsheet which details the relocation of requirements contained in the series of proposals.

Note: Supporting material is available for review at NFPA Headquarters.
Panel Meeting Action: Accept
Panel Statement: This proposal was used as the baseline for the reorganization of 690.15 conducted under Proposal 4-274a. See the panel action on Proposal 4-274a.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-276 Log #2199 NEC-P04 **Final Action: Accept in Principle**
(690.15)

Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum
Recommendation: Add the following third paragraph to 690.15
The direct current (dc) output of dc combiners mounted on roofs of dwellings or other buildings shall have a load break disconnecting means located in the combiner or within 1.8 m (6ft) of the combiner. The disconnecting means shall be permitted to be remotely controlled, but shall have a local operating mode that can be manually operated when control power is not available.
Substantiation: First responders have an immediate need to de-energize as many dc circuits as possible in buildings where the PV systems are mounted on the roof. Without disconnecting means at the outputs of these dc combiners, first responders are unable to quickly de energize specific circuits in life safety emergencies or to make roof penetrations. These disconnecting means are usually mounted on the roof and will typically allow conductors inside the walls of buildings to be deenergized.

A proposal has been submitted for defining dc combiners in 690.2.
Panel Meeting Action: Accept in Principle
Panel Statement: The proposed text is placed as item 690.15(c) as part of the reorganization the section. See panel action on Proposal 4-274a.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-277 Log #499 NEC-P04 **Final Action: Accept in Principle**
(690.15(C)(4))

TCC Action: The Correlating Committee directs that this proposal be correlated with the action on Proposal 4-254a that revised 690.13(D) for the maximum number of disconnecting means.
This action will be considered as a public comment.
Submitter: Joel A. Rencsok, Scottsdale, AZ
Recommendation: Delete "or in or on a switchboard" to read as follows.
(4) Maximum Number of Disconnects. The photovoltaic system disconnecting means shall consist of not more than six switches or six circuit breakers mounted in a single enclosure, in a group of a separate enclosures, ~~or in or on a switchboard~~.
Rest of section to remain as is.
Substantiation: Switchboard is by definition not intended to be enclosed. See definitions.
I do not believe it was the code panel's intent to allow this.
Panel Meeting Action: Accept in Principle
Revise proposed text as follows:
(4) Maximum Number of Disconnects. The photovoltaic system disconnecting means shall consist of not more than six switches or six circuit breakers mounted in a single enclosure, or in a group of a separate enclosures, ~~or in or on a switchboard~~**.**
Remainder of current NEC section to remain as written.
Panel Statement: The panel additionally added the word "or" to improve clarity.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-278 Log #2200 NEC-P04 **Final Action: Reject**
(690.16(B))

Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum
Recommendation: Revise as follows and add the informational note:
690.16(B) Fuse Servicing. Disconnecting means intended solely for fuse servicing shall be installed on PV output circuits within 1.8 m (6 ft) of fuse locations where ~~overcurrent devices (~~fuses~~)~~ must be serviced that cannot be isolated from energized circuits. The disconnecting means shall be within sight of, and accessible ~~to~~ from the location of the fuse or be integral with the fuse holder ~~and shall comply with 690.17~~. Where disconnecting means are located more than 1.8 m (6 ft) from the overcurrent device, a directory showing the location of each disconnect shall be installed at the overcurrent device location.
Non-load-break-rated disconnecting means shall be marked "do not open under load."
Informational Note: Multiple fuses bolted on the common busbars in inverter input circuits and fuses in non-load break rated fuse holders in dc combiners represent a shock hazard when being serviced unless all fuses are disconnected from all sources.
Substantiation: The intent of this original submission for the 2011 NEC was to address the problem of multiple, large bolt-on fuses in the input circuits of utility-interactive inverters or in PV output circuit combiners. With one end of every fuse connected to an energized PV output circuit and the other end bolted to a common bus bar, there is no way to service the fuses without going into the PV array field and finding all combiner boxes and opening possibly hundreds of finger safe fuse holders.
Unfortunately the interpretation of this requirement is being used to require load break rated disconnects at the output of combiners and in some cases even at the numerous inputs of source circuit combiners. While the inclusion of a load break rated disconnect at the output of each combiner is worthwhile, that requirement does not belong in this section and will be proposed in Section 690.15.
Panel Meeting Action: Reject
Panel Statement: The existing text is clear and adequate. The proposed text requiring a disconnect within 6 feet contradicts the 6 foot requirement in the the third sentence.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-278a Log #CP414 NEC-P04 **Final Action: Accept**
(690.17)

TCC Action: The Correlating Committee directs that the panel clarify the action on this proposal to correlate with the panel action taken on Proposal 4-264.
The Correlating Committee further directs that this proposal be clarified by modifying the accepted text based on the NEC Style Manual by removing the titles in the list of devices and changing the "(a) through (i)" to "(1) through (9)."
In addition, the Correlating Committee directs that the panel reconsider the Informational Notes as related to the use of permissive and mandatory text, in accordance with the NEC Style Manual.
This action will be considered as a public comment.
Submitter: Code-Making Panel 4,
Recommendation: Revise 690.17 to read as follows:
690.17 Disconnect Type.
(A) Manually Operable. The disconnecting means for ungrounded PV conductors shall consist of a manually operable switch(es) or circuit breaker(s). The disconnecting means shall be permitted to be power operable with provisions for manual operation in the event of a power supply failure. The disconnecting means shall be one of the following devices:
a) PV Industrial Control Switch. A listed industrial control switch marked for use in PV systems.
b) PV Molded Case Circuit Breaker. A listed molded case circuit breaker marked for use in PV systems
c) PV Molded Case Switch. A listed molded case switch marked for use in PV systems.
d) PV Enclosed Switch. A listed, enclosed switch marked for use in PV systems.
e) PV Open Type Switch. A listed, open type switch marked for use in PV systems.
f) Molded Case Circuit Breaker. A listed, dc rated molded case circuit breaker suitable for backfeed operation.
g) Molded Case Switch. A listed, dc rated, molded case switch suitable for backfeed operation.
h) Enclosed Switch. A listed, dc rated enclosed switch.
i) Open Type Switch. A listed, dc rated open type switch.
Informational Note: Devices marked with "line" and "load" are not suitable for backfeed or reverse current.
(B) Simultaneous Opening of Poles. The PV disconnecting means shall simultaneously disconnect all ungrounded supply conductors that it controls from the building or structure wiring system.
(C) Externally Operable and Indicating. The PV disconnecting means shall be externally operable without exposing the operator to contact with live parts and indicate whether in the open or closed position
(D) Disconnection of Grounded Conductor. A switch, circuit breaker, or other device shall not be installed in a grounded conductor if operation of that switch, circuit breaker, or other device leaves the marked, grounded conductor in an ungrounded and energized state.
Exception No. 1: A switch or circuit breaker that is part of a ground-fault detection system required by 690.5, or that is part of an arc-fault detection/ interruption system required by 690.11, shall be permitted to open the grounded conductor when that switch or circuit breaker is automatically opened as a normal function of the device in responding to ground faults.
Exception No. 2: A disconnecting switch shall be permitted in a grounded conductor if all of the following conditions are met:
(1) The switch is used only for PV array maintenance.
(2) The switch is accessible only by qualified persons.
(3) The switch is rated for the maximum dc voltage and current that could be present during any operation, including ground-fault conditions.
Informational Note: The grounded conductor may have a bolted or terminal disconnecting means to allow maintenance or troubleshooting by qualified personnel.
(F)Interrupting Rating. The building or structure disconnecting means shall have an interrupting rating sufficient for the maximum circuit voltage and current that is available at the line terminals of the equipment. Where all terminals of the disconnecting means may be energized in the open position, a warning sign shall be mounted on or adjacent to the disconnecting means. The sign shall be clearly legible and have the following words or equivalent:
WARNING
ELECTRIC SHOCK HAZARD.
DO NOT TOUCH TERMINALS.
TERMINALS ON BOTH THE LINE AND LOAD SIDES
MAY BE ENERGIZED IN THE OPEN POSITION.
Exception: A connector shall be permitted to be used as an ac or a dc disconnecting means, provided that it complies with the requirements of 690.33 and is listed and identified for use with specific equipment.
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

4-279 Log #2128 NEC-P04 **Final Action: Accept in Principle**
(690.17)

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

690.17 ~~Switch or Circuit Breaker~~ Disconnect Construction.

(A) Manually Operable. The disconnecting means for ungrounded conductors shall consist of a manually operable switch(es) or circuit breaker(s). ~~complying with all of the following requirements:~~
~~(1) Located where readily accessible~~

(B) Simultaneous Opening of Poles. Each building or structure disconnecting means shall simultaneously disconnect all ungrounded supply conductors that it controls from the building or structure wiring system.

(C) Externally Operable and Indicating. ~~(2)~~ The building or structure disconnecting means shall be externally operable without exposing the operator to contact with live parts and ~~(3) P~~plainly indicating whether in the open or closed position

(D) Disconnection of Grounded Conductor. A switch, circuit breaker, or other device shall not be installed in a grounded conductor if operation of that switch, circuit breaker, or other device leaves the marked, grounded conductor in an ungrounded and energized state.

Exception No. 1: A switch or circuit breaker that is part of a ground-fault detection system required by 690.5, or that is part of an arc-fault detection/ interruption system required by 690.11, shall be permitted to open the grounded conductor when that switch or circuit breaker is automatically opened as a normal function of the device in responding to ground faults.

Exception No. 2: A disconnecting switch shall be permitted in a grounded conductor if all of the following conditions are met:

(1) The switch is used only for PV array maintenance.

(2) The switch is accessible only by qualified persons.

(3) The switch is rated for the maximum dc voltage and current that could be present during any operation, including ground-fault conditions.

Informational Note: The grounded conductor may have a bolted or terminal disconnecting means to allow maintenance or troubleshooting by qualified personnel.

(E)Interrupting Rating. ~~(4)~~ The building or structure disconnecting means shall have ~~Having~~ an interrupting rating sufficient for the nominal circuit voltage and the current that is available at the line terminals of the equipment Where all terminals of the disconnecting means may be energized in the open position, a warning sign shall be mounted on or adjacent to the disconnecting means. The sign shall be clearly legible and have the following words or equivalent:

WARNING
ELECTRIC SHOCK HAZARD.
DO NOT TOUCH TERMINALS.
TERMINALS ON BOTH THE LINE
AND LOAD SIDES MAY BE ENERGIZED
IN THE OPEN POSITION.

Exception: A connector shall be permitted to be used as an ac or a dc disconnecting means, provided that it complies with the requirements of 690.33 and is listed and identified for the use.

Substantiation: This proposal is part of a series of proposals which group similar requirements for PV systems together in order to make the article easier to use. The title was changed and the requirements were moved into a list format for clarity. Paren (D) text comes from existing NEC 690.13. Revisions structure the requirements similar to NEC 225.38 and clarify the disconnect construction. See the summary spreadsheet which details the relocation of requirements contained in the series of proposals.

Note: Supporting material is available for review at NFPA Headquarters.

Panel Meeting Action: Accept in Principle
Panel Statement: This proposal was used as the baseline for the reorganization of 690.17 conducted under Proposal 4-278a. See panel action on Proposal 4-278a which incorporates the submitter's proposal with additional changes.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-280 Log #3417 NEC-P04 **Final Action: Accept in Principle**
(690.17)

Submitter: Thomas Hattert, SMA Solar Technology AG
Recommendation: Revise text to read as follows:

The disconnecting means for ungrounded conductors shall consist of ~~manually operable~~ switch(es) or circuit breaker(s) complying with all off the following requirements:

(1) Located where readily accessible

(2) Externally operable without exposing the operator to contact with live parts

(3) Plainly indicating whether in the open or closed position

(4) Having an interrupting rating sufficient for the nominal circuit voltage and the current that is available at the line terminals of the equipment

(5) Manually operable or power operable with provisions to ensure that the switch or circuit breaker can be opened by hand in event of a power supply failure.

Substantiation: The previous restriction of section 690.17, that switches or circuit breaker have to be manually operable only, leads to a discrepancy between the AC section in 230 and the PV section in 690. Therefore it shall be permitted to use manually switches as well as power operable ones. To ensure that the power operable switches still can be operated in case of a power supply failure the new paragraph uses the same requirements as in 230.76.

Panel Meeting Action: Accept in Principle
Panel Statement: See panel action on Proposal 4-278a, which addresses the submitter's concern.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-281 Log #2201 NEC-P04 **Final Action: Accept in Principle**
(690.17 Exception)

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

Revise 690.17 EX as follows: Renumber the existing exception as 1, revise as shown, and add the following new Exception 2.

Exception 1: A connector shall be permitted to be used as an ac or dc disconnecting means, provided that it is listed and indentified for the use with a specific piece of equipment and complies with the requirements of 690.33. ~~and is listed and indentified for the use~~

Exception 2: A power-operated switch or circuit breaker shall be permitted provided it can be manually operated in the event of a power failure.

Substantiation: Exception 1 is slightly reorganized and places the emphases that the connector being used as a disconnect must be listed with a specific piece of equipment. These connectors are generally only recognized components in most applications—except when listed as meeting the particular application requirements of a specific piece of equipment like a microinverter or an ac PV module.

EX 2. New PV systems are becoming increasingly complex with multiple inverters, multiple PV arrays with varying locations of equipment, in and outside of buildings. Flexibility in the location of the manually operated PV dc disconnecting means is limited. A remote controlled disconnecting means, will increase flexibility, increase safety and may meet increased safety concerns for first responders.

While the location of the main PV disconnect is still established by other *NEC* requirements, the permissive use of as remote, power operated disconnect will allow that disconnecting means to be activated, or deactivated from one or more locations, and the control in each location may meet varying requirements. A utility may dictate control from near the revenue meter for the building. A fire department may require a control near the service disconnect. A maintenance person, may require control from a roof top location.

Panel Meeting Action: Accept in Principle
Panel Statement: See panel action on Proposals 4-280 and 4-278a which address the submitter's concerns.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-282 Log #888 NEC-P04 **Final Action: Accept**
(690.17(4))

TCC Action: It was the action of the Correlating Committee that this proposal be reconsidered and correlated with the panel action on Proposal 4-278a with regard to the placement of the accepted text in 690.17.

This action will be considered as a public comment.

Submitter: Michael J. Johnston, National Electrical Contractors Association
Recommendation: Add a new last sentence after list item (4) and the warning text as follows:

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

Substantiation: This proposal is one of several coordinated companion proposals to provide consistency of danger, caution, and warning sign or markings as required in the NEC. The proposed revision will correlate this warning marking requirement with proposed 110.21(B) and the requirements in ANSI Z 535.4.

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

4-283 Log #2022 NEC-P04 **Final Action: Accept in Part**
(690.18)

Submitter: Brian Mehalic, Solar Energy International
Recommendation: Revise text to read as follows:

690.18 Installation and Service of an Array. Open circuiting, ~~or~~ short circuiting, ~~or opaque covering~~ shall be used to disable an array or portions of an array for installation and service.

Informational Note: Photovoltaic modules are energized while exposed to light. Installation, replacement, or servicing of array components while a module(s) is ~~irradiated~~ energized may expose persons to electric shock.

Substantiation: Using an opaque covering to "disable" a PV array is a false sense of security at best. Many coverings such as tarps allow through enough

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.

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

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

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

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.

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

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.

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

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

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

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

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

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

photovoltaic module interconnections within the photovoltaic 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.
~~(C)~~ **(D) 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(~~C~~D).
~~(D)~~ **(E) 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.
~~(E)~~ **(F) Direct-Current Photovoltaic Source and Output**
Circuits Inside a Building. Where dc photovoltaic source or output circuits from a building-integrated or other photovoltaic system 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 ~~690.14(A), (B), and (D)~~ 690.13(B), (C), and 690.15(A), (B). The wiring methods shall comply with the additional installation requirements in (1) through (4)
(1) Beneath Roofs. Wiring methods shall not be installed within 25 cm (10 in.) of the roof decking or sheathing except where directly below the roof surface covered by PV modules and associated equipment. Circuits shall be run perpendicular to the roof penetration point to supports a minimum of 25 cm (10 in.) below the roof decking.
Informational Note: The 25 cm (10 in.) requirement is to prevent accidental damage from saws used by fire fighters for roof ventilation during a structure fire.
(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 "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. Photovoltaic 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.

Table 690.31(~~C~~) (D) Corrections Factors

Ambient Temperature (°C)	Temperature Rating of Conductor				Ambient Temperatures (°F)
	60°C(140°F)	75°C(167 °F)	90°C(194° F)	105°C(221° F)	
30	1.00	1.00	1.00	1.00	86
31-35	0.91	0.94	0.96	0.97	87-95
36-40	0.82	0.88	0.91	0.93	96-104
41-45	0.71	0.82	0.87	0./89	105-113
46-50	0.58	0.75	0.82	0.86	114-122
51-55	0.41	0.67	0.76	0.82	123-131
56-60	-	0.58	0.71	0.77	132-140
61-70	-	0.33	0.58	0.68	141-158
71-80	-	-	0.41	0.58	159-176

~~(F)~~ **(G) Flexible, Fine-Stranded Cables.** Flexible, fine-stranded cables shall be terminated only with terminals, lugs, devices, or connectors in accordance with 110.14(A).
(H) 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.
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.
(I) 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 proposal groups the wiring method requirements for PV systems together. Revised 690.31(B) text comes from existing 690.4(B). New paren (H) comes from existing 690.4(G). New paren (I) comes from existing 690.4(C). See the summary spreadsheet which details the relocation of requirements contained in the series of proposals.
Note: Supporting material is available for review at NFPA Headquarters.
Panel Meeting Action: Accept in Principle
Panel Statement: This proposal was used as the baseline for the reorganization of 690.31, conducted under Proposal 4-284a. See panel action on Proposal 4-284a, which incorporates the submitter's proposal with additional changes.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-289 Log #2203 NEC-P04 **Final Action: Reject**
(690.31(B))

Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum
Recommendation: Revise text to read as follows:
Add the following second paragraph after the exception in 690.31(B)
Equipment-grounding conductors smaller than 4 AWG installed in exposed outdoor locations used to provide equipment-grounding for photovoltaic (PV) modules, PV panels, and PV mounting structures shall be permitted to have insulated or covered conductors permanently marked as equipment-grounding conductors with a green or green and yellow marking at each termination.
Substantiation: In most photovoltaic (PV) installations, uninsulated (bare) equipment grounding conductors are used to ground PV modules and associated equipment. However, in some PV power installations, exposed insulated conductors are required for equipment grounding to keep copper conductors from touching metal roofs or other structures that might be damaged or disfigured by dissimilar metals corrosion. While conductors are available with colored insulations that are marked sunlight resistant, many of these insulations have not withstood the high temperature, high UV radiation environment associated with the PV system for the required 40-50 years or more. Black colored conductors like USE-2 made of thermoset materials (synthetic rubber) containing high levels of carbon black have proven to have adequate durability. Allowing these black conductors to be properly marked will help to ensure that PV modules and nearby equipment remain safely grounded for the life of the system.
Panel Meeting Action: Reject
Panel Statement: Wires and conductors of this size are readily available with UV resistant green insulation. The panel is concerned with the UV resistance of markings. This is a design and maintenance issue.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-290 Log #2929 NEC-P04 **Final Action: Reject**
(690.31(B))

Submitter: Mark Albers, SunPower Corp.
Recommendation: Change the current 690.31(B) text to be 690.31(B)(1) and add the following text as 690.31(B)(2).
Photovoltaic source circuits and photovoltaic output circuits using single-conductor cable type USE-2 or PV wire shall be permitted in cable tray raceways as long as the cables are secured and supported in accordance with 334.30 and the PV system is not installed on a building. When determining the cable ampacity requirements and the cable tray fill requirements, each bundle of photovoltaic source circuit and output circuit cables shall be treated as a multi-conductor cable and the corresponding rules of 392.17 and 392.22 shall be applied.
Substantiation: Currently, the NEC permits the use of USE-2 or PV wire in exposed, outdoor environments (690.31(B)) because these cables are designed for outdoor use. Furthermore, the support requirements for USE cables in exterior locations is only every 4.5 feet as defined in 334.30, which is referenced by 338.10(B)(4)(b). All cable tray designs are superior to both of these conditions in that they provide protection from physical damage for these cables and the maximum support spans are much less than 4.5 feet. Additionally, PV or USE-2 conductors are often secured to PV racking structures for mechanical support. Mechanically supporting these conductors from cable trays is essentially equivalent. Unfortunately, section 392 does NOT address installation of single conductor cables smaller than #1/0AWG in cable trays; the sizes often used for PV source circuits and output circuits.
Also, it is important to remember that the spread of fire protection provided by the CT rating has no bearing on a ground mounted PV system, because the PV source circuits and output circuit cables are never passing through a fire barrier. Thus, there is no risk that cables would allow a fire to breech such a fire barrier.
In the end, various inspectors have approved of this wiring method in the past based on a collection of code references and supporting documentation from cable tray manufacturers and code experts. However, this approach is dependent upon the judgment of the inspector. It would be extremely beneficial to have this method more clearly defined as an approved wiring method in 690.31.
Note: Supporting material is available for review at NFPA Headquarters.
Panel Meeting Action: Reject
Panel Statement: Cable trays are restricted to industrial facilities due, in part, to the maintenance supervision and security of these types of facilities. Broadly allowing this wiring method in all ground mounted systems is not advisable. Section 392.10(A) gives a list of acceptable cables for installation in cable trays.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13
Comment on Affirmative:
ROGERS, J.: Cable trays are not restricted to industrial establishments and may be a viable option for some PV installations provided the wiring method is permitted to be installed in cable trays and the tray is listed for the environment where it is being installed. The submitter should also address the addition of the referenced wiring methods to CMP 7 and CMP 8 for their consideration.

4-291 Log #1175 NEC-P04 **Final Action: Reject**
(690.31(E))

Submitter: Richard E. Loyd, R & N Associates
Recommendation: Revise text to read as follows:
690.31 (E) Direct-Current Photovoltaic and Inverter Source, and Output Circuits Inside a Building. Where ~~de~~ photovoltaic and inverter source or output circuits from a building-integrated or other photovoltaic system 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 690.14(A), (B), and (D). The wiring methods shall comply with the additional installation requirements in (1) through (4).
Substantiation: The shock and fire hazards are equal regardless of the voltage ac or dc. Accepting this change will insure the proper wiring methods are used inside structures even is the inverters are relocated off the roof after the initial installation is completed.
The use of metallic wiring methods and enclosures will provide physical protection for these circuits and will likely contain any faults should they develop in the enclosed cables or conductors and will minimize the fire hazards in buildings with PV systems. Metallic wiring raceways provide an additional ground-fault detection path for the ground-fault protection device required by 690.5.
Please accept this revision it will provide added fire safety in buildings and in the event of a fire will provide protection from chop saws, axes and other equipment used by firefighters.
Panel Meeting Action: Reject
Panel Statement: Inverter output circuits are deenergized when utility power is disconnected making them no more hazardous than any other ac wiring method in a building.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-292 Log #1457 NEC-P04 **Final Action: Reject**
(690.31(E))

Submitter: William A. Wolfe, Steel Tube Institute of North America
Recommendation: Revise text to read as follows:
690.31(E) ~~Direct Current~~ Photovoltaic and Inverter Source, and Output Circuits Inside a Building. Where ~~de~~ photovoltaic and inverter source or output circuits from a building-integrated or other photovoltaic system 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 690.14(A), (B), and (D). The wiring methods shall comply with the additional installation requirements in (1) through (4).
Substantiation: The shock and fire hazards are equal regardless of the voltage ac or dc. The use of metal raceways and enclosures that are permitted where subject to physical damage provide physical protection for these circuits, will likely contain any faults, should they develop in the enclosed cables or conductors, and will minimize the fire hazards in buildings with PV systems. Metallic wiring raceways provide an additional ground-fault detection path for the ground-fault protection device required by 690.5.
This revision will provide added fire safety in buildings and in the event of a fire will provide protection from chop saws, axes and other equipment used by firefighters.
Panel Meeting Action: Reject
Panel Statement: Inverter output circuits are deenergized when utility power is disconnected making them no more hazardous than any other ac wiring method in a building.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-293 Log #1843 NEC-P04 **Final Action: Reject**
(690.31(E))

Submitter: Rhonda Parkhurst, City of Palo Alto
Recommendation: Revise text to read as follows:
(E) Direct-Current Photovoltaic Source and Output Circuits Inside a Building. Where dc photovoltaic source or output circuits from a building-integrated or other photovoltaic system are run inside a building or structure, they shall be contained in rigid metal conduit, intermediate metal conduit, electric metallic tubing, ~~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. 14(A), (B), and (D). The wiring methods shall comply with Ithe additional installation requirements in (1) through (3) ~~(4)~~ delete item (2) and renumber (3) and (4) as (2) & (3).
Substantiation: Flexible metal conduit does not provide adequate protection for photovoltaic power source and photovoltaic source circuit conductors. Exposed flexible conduit, such as attic locations, has the potential to be grabbed by personnel. During fire operation and/or salvage and overhaul after a fire, a pike pole could easily break through the conduit and would then be in contact with energized conductors putting fire fighters at risk. Flexible metal conduit does not provide the same level of protection as other metal conduit and tubing.
Panel Meeting Action: Reject
Panel Statement: The proposal requires specific wiring methods excluding other metallic wiring methods. No technical substantiation was provided to limit the wiring methods to only those proposed. See panel action on Proposal 4-253 for the direction taken by the panel.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 12 Negative: 1
Explanation of Negative:
STAFFORD, T.: While the submitter did not provide any technical substantiation it is understood by those who install flexible metal conduit that the integrity and continuity of the flexible metal conduit is not the same as rigid metal conduit, intermediate metal conduit and electric metallic tubing. Each proposed allowed installation method does provide an increased strength of support and protection of conductors. The submitter's concerns would be addressed by accepting this proposal.

4-294 Log #1870 NEC-P04 **Final Action: Reject**
(690.31(E))

Submitter: Denis L. Lachance, Wareham, MA
Recommendation: Revise text to read as follows:
First readily accessibly disconnecting means when a disconnect is placed at the point of penetration, otherwise PVC pipe will be used.
Substantiation: The reason for this change is safety. If the insulation on a conductor fails the metal will become energized with no way of deenergizing.
Note: Supporting material is available for review at NFPA Headquarters.

Panel Meeting Action: Reject
Panel Statement: The location of the disconnecting means does not change the hazard of an energized conductor faulting to a metal raceway as a disconnecting means does not necessarily contain short-circuit or ground-fault protective devices. The intention of this section is to enclose these conductors in metal raceways for greater physical protection.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-295 Log #2204 NEC-P04 **Final Action: Accept in Part**
(690.31(E))

Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum
Recommendation: Revise 690.31(E) as follows and add the informational note:
690.31 (E) Direct-current Photovoltaic Source and DC Output Circuits inside a Building. Where dc PV photovoltaic source and dc PV output circuits from a building integrated or other ~~photovoltaic~~ PV system 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 690.14(A) through (H)~~(B), and (D)~~. The wiring methods shall comply with the additional installation requirements in (1) through (4).
Informational Note: This requirement does not apply to the ac output circuits of inverters or ac PV modules because those circuits are very similar to ac branch circuits. They can be de-energized at the main service disconnect and at any intermediate disconnecting means or circuit breaker. These circuits respond to faults by activating an overcurrent protective device at the first panel to which they are connected.
Substantiation: The terms "dc" are inserted for clarity. Some AHJs throughout the country continue to apply this requirement to the ac output circuits from inverters. Only the dc PV circuits, always energized by the sun, present the fire and shock hazards.
Abbreviation of photovoltaic to PV after the first use is consistent with the NEC Style Manual
The reference to 690.14 (A) through (H) is changed to match a proposal for that section.
The informational note is required to inform AHJs that ac inverter output circuits are not to be treated as the sunlight-energized dc PV source and output circuits. With ac PV modules and micro inverters attached to dc PV modules, the situation can be confusing.
Panel Meeting Action: Accept in Part
Panel Statement: The panel accepts the addition of "dc" in two places. The panel rejects the addition of the information note as it better suited to product standards or instruction manuals.
The remainder of the proposal is rejected. Reorganization of 690.31 has made the proposal language unnecessary. See panel action on Proposal 4-284a.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-296 Log #2645 NEC-P04 **Final Action: Accept**
(690.31(E))

Submitter: William F. Brooks, Brooks Engineering
Recommendation: Revise text to read as follows:
(3) Marking or Labeling Required. The following wiring methods and enclosures that contain PV power source conductors shall be marked with the wording "~~Photovoltaic Power Source~~ 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, shall have all letters capitalized with a minimum height of 9.5mm (3/8 inch) white on red background. Photovoltaic 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.
Substantiation: This proposal is to make the NEC consistent with the 2012 International Fire Code (IFC). It is the intent of the IFC to simply reference the NEC, as it already does, thus allowing the IFC to remove all language relating to PV electrical circuits and labeling of PV electrical circuits. The IFC requires that labels are reflective, all caps, 3/8" in high capital letters that are white on a red background. The reason for the red background is for high visibility for firefighters while fighting a fire. OSHA recommends the use of orange background for "Warning" signs and red for "Danger" signs, but these are labels rather than signs and are not required to match the OSHA guidelines.
Panel Meeting Action: Accept
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-297 Log #3031 NEC-P04 **Final Action: Reject**
(690.31(E))

Submitter: D. Jerry Flaherty, Electrical Inspection Service, Inc.
Recommendation: Revise text to read as follows:
690.31(E)-Direct-Current Photovoltaic Source and Output Circuits Inside a Building. Where dc photovoltaic source or output circuit from a building-integrated or other photovoltaic system are run inside a building or structure, they shall be contained in metal raceway, Type MC metal-clad cable that complies with 250.118(10) or metal enclosure from the point of penetration of the surface of the building or structure to the ~~first readily accessible disconnecting means~~ inverter input or charge controller input. The disconnecting means shall comply with 690.14(A), (B), and ~~(D)~~ (C). The wiring method shall comply with the additional installation requirements in (1) through (4).
Substantiation: 690.31(E)(1) to (4) goes to great length to protect the first responders and others that might be working on or near the PV power source circuit conductors from accidentally contact with the conductors by requiring the conductors to be installed in a metal raceway, enclosure or cable. This is good as it should be. However, it permits the wiring method to be changed to non-metal wiring method (NM cable) after the first readily accessible disconnect. If the first readily accessible disconnect is in one part of the building and the inverter is in another part of the building or if the first readily accessible not able to be turned off for some reason, then the first responders or other are at great risk while fighting a fire after the disconnect.
Ex. The PV source power circuit enters a building in the garage or accessible attic and the first disconnect is located in the garage or attic requiring a metal raceway, enclosure or cable on the line side of the readily accessible disconnect. However, the load side of the first readily accessible disconnect can be NM cable. The NM cable can be run through the building following any route without any indication that the circuit is a photovoltaic circuit. If the fire makes it impossible to get to the disconnect, the first responders are at risk of cutting the PV source power conductors. This is not only dangerous to the first responders, but also to anyone else that might be doing work on the building wiring system.
Requiring the metal cable or raceway run to the inverter would insure that the PV source circuit(s) are protected from physical damage (accidentally being cut) and also identify the PV source circuit as required in 690.31(E) 1 to 4.
Panel Meeting Action: Reject
Panel Statement: The recommendation is technically incorrect because the submitter assumes that circuits will be terminated in an inverter or charge controller. The proposal would preclude nonmetallic wiring methods that may be advantageous based on environment.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13
Comment on Affirmative:
STAFFORD, T.: While the panel statement is correct for rejecting this proposal, the submitter does present a safety concern. Inclusion of metal raceways throughout the circuit described in proposal would allow for enhanced safety. Weatherization and other environmental concerns for not utilizing metallic conduit may also exist for type NM cable. There is no doubt that circuit integrity and safety is improved through the use of metallic conduit where conditions allow.

4-298 Log #3145 NEC-P04 **Final Action: Reject**
(690.31(E) and (2))

Submitter: Marcus R. Sampson, Lysistrata Electric
Recommendation: Revise text to read as follows:
(E) Direct-Current Photovoltaic Source and Output Circuits Inside a Building. Where dc photovoltaic source or output circuits from a building-integrated or other photovoltaic system are run inside a building or structure, they shall be contained in metal raceways, cables with a metallic sheath ~~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 690.14(A), (B), and (D). The wiring methods shall comply with the additional installation requirements in (1) through (4)
(2) Flexible Wiring Methods. Where flexible metal conduit (FMC) smaller than metric designator 21 (trade size ¾) 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. Aluminum flexible wiring methods including aluminum type MC, aluminum flexible metallic conduit and aluminum type AC shall not be used.
Substantiation: Section 690.31(E) in the 2011 NEC specifically permits type MC cable to be used for the DC source and output circuits installed within a building. This specific allowance for metal raceways, metal enclosures and type MC prohibits other wiring methods, i.e. type AC cable.
Type AC is a factory assembly of insulated conductors protected by an overall metallic sheath. The metal sheath can be steel or aluminum. Type MC is a factory assembly of one or more current carrying insulated conductors and can contain one or more equipment grounding conductors in an overall metallic

sheath. The sheath can be steel, aluminum or even copper.

Per the UL white book AWSX, aluminum type AC is permitted for alternating current circuits because when tested with direct current, the aluminum sheathing "melted" or otherwise deteriorated.

It appears that type AC cable has specifically been omitted from the list in 690.31(E) for this reason. If aluminum AC deteriorated when tested with direct current, logic dictates that testing aluminum MC or aluminum FMC would result in the same finding.

This section should prohibit all aluminum flexible wiring methods - aluminum MC, aluminum flexible metallic conduit and aluminum AC.

Panel Meeting Action: Reject

Panel Statement: The submitter has requested that the existing language be removed and language limiting to those with a metallic sheath be inserted. The existing reference mandates that metal clad cable comply with 250.118. The submitter has not shown any reason to limit the use of these cables unless CMP-5 takes action to restrict their use.

Type AC cable is not a wiring method allowed in Article 690.

Number Eligible to Vote: 13

Ballot Results: Affirmative: 13

Comment on Affirmative:

STAFFORD, T.: This panel member agrees with the panel action in rejecting this proposal, but thinks that MC or any metallic cable assembly that has not been specifically tested for high voltage DC should not be allowed for use in the DC circuits of Article 690. The submitter in his substantiation validates a concern that flexible metallic cable assemblies should not be used in DC source and output circuits of a PV system. This panel member agrees with the submitter's last sentence in his substantiation. This section should prohibit all aluminum wiring methods. Steel FMC or steel metal conduit should be the only allowable raceways allowed for DC circuits inside a building. Two code cycles ago the NEC did not allow these conductors to enter the building.

4-299 Log #3211 NEC-P04 **Final Action: Reject**
(690.31(E))

Submitter: Matthew A. Piantedosi, The Cadmus Group, Inc.

Recommendation: Revise text to read as follows:

Where dc photovoltaic source or output circuits from a building-integrated or other photovoltaic system 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 690.14(A), (B) and (D). the wiring methods shall comply with the additional installation requirements in (1) through (4).~~

Substantiation: Based on the existing wording of this article, it is permissible to use Type NM-B cable on the DC conductors up to 600V after the first readily accessible disconnecting means. This can lead to a hazardous situation due to the high operating voltage as well as the lack of overcurrent protection in this point of many systems.

Panel Meeting Action: Reject

Panel Statement: The submitter has not presented any documented safety issue or failure analysis to preclude the use of Type NM cable in these applications.

Number Eligible to Vote: 13

Ballot Results: Affirmative: 13

4-300 Log #2205 NEC-P04 **Final Action: Accept**
(690.31(F))

Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum

Recommendation: Revise text to read as follows:

Correct the reference in 690.31(F) as noted below.

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

Substantiation: The reference to 110.14(A) is incorrect and the correct reference is 110.14.

Panel Meeting Action: Accept

Number Eligible to Vote: 13

Ballot Results: Affirmative: 13

4-301 Log #3420 NEC-P04 **Final Action: Accept**
(690.31(G), Part IV (New))

Submitter: Nicholas P. Carter, Enecsys LLC

Recommendation: Add text to read as follows:

690.31 (G) Multi-conductor cable type TC-ER or USE-2 shall be permitted in outdoor locations in photovoltaic 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.

Substantiation: There is currently no specific cable designation for the alternating-current wiring between microinverters. This multi-conductor cable is typically installed in outdoor locations, attached to, or within, photovoltaic system racking.

Panel Meeting Action: Accept

Number Eligible to Vote: 13

Ballot Results: Affirmative: 13

Comment on Affirmative:

STAFFORD, T.: It seems that this recommendation to add new text as 690.31(G) does not include a mandatory title for this section. The title could be Multi-conductor Cables. The recommended new text should include wording to ensure that TC-ER / USE-2 has the appropriate environmental ratings (sunlight resistant, temperature) if it is to be used up on the roof.

4-302 Log #3157 NEC-P04 **Final Action: Accept in Part**
(690.35(C))

Submitter: Timothy P. Zgonena, Underwriters Laboratories Inc.

Recommendation: Revise text to read as follows;

690.35 (C) Ground-Fault Protection. All photovoltaic source and output circuits shall be provided with a ground-fault protection device or system that complies with (1) through(4) ~~(3)~~:

(1) Determine the pv input circuit has a minimum acceptable level of isolation prior to export of current,

(2)~~Detects a ground fault.~~ Detect ground fault(s).

(3) Indicates that a ground fault has occurred

(4) Automatically disconnects all conductors or causes the inverter or charge controller connected to the faulted circuit to automatically cease supplying power to output circuits.

Substantiation: Recent information on existing ground fault protection techniques has indicated that additional protection is necessary against high ground faults on PV systems. This proposal is intended to revise the ground fault protection requirements and add an additional array isolation measurement prior to export of current.

On May 27, 2010, UL introduced a CRD and a UL 1741 proposal for non-isolated PV inverters that was similar to draft IEC 62109-2 PV inverter requirements for non-isolated PV inverters. These set requirements include a measurement of the PV array isolation prior to initiating connection to the array and power export. Implementation of this protection scheme as part of ground fault protection circuits will result in daily verification of minimal PV array isolation and drastically reduce the potential for ground faults going unnoticed. In addition to the daily array isolation verification, these new GFDI requirements include a ground fault trip based upon a change in ground fault current as low as a 30mA delta.

Panel Meeting Action: Accept in Part

1) Reject the words "a minimum acceptable level of"

2) Accept the remainder of the proposal.

Panel Statement: The proposed text "a minimum acceptable level of" is not an enforceable requirement.

Number Eligible to Vote: 13

Ballot Results: Affirmative: 12 Negative: 1

Explanation of Negative:

BOWER, W.: The language :

(1) Determine the pv input circuit has isolation prior to export of current is not something an AHJ can determine in the field with the given information

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4-303 Log #2206 NEC-P04 **Final Action: Reject**
(690.35(D))

Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum

Recommendation: Revise text to read as follows:

Revise 690.35(D) as follows adding an additional item.

690.35(D) The photovoltaic source conductors shall consist of the following:

(1) Nonmetallic jacketed multiconductor cables

(2) Conductors installed in raceways, ~~or~~

(3) Conductors listed and identified as Photovoltaic (PV) Wire installed as exposed, single conductors, or

(4) Direct-buried conductors.

Substantiation: This section identifies PV source circuit conductors and/or wiring methods allowed for ungrounded PV systems. By listing the three most common methods, it perhaps inadvertently excludes an option for direct buried conductors. The ability to use direct-buried conductors in (especially) larger ground-mounted systems is useful, and there are no inherent fire-safety issues that should exclude direct burial conductors from use in PV applications. PV Wire is not specified exclusively in (4) because there are other suitable direct-burial conductors.

Panel Meeting Action: Reject

Panel Statement: This proposed language would allow the use of direct buried conductors anywhere in the system.

Number Eligible to Vote: 13

Ballot Results: Affirmative: 13

4-304 Log #3423 NEC-P04 **Final Action: Reject**
(690.35(D))

Submitter: Ryan Gaston, The Dow Chemical Company
Recommendation: Revise text to read as follows:
690.35(D) The photovoltaic source conductors shall consist of the following:
(1) Nonmetallic jacketed multiconductor cables
(2) Conductors installed in raceways, ~~or~~
(3) Conductors listed and identified as Photovoltaic (PV) Wire installed as exposed, single conductors, or
(4) Assemblies listed for Photovoltaic (PV) use.
Substantiation: Some PV products when fully assembled do not have exposed wires and include wire-protection features built into the product. Where these wire-protection features serve to prevent minimum bend radii and unsupported span lengths from being exceeded and prevent access to the wires, they function similar to a raceway or conduit.
When a PV array does not include any grounded metal, the safest electrical installation is an ungrounded PV system. This prevents an electrician from receiving a shock from the positive conductor through the ground-fault detection fuse to the metal conduit (required per code under the roof).
The current wording prevents these PV products from being installed in the safest manner.
Panel Meeting Action: Reject
Panel Statement: Proposed language is not consistent with the current list. A listed assembly is not a conductor. Conductors as part of a listed assembly should be proposed rather than the whole assembly.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 12 Negative: 1
Explanation of Negative:
ROGERS, J.: This proposal should have been accepted. The submitter is correct that there may be manufactured assemblies that are properly listed for PV applications that do not fall under the existing prescriptive list. Those assemblies should be allowed to be used in accordance with any installation and listing requirements.

4-305 Log #3424 NEC-P04 **Final Action: Reject**
(690.35(D), Informational Note (New))

Submitter: Ryan Gaston, The Dow Chemical Company
Recommendation: Add text to read as follows:
690.35(D) The photovoltaic source conductors shall consist of the following:
(1) Nonmetallic jacketed multiconductor cables
(2) Conductors installed in raceways, or
(3) Conductors listed and identified as Photovoltaic (PV) Wire installed as exposed, single conductors.
Informational Note: Some PV systems when fully assembled do not have exposed wires and include wire-protection features built into the product. Such assemblies, when evaluated and listed for PV use, are allowed.
Substantiation: Some PV products when fully assembled do not have exposed wires and include wire-protection features built into the product. Where these wire-protection features serve to prevent minimum bend radii and unsupported span lengths from being exceeded and prevent access to the wires, they function similar to a raceway or conduit.
When a PV array does not include any grounded metal, the safest electrical installation is an ungrounded PV system. This prevents an electrician from receiving a shock from the positive conductor through the ground-fault detection fuse to the metal conduit (required per code under the roof).
The current wording prevents these PV products from being installed in the safest manner.
Panel Meeting Action: Reject
Panel Statement: Enforceable requirements cannot be part of informational notes.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13
Comment on Affirmative:
BOWER, W.: This appears to be a UL listing issue.

4-305a Log #3521 NEC-P04 **Final Action: Accept**
(690.35(D)(1))

TCC Action: The Correlating Committee directs that appropriate first level subdivision titles be added throughout 690.35. See 2.1.5.2 of the NEC Style Manual.
This action will be considered as a public comment.
Submitter: Vince Baclawski, National Electrical Manufacturers Association (NEMA)
Recommendation: Revise text to read as follows:
(1) Metallic or n~~N~~onmetallic jacketed multiconductor cables.
Substantiation: Type MC cable can be used for photovoltaic source conductors. This revision allows both nonmetallic and metallic jacketed multiconductor cables.
Panel Meeting Action: Accept
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-306 Log #889 NEC-P04 **Final Action: Accept**
(690.35(F))

Submitter: Michael J. Johnston, National Electrical Contractors Association
Recommendation: Add a new last sentence after the warning text as follows:
The warning sign(s) or label(s) shall comply with 110.21(B).
Substantiation: This proposal is one of several coordinated companion proposals to provide consistency of danger, caution, and warning sign or markings as required in the NEC. The proposed revision will correlate this warning marking requirement with proposed 110.21(B) and the requirements in ANSI Z 535.4.
Panel Meeting Action: Accept
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-307 Log #2652 NEC-P04 **Final Action: Accept**
(690.41)

TCC Action: The Correlating Committee directs that the panel rewrite this section as multiple sentences for clarity.
This action will be considered as a public comment.
Submitter: William F. Brooks, Brooks Engineering
Recommendation: Revise text to read as follows:
690.41 System Grounding.
For a photovoltaic power source, systems shall comply with 690.35 or one conductor of a 2-wire system with a photovoltaic system voltage over 50 volts but not greater than 300 volts and the reference (center tap) conductor of a bipolar system shall be solidly grounded or shall use other methods that accomplish equivalent system protection in accordance with 250.4(A) and that utilize equipment listed and identified for the use.
~~Exception: Systems complying with 690.35.~~
Substantiation: This proposal is to limit the use of solidly grounded systems to only those below 300 volts to be consistent with 250.162. Conventional wisdom believed that all systems above 50 volts would be safer if grounded, but field practice has shown that higher voltage systems become much more dangerous when grounded, particularly above 300 volts—the majority of systems now being installed in the U.S. Recent fires have also shown that grounding of systems has created critical blindspots in ground-fault detection systems allowing grounded conductor faults to persist undetected setting up the circumstances for a full array short circuit condition under an ungrounded conductor fault. These faults can flow over 1000 amps in large 500 kW PV arrays. As 600Vdc PV arrays continue to proliferate, 1000Vdc systems are also being installed. These systems, if allowed to be grounded at the recommendation of the NEC, will result in even more significant fires and electrocution hazards. The fault detection schemes required by ungrounded PV arrays substantially improve both fire and life safety. It should be noted that 690 has been in conflict with article 250.162 and it turns out that article 250 is correct and should be followed above 300Vdc. Since the provisions of 690.35 provide guidelines on how to install ungrounded systems properly, it is straightforward to make this a requirement of all systems greater than 300Vdc. The exception is unnecessary since the section is now written in as a positive provision, eliminating the need for the exception which is consistent with the direction in the style manual.
Panel Meeting Action: Accept
Panel Statement: The panel recognizes that a "," should be inserted between "690.35" and "or".
Number Eligible to Vote: 13
Ballot Results: Affirmative: 12 Negative: 1
Explanation of Negative:
ROGERS, J.: This proposal as written is too restrictive and actually prohibits the design and installation of a grounded PV system operating over 300 volts. Section 690.35 already permits this, it should also be permissible to design and install a grounded system at voltages over 300 if deemed necessary to do such.
Comment on Affirmative:
BOWER, W.: This is new language and is using the term photovoltaic in the sentence. The final should read:
For a PV power source, systems shall comply with 690.35 or "one conductor of a 2-wire system with a PV system voltage over 50 volts dc, but not greater than 300 volts dc and the reference (center tap) conductor of a bipolar system shall be solidly grounded" or shall use other methods that accomplish equivalent system protection in accordance with 250.4(A) and that utilize equipment listed and identified for the use.
Exception: Systems complying with 690.35."
Note: This proposal is more relevant given the fact that the NEC is redefining low voltage as 1000Volt or less. Products that require resistive grounding for depolarization would still be allowed. Solid grounded systems would not be allowed above 300Volts dc as a result of this proposal.

4-308 Log #1514 NEC-P04 **Final Action: Reject**
(690.43(B))

Submitter: Vince Baclawski, National Electrical Manufacturers Association (NEMA)
Recommendation: Revise text to read as follows:
(B) Equipment Grounding Conductor Required. An equipment grounding conductor in accordance with 250.118 shall be installed between a PV array and other equipment ~~shall be required~~ in accordance with 250.110.
Substantiation: There is confusion in the industry regarding the proper equipment grounding conductors that can be used. This confusion revolves around the attempted use of strut as an EGC and using bonding washers between the array and strut. Metal strut is not identified as an EGC in 250.118. This proposal makes it clear that an EGC must be installed and that EGC must meet the requirements in 250.118.
Panel Meeting Action: Reject
Panel Statement: An equipment grounding conductor as defined in the NEC already refers to 250.118.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-308a Log #CP408 NEC-P04 **Final Action: Accept**
(690.45)

Submitter: Code-Making Panel 4,
Recommendation: 1) **Delete 690.45(B) and associated informational note.**
2) **Move existing 690.45(A) into main body of 690.45**
3) **Revise 690.45 text to read as follows:**
690.45 Size of Equipment Grounding Conductors. Equipment Grounding conductors for PV source and PV output circuits shall be sized in accordance with Table 250.122. Where no overcurrent protective device is used in the circuit, an assumed overcurrent device rated at the PV maximum circuit current shall be used in Table 250.122. Increases in equipment grounding conductor size to address voltage drop considerations shall not be required. An equipment grounding conductor shall not be smaller than 14 AWG.
Substantiation: Because of actions taken at the CMP-4 meeting to act on proposals, this panel proposal is required to delete the text in 690.45(B) and associated Informational Note. The text is no longer necessary as worded due to the panel taking action to delete 690.5 Exception #2. The text in 690.45(A) was moved into 690.45 and revised to bring it into compliance with the Manual of Style.
Changes made to 690.45 include:
Changing photovoltaic to PV in several locations.
Changing "rated short circuit current" to "maximum circuit current"
Changing "The equipment grounding conductors shall be no smaller than 14 AWG." to "The equipment grounding conductor shall not be smaller than 14 AWG."
Panel Meeting Action: Accept
Number Eligible to Vote: 13
Ballot Results: Affirmative: 12 Negative: 1
Explanation of Negative:
ROGERS, J.: The installation of solid conductors larger than #8 have been proven over time to be an installation problem that is why the restriction is in place. Many inspectors are mandating larger bonding conductors than are really necessary and that is where the problem should be addressed.

4-309 Log #2207 NEC-P04 **Final Action: Accept**
(690.46)

TCC Action: The Correlating Committee directs that this proposal be reconsidered and the use of the term "solid" be clarified with respect to the use of equipment grounding conductors and grounding electrode conductors.
The Correlating Committee further directs that this proposal be clarified with respect to the use of the phrase "of 6 AWG and smaller", as it applies to equipment grounding conductors and grounding electrode conductors.
This action will be considered as a public comment.
Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum
Recommendation: Revise text to read as follows:
Revise 690.46 as follows. Add the following second paragraph.
690.46 Array Equipment Grounding Conductors. Equipment grounding conductors for PV modules smaller than 6 AWG shall comply with 250.120(C). Solid (non-stranded) equipment-grounding conductors and grounding-electrode conductors of 6 AWG and smaller shall be permitted in raceways for PV array grounding.
Substantiation: 310.106(C) requires the use of stranded conductors of 8 AWG and larger in raceways, with an exception for the use larger, solid conductors where permitted elsewhere in the Code. This proposal allows the use of solid conductors larger than 8 AWG.
Given the problem of moisture, which is generally present at the location of the modules, and the installation requirements of 690.46/250.120(C), it would simplify PV installations if the use of solid conductors of 6 AWG in raceways were allowed. This would address not only issues of water migration into stranded grounding conductors and subsequent degradation of the conductor and/or connection, but would also allow electricians to more effectively deal with the concerns of inspectors who expect to see grounding conductors smaller than 6 AWG protected in a raceway. The allowance of 6 AWG solid conductors in raceways would allow an electrician to run an unspliced #6 (or smaller) solid conductor from the DC disconnect or combiner box to the array. This conductor could then be used to bond all of the mounting components and even connect to any auxiliary grounding electrodes installed at the location of the array without a splice.
Panel Meeting Action: Accept
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-310 Log #3029 NEC-P04 **Final Action: Reject**
(690.46(C) and 690.47(C))

Submitter: D. Jerry Flaherty, Electrical Inspection Service, Inc.
Recommendation: Revise text to read as follows:
690.47(C) ~~Combined Direct-Current Grounding Electrode Conductor and Alternating-Current Equipment Grounding Conductor. An unspliced, or irreversibly spliced, combined grounding conductor shall be run from the marked dc grounding electrode conductor connection point along with the ac circuit conductors to the grounding busbar in the associated ac equipment. This combined grounding conductor shall be the larger of the sizes specified by 250.122 or 250.166 and shall be installed in accordance with 250.65(E).~~
690.46(C) Common Direct-Current and Alternating Grounding Electrode Conductor and Taps. A common dc grounding electrode conductor and ac grounding electrode conductor shall be permitted to serve the PV system and associated ac system. The size of the common grounding conductor shall be the larger as specified by 250.66 or 250.166. The connection or tap shall be exothermic welding or with connectors listed for grounding and bonding in such a manner that the common grounding electrode conductor remains without a splice or joint.
Substantiation: If the "associated ac equipment" or the ac equipment downstream towards the ac system grounding electrode is serviced or removed the PV output circuit can become ungrounded.
There are no provisions requiring that the equipment grounding conductor(s) downstream from the "associated ac equipment" be sized per 250.166 or be unspliced or irreversibly spliced. This section does not meet the intent of a solidly ground as outlined in 690.47(A), 690.47(B), 250.4(A)(5), and 250.64(C). The grounding electrode "system" could also be disabled in the event of a fire.
Ex. Combined DC GEC and AC EGC is connected to a panel feed be EMT. During a fire the couplings on the EMT melt opening the equipment grounding path and leaving the energized PV source circuit ungrounded. The first responders are a great risk of high voltage electrical shock form not only the PV system but also from other conductive paths to ground.
If the PV system grounding electrode conductor is taped onto the ac service or separately derived system grounding electrode conductors the PV system will more than likely remain grounded during a fire. 250.64(D) addresses common grounding electrode conductor for services. The methods listed in 250(D)(1) are approved in Article 250.64 for services, Article 250.30(A)(7) for separately derived systems and, Article 250.160 for dc systems. The intent of 690.47 is to provide a solidly grounded system, just as required for services, separately derived systems and dc systems, why not use the same proven method as in 250.64(D) for photovoltaic.
Panel Meeting Action: Reject
Panel Statement: There is no technical substantiation to support the change. The proposal does not meet Section 4.3.3(d), Regulations Governing Committee Projects.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-310a Log #CP407 NEC-P04 **Final Action: Accept**
(690.47(B), 690.47(C)(3))

TCC Action: The Correlating Committee directs that the panel clarify the panel action on this proposal by adding the word "for" to the final phrase of the text appended to 690.47(B) as follows: "…and for the ground-fault detection reference for ungrounded PV systems".
The Correlating Committee also directs that the panel clarify the term "combined bonding grounding conductor" in the proposed revised text for 690.47(C)(3).
The Correlating Committee directs that this proposal be referred to Code-Making Panel 5 for comment.
This action will be considered as a public comment by Code-Making Panel 4.
Submitter: Code-Making Panel 4,
Recommendation: Change 690.47(B) and 690.47(C)(3) as follows:
Append a third paragraph to 690.47(B) to read as follows:
An ac equipment grounding system shall be permitted to be used for equipment grounding of inverters and other equipment, and the ground-fault detection reference for ungrounded PV systems.
Revise 690.47(C)(3) to read as follows:
690.47(C)(3) Combined Direct-Current Grounding Electrode Conductor PV

Bonding Jumper and Alternating-Current Equipment Grounding Conductor.

An unspliced, or irreversibly spliced, combined grounding bonding conductor shall be run from the marked dc grounding electrode conductor or PV bonding jumper connection point along with the ac circuit conductors to the grounding busbar located in the main service disconnect or the first disconnect of a separately derived system in the associated ac equipment. This combined grounding bonding conductor shall be the larger of the sizes specified by 250.122 based on the rating of the inverter output circuit overcurrent device or 250.168. or 250.166, and shall be installed in accordance with 250.64(E).

Substantiation: The new paragraph appended to 690.47(B) satisfies the concern of Proposal 4-311 through clearer language.

The change to 690.47(C)(3) is in response to the TCC Directed Task Group consisting of CMP-4 and CMP-5 members to discuss the conflict between 250.121 and 690.47(C)(3). The change in 690.47(C)(3) from the term "Grounding Electrode Conductor" to "PV Bonding Conductor" resolves the conflict with 250.121. The other changes reflect the change from a grounding electrode conductor to a bonding jumper.

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

4-311 Log #2208 NEC-P04 **Final Action: Reject**
(690.47(B))

Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum
Recommendation: Add a new third paragraph as follows:
Ungrounded DC PV arrays connected to utilization equipment with common ac and dc equipment-grounding terminals shall be permitted to have equipment-grounding requirements met by the ac equipment-grounding system without the requirement for a dc grounding electrode conductor or grounding system.
Substantiation: The first paragraph of 690.47(B), as currently written, applies to stand-alone ungrounded DC PV systems where a new grounding electrode and grounding electrode conductor are required. There is no requirement directly addressing the ungrounded PV array connected to a utility-interactive inverter as allowed by 690.35.

The great majority of ungrounded PV arrays will be connected to utility-interactive inverters and those inverters have common ac and dc equipment-grounding terminals. The PV array dc equipment-grounding conductors, when connected to such inverters, have the array dc equipment grounding conductors connected to earth through the ac equipment grounding system and the existing ac grounding system. Additional grounding electrodes and grounding electrode conductors are not required, but may be used.

Panel Meeting Action: Reject
Panel Statement: The proposed text could be misinterpreted to mean that a dc grounding system is not required. The reference to utilization equipment should also include conversion equipment.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-312 Log #3030 NEC-P04 **Final Action: Accept**
(690.47(C)(2))

TCC Action: The Correlating Committee directs that this proposal be clarified by adding "by a" before "connector listed for grounding and bonding" as an editorial correction.

This action will be considered a public comment.

Submitter: D. Jerry Flaherty, Electrical Inspection Service, Inc.
Recommendation: Revise text to read as follows:

690.47(C)(2) Common Direct-Current and Alternating-Current Grounding Electrode. A dc grounding electrode conductor of the size specified by 250.166 shall be run from the marked dc grounding electrode connection point to the ac grounding electrode. Where an ac grounding electrode is not accessible, the dc grounding electrode conductor shall be connected to the ac grounding electrode conductor in accordance with 250,64(C)(1), 250.64(C)(2) or connector listed for grounding and bonding. The dc grounding electrode conductor shall not be used as a substitute for any required ac equipment grounding conductor.

Substantiation: Large commercial and industrial facilities might already have a grounding bus bar. Connecting to this bus bar as outlined in 250.64(C)(2) will provide an effective ground-fault current path as required in 250.4(A)(5). Connector listed for grounding and bonding have been used effectively on ac systems to provide an effective ground-fault current path and meet all the requirements of 250.4, General Requirements for Grounding and Bonding.

When the ac and dc grounding electrode conductors are connected there is a common grounding electrode conductor. 250.64(D) addresses common grounding electrode conductor for services. The methods listed in 250(D)(1) are approved in Article 250.64 for services and Article 250.30(A)(7) for separately derived systems, Article 250.160 for dc systems and for photovoltaic as outlined in 690.47(B). Since 690.47(C)(2) is accomplishing the same thing, the methods in 250.64(D)(1) should apply to photovoltaic.

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

4-313 Log #1159 NEC-P04 **Final Action: Reject**
(690.47(D))

Submitter: James C. Willey, James C. Willey PE, PLLC
Recommendation: Revise 690.47(D) To read as per 2008 NEC as follows:
(D) Additional Electrodes for Array Grounding. Grounding electrodes shall be installed in accordance with 250.52 at the location of all ground- and pole-mounted photovoltaic arrays and as close as practicable to the location of roof-mounted photovoltaic arrays. The electrodes shall be connected directly to the array frame(s) or structure. The dc grounding electrode conductor shall be sized according to 250.166. Additional electrodes are not permitted to be used as a substitute for equipment bonding or equipment grounding conductor requirements.
The structure of a ground- or pole-mounted photovoltaic array shall be permitted to be considered a grounding electrode if it meets the requirements of 250.52. Roof mounted photovoltaic arrays shall be permitted to use the metal frame of a building or structure if the requirements of 250.52(A)(2) are met.
Exception No. 1: Array grounding electrode(s) shall not be required where the load served by the array is integral with the array.
Exception No. 2: Additional array grounding electrode(s) shall not be required if located within 6 ft of the premises wiring electrode.
Substantiation: During the 2011 code making process a proposal was submitted to delete this section (Proposal 4-238, Log #2509 NEC-P04). This proposal was rejected by the panel. During the rewrite of this Article, this paragraph was apparently left out and does not appear in the 2011 code.

This section needs to be in the code to make it clear that ground and pole mounted pv arrays require a grounding electrode system.

Panel Meeting Action: Reject
Panel Statement: There is no Section 690.47(D) to revise. There is no technical justification for the inclusion of this language.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-314 Log #1563 NEC-P04 **Final Action: Reject**
(690.47(D) (New))

Submitter: David Clements, International Association of Electrical Inspectors
Recommendation: Revise text to read as follows:
690.47 (D) To read as per 2008 NEC as follows:
(D) Additional Electrodes for Array Grounding. Grounding electrodes shall be installed in accordance with 250.52 at the location of all ground- and pole-mounted photovoltaic arrays and as close as practicable to the location of roof-mounted photovoltaic arrays. The electrodes shall be connected directly to the array frame(s) or structure. The dc grounding electrode conductor shall be sized according to 250.166. Additional electrodes are not permitted to be used as a substitute for equipment bonding or equipment grounding conductor requirements. The structure of a ground- or pole-mounted photovoltaic array shall be permitted to be considered a grounding electrode if it meets the requirements of 250.52. Roof mounted photovoltaic arrays shall be permitted to use the metal frame of a building or structure if the requirements of 250.52(A)(2) are met.
Exception No. 1: Array grounding electrode(s) shall not be required where the load served by the array is integral with the array.
Exception No. 2: Additional array grounding electrode(s) shall not be required if located within 6 ft of the premises wiring electrode.
Substantiation: During the 2011 code making process a proposal was submitted to delete this section, 4-238 log #2509 NEC-p04. This proposal was rejected by the panel. During the rewrite of this Article, this paragraph was apparently left out and does not appear in the 2011 code. This section needs to be in the code to make it clear that ground and pole mounted pv arrays require a grounding electrode system.

Panel Meeting Action: Reject
Panel Statement: There is no Section 690.47(D) to revise. There is no technical justification for the inclusion of this language.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 12 Negative: 1
Explanation of Negative:

ROGERS, J.: This proposal should have been accepted. The Panel never voted to remove this requirement in the last cycle the TCC interpreted a Panel statement as wanting to remove the requirement. There is no sound technical substantiation for removing this additional safety requirement. The large quantity of conductive material that is added to a roof when a PV system is installed increases the likelihood of a lightning strike, this electrode installation would help to minimize the effects of such a strike.

4-315 Log #3287 NEC-P04 **Final Action: Accept in Part**
(690.47(D) (New))

Submitter: James J. Rogers, Bay State Inspectional Agency
Recommendation: Add new text to read as follows:
690.47(D) Additional Electrodes for Array Grounding. Grounding electrodes shall be installed in accordance with 250.52 at the location of all ground- and pole-mounted photovoltaic arrays and as close as practicable to the location of roof-mounted photovoltaic arrays. The electrodes shall be connected directly to the array frame(s) or structure. The dc grounding electrode conductor shall be sized according to 250.166. Additional electrodes are not permitted to be used as a substitute for equipment bonding or equipment grounding conductor requirements.
Substantiation: Replace this part D into 690.47, the panel never intended to remove this requirement, the TCC interpreted a panel action in the ROC when the panel accepted a comment as agreeing with the submitter to remove this requirement, that is not what the panel intended and this basic safety requirement should be restored.
Panel Meeting Action: Accept in Part
Revise proposed text as follows:
690.47(D) Additional Electrodes for Array Grounding. Grounding electrodes shall be installed in accordance with 250.52 at the location of all ground- and pole-mounted photovoltaic arrays ~~and as close as practicable to the location of roof-mounted photovoltaic arrays.~~ The electrodes shall be connected directly to the array frame(s) or structure. The dc grounding electrode conductor shall be sized according to 250.166. Additional electrodes are not permitted to be used as a substitute for equipment bonding or equipment grounding conductor requirements.
Panel Statement: There is no technical requirement for an additional grounding electrode for a roof-mounted PV array.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 12 Negative: 1
Explanation of Negative:
STAFFORD, T.: Not including roof mounted arrays in this requirement does leave out a majority of PV arrays that are installed. The safety concern is the same no matter if a PV array is mounted on a roof-top or ground or pole mounted. The proposed wording may not have been practically enforceable but wording should include a reference to roof top mounted arrays. The panel statement referring to lack of technical substantiation into the roof top requirement also would apply to ground mounted or pole mounted arrays which the proposal as accepted would address. The submitter's concern that this requirement was removed inadvertently is not addressed.
Comment on Affirmative:
BOWER, W.: This provision should be limited to ground-mounted arrays since roof-mounted arrays are already on structures that require grounding.

4-316 Log #2209 NEC-P04 **Final Action: Reject**
(690.51)

Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum
Recommendation: 690.51 Modules. Delete in its entirety.
Substantiation: 690.4(D) requires that all PV modules be listed. The UL Standard 1703 establishes the requirements for marking and these requirements should not be in the NEC. The section should be deleted.
Panel Meeting Action: Reject
Panel Statement: Even if a product is listed, the only enforcement tool that an AHJ has is to utilize a requirement that is found in the NEC. Although 110.3(B) could be used that does not always suffice in the same fashion as a direct NEC requirement.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-317 Log #2210 NEC-P04 **Final Action: Reject**
(690.52)

Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum
Recommendation: 690.51. Modules. Delete in its entirety.
Substantiation: 690.4(D) requires that all PV modules be listed. The UL Standard 1703 establishes the requirements for marking and these requirements should not be in the NEC. Delete.
Panel Meeting Action: Reject
Panel Statement: Even if a product is listed the only enforcement tool that an AHJ has is to utilize a requirement that is found in the NEC. Although 110.3(B) could be used that does not always suffice in the same fashion as a direct NEC requirement.
The panel understands that the recommendation is addressed to 690.52.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-318 Log #114 NEC-P04 **Final Action: Accept**
(690.53(4))

Submitter: Brian Mehalic, Solar Energy International
Recommendation: Revise text to read as follows:
(4) Maximum circuit ~~Short circuit~~ current
Informational Note to (4): See 690.8(A) for calculation of maximum circuit current.
Substantiation: Section 690.53(4) requires a label stating the short-circuit current for the direct-current photovoltaic power source be installed at the photovoltaic disconnecting means. However, information supplied in the accompanying Informational Note refers to 690.8(A) for calculation of maximum circuit current. These two terms refer to different values. Short-circuit current is a manufacturer rating marked on all photovoltaic modules per 690.51(5). Maximum circuit current is a calculated value, which is defined by 690.8(A)(1) for PV source circuits as the sum of parallel module rated short-circuit currents times 125 percent, and by 690.8(A)(2) for PV output circuits as the sum of parallel source circuit maximum currents. While a calculated value, maximum current can be produced by a given photovoltaic power source due to increased irradiance and other environmental conditions, and is thus used for sizing overcurrent protection and conductors. The change to "Maximum circuit current" would harmonize the terminology and clarify the intention of the 690.53(4) requirement to label the photovoltaic disconnecting means with the value found via 690.8(A).
Panel Meeting Action: Accept
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-319 Log #2211 NEC-P04 **Final Action: Accept**
(690.53(4))

Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum
Recommendation: Revise 690.53(4) as shown and add the sentence.
690.53(4) Maximum circuit ~~Short-circuit~~ current
Where the PV power source has multiple outputs, items (1) and (4) shall be specified for each output.
Substantiation: The word "maximum circuit" is substituted for "short circuit" for correctness and clarity so that the specified current can now be calculated from the short-circuit current ratings on the backs of the modules connected to this circuit. The requirement is now consistent with the way the other items are determined and the Informational Note applies.
Many small and large inverters have multiple dc inputs. The required currents in items (1) and (4) should be listed per output of the PV power source. This label is used to allow the AHJ to make a quick determination if the correct conductor size was used for the output circuits.
Panel Meeting Action: Accept
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-320 Log #2644 NEC-P04 **Final Action: Accept**
(690.56(A) and (B))

Submitter: William F. Brooks, Brooks Engineering
Recommendation: Add text to read as follows:
(A) Facilities with Stand-Alone Systems. Any structure or building with a photovoltaic power system that is not connected to a utility service source and is a stand-alone system shall have a permanent plaque or directory installed on the exterior of the building or structure at a readily visible location acceptable to the authority having jurisdiction. The plaque or directory shall indicate the location of system disconnecting means and that the structure contains a stand-alone electrical power system. The marking shall be in accordance with 690.31(E).
(B) Facilities with Utility Services and PV Systems. Buildings or structures with both utility service and a photovoltaic system shall have a permanent plaque or directory providing the location of the service disconnecting means and the photovoltaic system disconnecting means if not located at the same location. The marking shall be in accordance with 690.31(E). For PV systems complying with 690.12, the plaque or directory shall include the wording:
MAXIMUM VOLTAGE AT ARRAY 80VDC AFTER SHUTDOWN
Substantiation: This proposal is to make the NEC consistent with the 2012 International Fire Code (IFC). It is the intent of the IFC to simply reference the NEC, as it already does, thus allowing the IFC to remove all language relating to PV electrical circuits and labeling of PV electrical circuits. The IFC requires that labels are reflective, all caps, 3/8" in high capital letters that are white on a red background. The reason for the red background is for high visibility for firefighters while fighting a fire. OSHA recommends the use of orange background for "Warning" signs and red for "Danger" signs, but these are labels rather than signs and are not required to match the OSHA guidelines.
Panel Meeting Action: Accept
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-321 Log #107 NEC-P04 **Final Action: Reject**
(690.64(B))

Submitter: Jim Stack, Chandler, AZ
Recommendation: I propose to correct the wording on code section 690.64 to add the note stating the main power into a power panel from the utility should be used as the ampacity of the bus bar. Since the PV added to the panel is day hours only and meant to replace the utility power during peek hours. It is not meant to add additional capacity for more loads. As long as the total PV ampacity does not exceed the total utility power, no bus bar change is required.
Substantiation: This section of Code was written to address a general condition where any panelboard busbar or conductor might be fed by multiple sources of power that are connected to the busbar or conductor through overcurrent devices. There are no restrictions in the code requirement as to the particulars of any specific installation. There are no restrictions as to where the multiple power sources might be connected on the busbar or conductor nor are there any limits on the number of overcurrent devices. There are no restrictions on the loads connected to the busbar or conductor either in terms of their connection point or their rating of the overcurrent device. When applying this requirement, no assumptions should be made as to the configuration of the circuit with respect to the location of taps and the number, magnitude and locations of any sources or loads.

This is the manner in which many Code requirements are formulated. The requirement is written in general terms and then the general requirement is modified by exceptions (restrictions or allowances) or additions to the requirement.

In at least five code cycles, various changes and modifications have been proposed to change the basic requirement and wording. CMP-13 has ruled that the *only* way to protect this general busbar or conductor, that has no restrictions, is that the busbar or conductor must have an ampacity equal to or greater than the sum of the ratings of all overcurrent devices supplying that busbar or conductor.

As the time progresses, we have seen various wiring configurations for that general, unrestricted, busbar or conductor that might allow exceptions to the basic requirements. These wiring configurations are discussed among inspectors, electricians, conductor and panel board manufacturers and, as they are vetted to be safe, proposals are made to change the *NEC*. These are in the form of exceptions or modifications to the basic requirements.

This process is not unique to 690.64(B)(2) and similar actions have been taken throughout the *NEC*.

With respect to 690.64(B)(2), it has long been recognized that if there are only two supply overcurrent devices and that they are opposite ends of the busbar or conductor, then even if unrestricted loads or load taps are added between the two supply overcurrent devices, there is nowhere on the conductor or busbar where the currents may exceed the rating of the largest overcurrent device.

A change was accepted in the *2008 NEC* that recognizes this fact and requires that in a panel board, if the two supply overcurrent devices are at opposite ends of the busbar, the sum of the ratings of the busbar may exceed the current rating of the busbar by 20%. The assumption is made that actual load on the panel will not exceed the panel rating in most residential and commercial locations.

Unfortunately, actual experience dictates that plug loads are essentially unrestricted and unmonitored and may result in loads higher than calculated by the installing electrician.

A related proposal is being drafted for the *2011 NEC* that would apply to end-fed conductors that have a restriction that they not be tapped for either loads or supplies.

The information in the following paragraph is technical in nature and may be subject to further investigation. It gives some indication that the Code may not be as conservative as many feel it is.

While this situation of connecting supply overcurrent devices at opposite ends may be safe for restricted conductors, it may not be suitable for busbars in panel boards, even though this allowance is in the 2008 NEC. Panel boards are subject to busbar current limitations and are also subject to thermal limitations due to the heating associated with the thermal trip elements in the common thermal/magnetic molded case circuit breakers. For example a 100-amp, 120/240V panel board is tested during the listing process with a 100 amp main breaker and two 100-amp load breakers (one per phase) mounted directly below the main breaker. The ambient temperature is raised to 45 degrees Celsius, the input and output currents are set at 100 amps, the temperature is allowed to stabilize, and the panel must pass this test with no deformation of any parts. If we add a backfed PV breaker pair, for example 50 amps, at the bottom of the panel, and if the loads on the panel were increased to 150 amps, no breakers would trip, no busbars would be over loaded, but the thermal load in the panel would be that associated with 300 amps, not the 200 amps the panel was designed and listed for. Panel manufacturers have stated that these panels cannot pass UL listing tests with those excessive thermal loads.

How likely is it that increased loads would occur at the same time as high daytime PV outputs? No one knows, but the possibility exists and some inspectors report warm/hot load centers (without PV input) that may be operating already close to the rating of the main breaker.

Exceptions were proposed to 690.64 (moving to 705.12(D)) to allow more flexible installations. These exceptions place restrictions or allowances on the general conditions of an unrestricted busbar or conductor. The restrictions keep the various installations safe.

For example, the 2005 NEC 690.64(B)(2) requirement says to add the ratings of all breakers supplying current to the panel. This would include the main plus all backfed PV breakers. Assume that it is desired to combine the outputs of two inverters in a dedicated PV ac combining panel with two 40A breakers. An 80A main breaker would be needed. The sum of all breakers would be 160 amps, necessitating a 200A panel to meet 690.64(B)(2). However, if an exception (restriction) were added that prevented any loads from being added to the panel, then the maximum current that the busbar would ever see would be limited to the sum of the PV breakers. The panel could then be rated at 80A or 100A—still safe, and less costly.

In summary, 690.64(B)(2) is written as an unrestricted requirement for sizing conductors and busbars. The conductor or busbar is protected for any combination of loads and/or multiple sources and locations of loads or sources connected to the busbar or conductor.

Unfortunately, the proposals for revisions of 690.64(B)/705.12(D) in the 2011 NEC were not accepted.

An AHJ may certainly look at a specific installation consisting of a specific set of supply breakers, loads, and locations of the same and evaluate the ampacity requirements of the conductors or busbar. If an alternate methods and materials (AMM) approval is issued to allow a deviation from the wording of the *NEC*, then the AMM approval might also include instructions to the installer to modify the installation in a way to minimize the possibility of future changes to the installation that might violate the exceptions (restrictions). For example, a "No Loads Allowed" placard might be required on an ac PV inverter combining panel when an AMM approval has allowed the rating of the panel as either the main breaker rating of the sum of the PV breakers, whichever is greater. Another example (proposed for the *2011 NEC but not accepted*) is to allow a conductor fed from supply breakers at each end, to have an ampacity of the greater breaker rating, not the sum of the breakers, when the conductor is marked, "Multiple Power Sources—Do Not Tap" every ten feet where the conductor is accessible.
Panel Meeting Action: Reject
Panel Statement: The proposal does not meet Section 4.3.3(c), Regulations Governing Committee Projects.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-322 Log #2212 NEC-P04 **Final Action: Reject**
(690.66)

Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum
Recommendation: Add the following new section to Art 690.
690.66 DC-To-DC Power Converters. DC-to-DC power converters connected to the output circuit of one or more PV modules shall be installed in full compliance with the requirements of the certification/listing, all labels, and the instruction manual.

The dc output of these devices shall not be required to meet the requirements of a dc PV module.
Substantiation: DC-to-DC converters being used in and developed for PV systems differ from manufacturer to manufacturer and each has significantly different input and output characteristics. There are far too many input and output variations and combinations as well as interactions with external equipment such as inverters and other devices to specifically address each device in the Code.

This requirement will re-enforce the 110.3(B) requirement that these listed, very complex and numerous devices be installed as labeled and by following the instructions provided with the product.

The last sentence is required to inform AHJs that the dc module output requirements are not applicable to these devices.
Panel Meeting Action: Reject
Panel Statement: Making reference to 110.3(B) requirements is not necessary. There is no technical substantiation to add the second paragraph.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-323 Log #61 NEC-P04 **Final Action: Accept in Principle**
(690.71 (New))

TCC Action: It was the action of the Correlating Committee that this proposal be reconsidered and correlated with the action on Proposal 4-375 as directed by the Correlating Committee.

This action will be considered a public comment.

NOTE: This Proposal appeared as Comment 4-106 (Log #2470) on Proposal 4-247 in the 2010 Annual Meeting National Electrical Code Committee Report on Proposals. This comment was held for further study during the processing of the 2011 NATIONAL ELECTRICAL CODE. The Recommendation in Proposal 4-247 was: Revise text to read as follows:

VIII. Storage Batteries

690.71 Installation.

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

photovoltaic power source is installed in accordance with 690.41. Batteries in PV power systems are usually grounded when the PV power system is grounded in accordance with Article 690, Part VI.
~~**(B) Dwellings.**~~
~~**(1) Operating Voltage. Storage batteries for dwellings shall have the cells connected so as to operate at less than 50 volts nominal. Lead-acid storage batteries for dwellings shall have no more than twenty-four 2-volt cells connected in series (48-volts nominal).**~~
~~**Exception: Where live parts are not accessible during routine battery maintenance, a battery system voltage in accordance with 690.7 shall be permitted.**~~
~~**(2) Guarding of Live Parts. Live parts of battery systems for dwellings shall be guarded to prevent accidental contact by persons or objects, regardless of voltage or battery type.**~~
~~**FPN: Batteries in solar photovoltaic systems are subject to extensive charge–discharge cycles and typically require frequent maintenance, such as checking electrolyte and cleaning connections.**~~
~~**At any voltage, a primary safety concern in battery systems is that a fault (e.g., a metal tool dropped onto a terminal) might cause a fire or an explosion. Guarded, as defined in Article 100, describes the best method to reduce this hazard.**~~
~~**(C) Current Limiting. A listed, current-limiting, overcurrent device shall be installed in each circuit adjacent to the batteries where the available short-circuit current from a battery or battery bank exceeds the interrupting or withstand ratings of other equipment in that circuit. The installation of current-limiting fuses shall comply with 690.16.**~~
~~**Large banks of storage batteries can deliver significant amounts of short-circuit current. Current-limiting overcurrent devices should be used if necessary.**~~
~~**(D) Battery Nonconductive Cases and Conductive Racks. Flooded, vented, lead-acid batteries with more than twenty-four 2-volt cells connected in series (48 volts, nominal) shall not use conductive cases or shall not be installed in conductive cases. Conductive racks used to support the nonconductive cases shall be permitted where no rack material is located within 150 mm (6 in.) of the tops of the nonconductive cases.**~~
~~**This requirement shall not apply to any type of valve-regulated lead-acid (VRLA) battery or any other types of sealed batteries that may require steel cases for proper operation.**~~
~~**Grounded metal trays and cases or containers (as normally required by 250.110) in flooded, lead-acid battery systems operating over 48 volts, nominal, have been shown to be a contributing factor in ground faults. Nonconductive racks, trays, and cases minimize this problem.**~~
~~**(E) Disconnection of Series Battery Circuits. Battery circuits subject to field servicing, where more than twenty-four 2-volt cells are connected in series (48 volts, nominal), shall have provisions to disconnect the series-connected strings into segments of 24 cells or less for maintenance by qualified persons. Non–load-break bolted or plug-in disconnects shall be permitted.**~~
~~**(F) Battery Maintenance Disconnecting Means. Battery installations, where there are more than twenty-four 2-volt cells connected in series (48 volts, nominal), shall have a disconnecting means, accessible only to qualified persons, that disconnects the grounded circuit conductor(s) in the battery electrical system for maintenance. This disconnecting means shall not disconnect the grounded circuit conductor(s) for the remainder of the photovoltaic electrical system. A non–load-break-rated switch shall be permitted to be used as the disconnecting means.**~~
(G) Battery Systems of More Than 48 Volts. On photovoltaic systems where the battery system consists of more than twenty-four 2-volt cells connected in series (more than 48 volts, nominal), the battery system shall be permitted to operate with ungrounded conductors, provided that the photovoltaic array source and output circuits comply with 690.41.
~~**(2) The dc and ac load circuits shall be solidly grounded.**~~
~~**(3) All main ungrounded battery input/output circuit conductors shall be provided with switched disconnects and overcurrent protection.**~~
~~**(4) A ground-fault detector and indicator shall be installed to monitor for ground faults in the battery bank.**~~

Insert into Article 480, Storage Batteries

480.xx Installation.
(A) Dwellings.
(1) Operating Voltage. Storage batteries for dwellings shall have the cells connected so as to operate at less than 50 volts nominal. Lead-acid storage batteries for dwellings shall have no more than twenty-four 2-volt cells connected in series (48-volts nominal).
Exception: Where live parts are not accessible during routine battery maintenance, a battery system voltage in accordance with 690.7 shall be permitted.
(2) Guarding of Live Parts. Live parts of battery systems for dwellings shall be guarded to prevent accidental contact by persons or objects, regardless of voltage or battery type.
FPN: Batteries in systems subject to extensive charge–discharge cycles typically require frequent maintenance, such as checking electrolyte and cleaning connections.
At any voltage, a primary safety concern in battery systems is that a fault (e.g., a metal tool dropped onto a terminal) might cause a fire or an explosion. Guarded, as defined in Article 100, describes the best method to reduce this hazard.
(B) Current Limiting. A listed, current-limiting, overcurrent device shall be installed in each circuit adjacent to the batteries where the available short-circuit current from a battery or battery bank exceeds the interrupting or withstand ratings of other equipment in that circuit. The installation of current-limiting fuses shall comply with 690.16.
Large banks of storage batteries can deliver significant amounts of short-circuit current. Current-limiting overcurrent devices should be used if necessary.
(C) Battery Nonconductive Cases and Conductive Racks. Flooded, vented, lead-acid batteries with more than twenty-four 2-volt cells connected in series (48 volts, nominal) shall not use conductive cases or shall not be installed in conductive cases. Conductive racks used to support the nonconductive cases shall be permitted where no rack material is located within 150 mm (6 in.) of the tops of the nonconductive cases.
This requirement shall not apply to any type of valve-regulated lead-acid (VRLA) battery or any other types of sealed batteries that may require steel cases for proper operation.
Grounded metal trays and cases or containers (as normally required by 250.110) in flooded, lead-acid battery systems operating over 48 volts, nominal, have been shown to be a contributing factor in ground faults. Nonconductive racks, trays, and cases minimize this problem.
(D) Disconnection of Series Battery Circuits. Battery circuits subject to field servicing, where more than twenty-four 2-volt cells are connected in series (48 volts, nominal), shall have provisions to disconnect the series-connected strings into segments of 24 cells or less for maintenance by qualified persons. Non–load-break bolted or plug-in disconnects shall be permitted.
(E) Battery Maintenance Disconnecting Means. Battery installations, where there are more than twenty-four 2-volt cells connected in series (48 volts, nominal), shall have a disconnecting means, accessible only to qualified persons, that disconnects the grounded circuit conductor(s) in the battery electrical system for maintenance. This disconnecting means shall not disconnect the grounded circuit conductor(s) for the remainder of the electrical system. A non–load-break-rated switch shall be permitted to be used as the disconnecting means.
(F) Battery Systems of More Than 48 Volts. On systems where the battery system consists of more than twenty-four 2-volt cells connected in series (more than 48 volts, nominal), the battery system shall be permitted to operate with ungrounded conductors, provided the following conditions are met:
(1) The dc and ac load circuits shall be solidly grounded.
(2) All main ungrounded battery input/output circuit conductors shall be provided with switched disconnects and overcurrent protection.
(3) A ground-fault detector and indicator shall be installed to monitor for ground faults in the battery bank.

Submitter: Robert H. Wills, Intergrid, LLC / Rep. American Wind Energy Association

Recommendation: Move common language on Storage Batteries (Section VIII) in Articles 690, 692 & 694 to a new common Article 69X.

Rename this article "Energy Storage Systems":

Article 69X – Energy Storage Systems

70X.1 Scope. The provisions of this article apply to energy storage systems such as batteries, ultra-capacitors, flywheels, etc. Energy storage systems can be ac or dc devices, and can include inverters and converters to transform from one form to the other.

70X.3 Other Articles. Whenever the requirements of other articles of this *Code* and Article 69X differ, the requirements of Article 69X shall apply.

690.11 Installation.

(A) General. Storage batteries in an energy storage system shall be installed in accordance with the provisions of Article 480. For photovoltaic power sources, the storage system shall be considered to be grounded when the connected power source is installed in accordance with 690.41.

(B) Dwellings.

(1) Operating Voltage. Energy storage systems for dwellings shall be configured so as to operate at less than 50 volts nominal. Lead-acid storage batteries for dwellings shall have no more than twenty-four 2-volt cells connected in series (48-volts nominal).

Exception: Where live parts are not accessible during routine battery maintenance, an energy storage system voltage in accordance with the maximum permitted for the connected energy source shall be permitted.

(2) Guarding of Live Parts. Live parts of energy storage systems for dwellings shall be guarded to prevent accidental contact by persons or objects, regardless of voltage or type.

Informational Note: Batteries in energy storage systems are subject to extensive charge–discharge cycles and typically require frequent maintenance, such as checking electrolyte and cleaning connections.

(C) Current Limiting. A listed, current-limiting, overcurrent device shall be installed in each circuit adjacent to the energy storage system where the available short-circuit current from a source exceeds the interrupting or withstand ratings of other equipment in that circuit. The installation of current-limiting fuses shall comply with 69x.20.

(D) Battery Nonconductive Cases and Conductive Racks. Flooded, vented, lead-acid batteries with more than twenty-four 2-volt cells connected in series (48 volts, nominal) shall not use conductive cases or shall not be installed in

conductive cases. Conductive racks used to support the nonconductive cases shall be permitted where no rack material is located within 150 mm (6 in.) of the tops of the nonconductive cases. This requirement shall not apply to any type of valve regulated lead-acid (VRLA) battery or any other types of sealed batteries that may require steel cases for proper operation.

(E) Disconnection of Series Battery Circuits. Battery circuits subject to field servicing, where more than twenty four 2-volt cells are connected in series (48 volts, nominal), shall have provisions to disconnect the series-connected strings into segments of 24 cells or less for maintenance by qualified persons. Non–load-break bolted or plug-in disconnects shall be permitted.

(F) Battery Maintenance Disconnecting Means. Battery installations, where there are more than twenty-four 2-volt cells connected in series (48 volts, nominal), shall have a disconnecting means, accessible only to qualified persons, that disconnects the grounded circuit conductor(s) in the battery electrical system for maintenance. This disconnecting means shall not disconnect the grounded circuit conductor(s) for the remainder of the photovoltaic electrical system. A non–load-break-rated switch shall be permitted to be used as the disconnecting means.

(G) Battery Systems of More Than 48 Volts. On energy storage systems where the battery system consists of more than twenty-four 2-volt cells connected in series (more than 48 volts, nominal), the battery system shall be permitted to operate with ungrounded conductors, provided the following conditions are met:

~~(1) The photovoltaic array source and output circuits shall comply with 690.41.~~

(1) The dc and ac load circuits shall be solidly grounded.

(2) All main ungrounded energy storage system input/output circuit conductors shall be provided with switched disconnects and overcurrent protection.

(3) A ground-fault detector and indicator shall be installed to monitor for ground faults in the system.

69X.20 Fuses. Means shall be provided to disconnect a fuse from all sources of supply if the fuse is energized from both directions and is accessible to other than qualified persons. Switches, pullouts, or similar devices that are rated for the application shall be permitted to serve as a means to disconnect fuses from all sources of supply.

69X.30 Charge Control.

(A) General. Equipment shall be provided to control the charging process of the energy storage system. Charge control shall not be required where the design of the energy source is matched to the voltage rating and charge current requirements of the energy storage system. For battery systems, this requirement can be met if the maximum charging current multiplied by 1 hour is less than 3 percent of the rated battery capacity expressed in ampere-hours or as recommended by the battery manufacturer. All adjusting means for control of the charging process shall be accessible only to qualified persons.

Informational Note: Certain battery types such as valve regulated lead acid or nickel cadmium can experience thermal failure when overcharged.

(B) Diversion Charge Controller.

(1) Sole Means of Regulating Charging. An energy storage system employing a diversion charge controller as the sole means of regulating charging shall be equipped with a second independent means to prevent overcharging.

(2) Circuits with Direct-Current Diversion Charge Controller and Diversion Load. Circuits containing a dc diversion charge controller and a dc diversion load shall comply with the following:

(1) The current rating of the diversion load shall be less than or equal to the current rating of the diversion load charge controller. The voltage rating of the diversion load shall be greater than the maximum energy storage system voltage. The power rating of the diversion load shall be at least 150 percent of the power rating of the energy source.

(2) The conductor ampacity and the rating of the overcurrent device for this circuit shall be at least 150 percent of the maximum current rating of the diversion charge controller.

(3) Energy Storage Systems Using Utility-Interactive Inverters. Systems using utility-interactive inverters to control energy storage state-of-charge by diverting excess power into the utility system shall comply with (1) and (2):

(1) These systems shall not be required to comply with 69X.30(B)(2). ~~The charge regulation circuits used shall comply with the requirements of 690.8.~~ Energy system currents shall be considered to be continuous.

(2) These systems shall have a second, independent means of controlling the energy storage system charging process for use when the utility is not present or when the primary charge controller fails or is disabled.

(C) Buck/Boost dc Converters. When buck/boost charge controllers and other dc power converters that increase or decrease the output current or output voltage with respect to the input current or input voltage are installed, the following requirements must be met:

(1) The ampacity of the conductors in output circuits shall be based on the maximum rated continuous, output current of the charge controller or converter for the selected output voltage range.

(2) The voltage rating of the output circuits shall be based on the maximum voltage output of the charge controller or converter for the selected output voltage range.

690.74 Battery Interconnections. Flexible cables, as identified in Article 400, in sizes 2/0 AWG and larger shall be permitted within the battery enclosure from battery terminals to a nearby junction box where they shall be connected to an approved wiring method. Flexible battery cables shall also be permitted between batteries and cells within the battery enclosure. Such cables shall be listed for hard-service use and identified as moisture resistant. Flexible, fine-stranded cables shall only be used with terminals, lugs, devices, and connectors that are listed and marked for such use.

Substantiation: The same language for stand-alone systems is included in the three renewable energy Articles (690, 692 and 694).

It makes sense to eliminate redundancy and to move it to a general Article so that common language can serve all three.

In this code cycle, we are already seeing significant divergence in the requirements for energy storage systems for PV, fuel cells and wind as it is difficult to coordinate the proposals for all of the technologies.

It is possible to write a generic Article that addresses the issues raised in the existing Articles.

Further, energy storage in renewable energy systems has gone beyond storage batteries. Ultracaps are commonly used for example.

By creating a new Article in Chapter 6 titled “Energy Storage Systems”, we have a place to address emerging technologies such as home energy storage, ultra-capacitors, bi-directional electric vehicle charging (V2G) etc.

The language above is based on that of Article 690.71-74, but with the specific references to changed to the generic term “energy storage system”. The language was also changed to make it compliant with the NEC Style Manual.

This proposal was originally rejected for not being presented as a complete article. I trust that this revision meets the panel’s requirements.

Panel Meeting Action: Accept in Principle

Panel Statement: See panel action on Proposal 4-375 which addresses the submitter’s concerns.

Number Eligible to Vote: 13

Ballot Results: Affirmative: 13

4-324 Log #2921 NEC-P04 **Final Action: Accept**

(690.71)

TCC Action: It was the action of the Correlating Committee that this proposal be reconsidered and correlated with the action on Proposal 13-33.

This action will be considered as a public comment.

Submitter: Robert H. Wills, Intergrid, LLC

Recommendation: Revise text to read as follows:

VIII. Storage Batteries

690.71 Installation

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

(B) Dwellings.

(1) Operating Voltage. Storage batteries for dwellings shall have the cells connected so as to operate at less than ~~50 volts nominal~~ 60 volts. ~~Lead-acid storage batteries for dwellings shall have no more than twenty-four 2-volt cells connected in series (48-volts nominal).~~

Substantiation: This proposal was developed by a subgroup of the NEC DC Task Force of the Technical Correlating Committee. The Task Force is chaired by John R. Kovacik, Underwriters Laboratories. The subgroup members are Robert Wills, Intergrid, LLC - subgroup lead), Audie Spina (Armstrong Industries) and David Geary (Starline DC Solutions).

In other places in the *Code,* (including Art 480 revisions) the limit of 60V is becoming standard. Lead acid batteries are no longer the only type being used. The change makes the second sentence in 690.71(B)(1) unnecessary.

Panel Meeting Action: Accept

Number Eligible to Vote: 13

Ballot Results: Affirmative: 13

4-325 Log #2213 NEC-P04 **Final Action: Accept**

(690.71(H) (New))

Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum

Recommendation: Add the following section H to 690.71

(H) Disconnects and Overcurrent Protection. Where energy storage device input and output terminals are more than 1.5 meters (5 feet) from connected equipment, or where the circuits from these terminals pass through a wall or partition the installation shall comply with (1) through (4):

(1) A disconnecting means and overcurrent protection shall be provided at the energy storage device end of the circuit. Fused disconnecting means or circuit breakers are acceptable.

(2) Where fused disconnecting means are used, the “Line” terminals of the disconnecting means shall be connected toward the energy storage device terminals.

(3) Overcurrent devices or disconnecting means shall not be installed in energy storage device enclosures where explosive atmospheres can exist.

(4) A second disconnecting means located at the connected equipment shall be installed where the disconnecting means required by (1) is not within sight of the connected equipment.

(5) Where the energy storage device disconnecting means is not within sight of the PV system ac and dc disconnecting means, placards or directories shall be installed at the locations of all disconnecting means indicating the location of all disconnecting means.

Substantiation: Batteries and other energy storage devices represent significant sources of short-circuit current (10,000 amps or more), and circuits connected to these sources must be protected with overcurrent devices. Circuits are bidirectional and confusion exists as to where the disconnects and overcurrent protection are required since there are two supply sources. Operating voltages for residential systems are under development that operate above 300 volts dc. A switched disconnecting means is required to allow rapid disconnection of the batteries from the circuit under connected equipment failure and during maintenance. It is difficult to install this equipment when the cable lengths are shorter than about five feet, and this is the distance that Underwriters Laboratories (UL) generally allows for unprotected cable lengths when testing PV power centers. Any penetration of a wall or partition necessitates the installation of a disconnecting means and overcurrent protection at the battery end of the circuit to protect the circuit as it passes through the wall and to allow the battery to be disconnected at the source. Overcurrent protection is generally required at the battery or energy storage device end of the circuit since this is the source of the highest continuous currents and the source of the highest fault currents in the circuit. Where a wall is involved, disconnects are required at each end of the circuit.
Panel Meeting Action: Accept
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13
Comment on Affirmative:
STAFFORD, T.: While this panel member agrees with the submitter's intent to clarify disconnecting means in and around energy storage devices, subpart (5) does not clearly indicate which disconnects are to be marked with the additional plaque or directory. " …all disconnecting means indicating the location of all disconnecting means.", is confusing and ambitious.

4-326 Log #2214 NEC-P04 **Final Action: Accept**
(690.74(A))

Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum
Recommendation: Correct the reference in the second paragraph of 690.74(A) as noted below.
Flexible, fine-stranded cables shall be terminated only with terminals, lugs, devices, and connectors in accordance with 110.14~~(A)~~.
Substantiation: The reference to 110.14(A) is incorrect and the correct reference is 110.14.
Panel Meeting Action: Accept
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

4-327 Log #1007 NEC-P04 **Final Action: Accept in Principle**
(690.80)

Submitter: James T. Dollard, Jr., IBEW Local 98
Recommendation: Replace 600V with 1000V.
Substantiation: This proposal is the work of the "High Voltage Task Group" appointed by the Technical Correlating Committee. The task group consisted of the following members: Alan Peterson, Paul Barnhart, Lanny Floyd, Alan Manche, Donny Cook, Vince Saporita, Roger McDaniel, Stan Folz, Eddie Guidry, Tom Adams, Jim Rogers and Jim Dollard.
The Task Group identified the demand for increasing voltage levels used in wind generation and photovoltaic systems as an area for consideration to enhance existing NEC requirements to address these new common voltage levels. The task group recognized that general requirements in Chapters 1 through 4 need to be modified before identifying and generating proposals to articles such as 690 specific for PV systems. These systems have moved above 600V and are reaching 1000V due to standard configurations and increases in efficiency and performance. The committee reviewed Chapters 1 through 8 and identified areas where the task group agreed that the increase in voltage was of minimal or no impact to the system installation. Additionally, there were requirements that would have had a serious impact and the task group chose not to submit a proposal for changing the voltage. See table (supporting material) that summarizes all sections considered by the TG.
Note: Supporting material is available for review at NFPA Headquarters.
Panel Meeting Action: Accept in Principle
Replace the number "600" with the number "1000" in two places within 690.80.
Panel Statement: The panel clarified the specific location(s) for the proposed change(s).
Number Eligible to Vote: 13
Ballot Results: Affirmative: 11 Negative: 2
Explanation of Negative:
MCDANIEL, R.: It is recognized that increasing voltage from 600 to 1,000 Volts may be applicable to specific installations. However, adequate technical substantiation has not been provided to support the change in this Article.
STAFFORD, T.: It is recognized that the distributed generation sources covered by the NEC such as wind and photovoltaics are demanding increased voltage levels to improve performance and efficiency, but this panel member feels that extensive training and equipment research is needed before implementing a "new" voltage threshold to which electricians may be exposed.
Meters and other testing equipment need to be evaluated and tested for 1000 volts as compared to some existing 600 volt limitations. Proper PPE also needs to be evaluated and determined for increased level of arc /blast hazards that may occur. Conductor insulation(s), equipment and terminal spacing, termination points, overcurrent protection devices, work space clearances, etc.- all will be affected by proposed change. Increasing existing voltage levels to 1000 volts from 600 volts immediately renders existing equipment today that is rated for 600 volts unsafe. There is a concern of this panel member as to what is going to be available to present clarity in the proper selection of meters and tools to identify 1000 volt use as compared to 600 volts. Concern is also raised as to making sure specification's for all equipment also meets new voltage levels, even existing equipment being supplied today. This panel member does not believe that all equipment, tools, meters, etc. will immediately become available for use by the electrician upon the issue of the 2014 NEC. The electrical worker is the one exposed to such hazards immediately upon issue of 2014 NEC if this proposal is accepted.
The task group submitted in their substantiation that, "minimal or no impact to the system installation" would be a result of increasing the voltage level to 100 volts. This panel member agrees with that statement but the impact upon the worker in the specific industries will be affected. Time for implementation of the new voltage levels needs to be outlined and detailed as to when such a voltage increase may be placed into the NEC. Proper timing and opportunities for training, and new equipment needs to be provided before allowing a voltage increase to be implemented.
This panel member is in favor of increasing the voltage level to 1000 volts as outlined in this proposal and companion proposals outlining the same change- But, this panel member cannot support the industry changing voltage level increase without sufficient reporting upon the effects of such a change will have upon the electrical worker. Perhaps a timeline for implementation is also needed to prepare workers for the change rather than allowing such a change to occur upon issue of the 2014 NEC.

4-328 Log #1040 NEC-P04 **Final Action: Accept in Principle**
(690, Part IX - Title)

Submitter: James T. Dollard, Jr., IBEW Local Union 98
Recommendation: Replace 600V with 1000V.
Substantiation: This proposal is the work of the "High Voltage Task Group" appointed by the Technical Correlating Committee. The task group consisted of the following members: Alan Peterson, Paul Barnhart, Lanny Floyd, Alan Manche, Donny Cook, Vince Saporita, Roger McDaniel, Stan Folz, Eddie Guidry, Tom Adams, Jim Rogers and Jim Dollard.
The Task Group identified the demand for increasing voltage levels used in wind generation and photovoltaic systems as an area for consideration to enhance existing NEC requirements to address these new common voltage levels. The task group recognized that general requirements in Chapters 1 through 4 need to be modified before identifying and generating proposals to articles such as 690 specific for PV systems. These systems have moved above 600V and are reaching 1000V due to standard configurations and increases in efficiency and performance. The committee reviewed Chapters 1 through 8 and identified areas where the task group agreed that the increase in voltage was of minimal or no impact to the system installation. Additionally, there were requirements that would have had a serious impact and the task group chose not to submit a proposal for changing the voltage. See table (supporting material) that summarizes all sections considered by the TG.
Note: Supporting material is available for review at NFPA Headquarters.
Panel Meeting Action: Accept in Principle
Replace the number "600" with the number "1000" in the title of Article 690, Part IX.
Panel Statement: The panel clarified the specific location(s) for the proposed change(s).
Number Eligible to Vote: 13
Ballot Results: Affirmative: 11 Negative: 2
Explanation of Negative:
MCDANIEL, R.: It is recognized that increasing voltage from 600 to 1,000 Volts may be applicable to specific installations. However, adequate technical substantiation has not been provided to support the change in this Article.
STAFFORD, T.: It is recognized that the distributed generation sources covered by the NEC such as wind and photovoltaics are demanding increased voltage levels to improve performance and efficiency, but this panel member feels that extensive training and equipment research is needed before implementing a "new" voltage threshold to which electricians may be exposed.
Meters and other testing equipment need to be evaluated and tested for 1000 volts as compared to some existing 600 volt limitations. Proper PPE also needs to be evaluated and determined for increased level of arc /blast hazards that may occur. Conductor insulation(s), equipment and terminal spacing, termination points, overcurrent protection devices, work space clearances, etc.- all will be affected by proposed change. Increasing existing voltage levels to 1000 volts from 600 volts immediately renders existing equipment today that is rated for 600 volts unsafe. There is a concern of this panel member as to what is going to be available to present clarity in the proper selection of meters and tools to identify 1000 volt use as compared to 600 volts. Concern is also raised as to making sure specification's for all equipment also meets new voltage levels, even existing equipment being supplied today. This panel member does

not believe that all equipment, tools, meters, etc. will immediately become available for use by the electrician upon the issue of the 2014 NEC. The electrical worker is the one exposed to such hazards immediately upon issue of 2014 NEC if this proposal is accepted.

The task group submitted in their substantiation that, "minimal or no impact to the system installation" would be a result of increasing the voltage level to 100 volts. This panel member agrees with that statement but the impact upon the worker in the specific industries will be affected. Time for implementation of the new voltage levels needs to be outlined and detailed as to when such a voltage increase may be placed into the NEC. Proper timing and opportunities for training, and new equipment needs to be provided before allowing a voltage increase to be implemented.

This panel member is in favor of increasing the voltage level to 1000 volts as outlined in this proposal and companion proposals outlining the same change- But, this panel member cannot support the industry changing voltage level increase without sufficient reporting upon the effects of such a change will have upon the electrical worker. Perhaps a timeline for implementation is also needed to prepare workers for the change rather than allowing such a change to occur upon issue of the 2014 NEC.

4-329 Log #2215 NEC-P04 **Final Action: Reject**
(690.80)

Submitter: John C. Wiles, Southwest Technology Development Institute, New Mexico State University / Rep. PV Industry Forum
Recommendation: Revise as shown below and add the Informational Note:
690.80 General

Solar photovoltaic systems with a maximum system voltage over 600 volts but not exceeding 1000 volts dc shall comply with the requirements in Article 690 for systems operating at 600 volts or less where the following conditions are met:
(a) All modules, conductors, and equipment assemblies shall be listed and identified for use at the applicable voltage.
(b) Doors and other access points that would provide unqualified persons access to energized dc parts shall be locked.
Informational Note: These requirements will generally apply to the calculations of the maximum system voltage and the sizing and application of overcurrent devices to circuits and equipment.
Systems with a maximum system voltage over 1000 volts dc shall comply with all the applicable provisions of the preceding sections of this article, and shall comply with Article 490 and other requirements applicable to installations rated over 600 volts.

Substantiation: PV systems rated for 1000 volts dc are common worldwide and an increasing number are being installed in the U.S., categorized rightly or wrongly as "behind-the-fence" installations. Modules, inverters and other BOS equipment certified internationally are mostly being used in these installations. However, domestic manufacturers are beginning to list 1000 volt products to UL Standards 1741 and UL 1703. Additionally, significant efforts are being made in the U.S. to harmonize these standards with equivalent IEC standards, which define low voltage at 1000V.

Meanwhile, the NEC is a source of confusion and ambiguity in its treatment of 1000 volt dc PV systems. Reference to "Article 490 and other requirements applicable to installations rated over 600 volts" is well-intentioned but some of these requirements are clearly written in the context of equipment and switchgear operating at voltages much greater than 1000V and with fault currents far greater than available from PV systems. Overcurrent protection requirements for MV equipment is also overly relaxed relative to the requirements in 690 and should be avoided. Some requirements are well founded and are addressed in the conditions above.
Panel Meeting Action: Reject
Panel Statement: These issues have been covered in the general increase from 600 volts to 1000 volts throughout the article and no special provisions are required.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 12 Negative: 1
Explanation of Negative:

MCDANIEL, R.: The panel action should have been to Accept in Principle and Part. The panel agreed to change 600 Volts to 1,000 Volts, but did not accept the additional conditions in the proposal. The proposal adds requirements for systems operating between 600 and 1,000 Volts DC, which are not required because they are covered by the proposed general changes of voltage from 600 to 1,000 Volts.

4-330 Log #1340 NEC-P04 **Final Action: Reject**
(690.85)

Submitter: James F. Williams, Fairmont, WV
Recommendation: Delete the following text:
~~**Photovoltaic Circuits.** In dc photovoltaic source circuits and photovoltaic output circuits, the maximum system voltage.~~
Substantiation: The defined term is never referenced. The definition makes no sense.
Panel Meeting Action: Reject
Panel Statement: The titles of paragraph 2 and 3 of 690.85 are not definitions; they are conditions.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13
Comment on Affirmative:

STAFFORD, T.: This panel member agrees with the panel action taken on this proposal, but does agree with the submitter that the title of 690.85 does create confusion. Changing the title of 690.85 to "Voltage ratings of cables and equipment" might cause less confusion.

4-331 Log #2922 NEC-P04 **Final Action: Accept in Part**
(690.90 and 690.91 (New))

Submitter: Robert H. Wills, Intergrid, LLC
Recommendation: Add text to read as follows:

X. Electric Vehicle Charging
690.90 General
Solar photovoltaic systems used directly to charge electric vehicles shall comply with Article 625 in addition to the requirements of this article.
690.91 Charging Equipment
Electric vehicle couplers shall comply with 625.9. Personnel protection systems according to 625.22 and automatic de-energization of cables according to 625.19 are not required for photovoltaic systems with maximum system voltages of less than 80V dc.

Substantiation: This proposal was developed by a subgroup of the NEC DC Task Force of the Technical Correlating Committee. The Task Force is chaired by John R. Kovacik, Underwriters Laboratories. The subgroup members are Robert Wills, Intergrid, LLC - subgroup lead), Audie Spina (Armstrong Industries) and David Geary (Starline DC Solutions).
While most electric vehicles will be recharged with alternating current, it is likely some vehicles will be charged directly from solar systems.
The advantages of direct solar charging include:
Higher efficiency (no dc-ac inversion, and potentially a more efficient dc-dc charger)
Can operate without grid connection, minimizing wire runs in large parking areas
Hybrid systems will also likely evolve, consisting of ac-dc rectifiers with direct coupling of PV power to a dc charging bus. It is important that these EV charging systems have the same level of safety as ac-fed systems.
It is also important to define a dc voltage level below which personnel protection and automatic de-energization is not required. For ac, it is 120V and below. For dc, with a greater arc hazard, the 80V limit adopted by 690.11 (Arc Fault).
Panel Meeting Action: Accept in Part
1) Reject the term "solar photovoltaic" in all places
2) Revise proposed text to read as follows:
X. Electric Vehicle Charging
690.90 General
PV systems used directly to charge electric vehicles shall comply with Article 625 in addition to the requirements of this article.
690.91 Charging Equipment
Electric vehicle couplers shall comply with 625.9. Personnel protection systems according to 625.22 and automatic de-energization of cables according to 625.19 are not required for PV systems with maximum system voltages of less than 80V dc.
Panel Statement: The panel changed the proposed term "solar photovoltaic" to "PV" to correlate with similar actions taken other proposals for Article 690.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13

ARTICLE 692 — FUEL CELL SYSTEMS

4-332 Log #1266 NEC-P04 **Final Action: Reject**
(692.2. Fuel Cell)

Submitter: Marcelo M. Hirschler, GBH International
Recommendation: Revise text to read as follows:

Fuel Cell. An electrochemical system that consumes fuel to produce an electric current. ~~The main chemical reaction used in a fuel cell for producing electric power is not combustion. However, there may be sources of combustion used within the overall fuel cell system such as reformers/fuel processors.~~
Informational Note: The main chemical reaction used in a fuel cell for producing electric power is not combustion. However, there may be sources of combustion used within the overall fuel cell system such as reformers/fuel processors.

Substantiation: The NFPA Manual of Style requires definitions to be in single sentences. The information provided in the subsequent sentences is not really a part of the definition; it is further information that is best placed in an informational note.
Panel Meeting Action: Reject
Panel Statement: There is no requirement in the NEC Manual of Style that definitions be only one sentence.
Number Eligible to Vote: 13
Ballot Results: Affirmative: 13