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AGENDA

I. Call to Order
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III. Announcements
IV. Self-Introductions
V. Review and Approval of Agenda
VI. Approval of Minutes from Previous Meeting (April 16, 2019 - Teleconference)
VII. Discussion of Code Change Proposals to the Uniform Solar, Hydronics & Geothermal Code
VIII. Other Business
IX. Future Meetings
X. Adjournment
The following is the tentative order of discussion on which the proposed changes will be discussed at the Technical Committee Meeting. Proposed code changes that are grouped together are those that are both indented and separated by lines. Indented proposed code changes are those being discussed out of numerical order.

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Item #: 001

USHGC 2021  Section: 206.0

SUBMITTER: Mark Eatherton
Advanced Hydronics

RECOMMENDATION:
Delete text without substitution

206.0  -D-

Draindown. An active solar energy system in which the fluid in the solar collector is drained from the solar energy system under prescribed circumstances.

SUBSTANTIATION:
The term “draindown” should be removed as it is not referenced within this code. Draindown systems are the most problematic of all freeze protection systems and commonly experience frozen vacuum breakers, malfunctions with draindown valves, and lack of proper pipe drainage. For these reasons, draindown systems are seldomly installed and are not recommended. The removal of such language prevents the code from referencing material that is not current in the industry. It is also recommended that this term be removed from the Chapter 5 description on page vii of the Preface and from the Index on page 98.
Item #: 002

USHGC 2021  Section: 208.0

SUBMITTER: Christopher Jensen
UL LLC

RECOMMENDATION:
Add new text

208.0  -F-

**Field Evaluation Body (FEB).** An organization or part of an organization that performs field evaluations of electrical or other equipment. [NFPA 70:100]

**Field Labeled (as applied to evaluated products).** Equipment or materials to which has been attached a label, symbol, or other identifying mark of an FEB indicating the equipment or materials were evaluated and found to comply with requirements as described in an accompanying field evaluation report. [NFPA 70:100]

SUBSTANTIATION:
The term "field labeled" is used several times within Chapter 8. This term is currently not defined and without a definition may be misunderstood to imply permission to affix a listed label in the field. Since the sections containing the term field labeled are all extracted material from NFPA 70, and this term is defined in NFPA 70, the definition of field labeled needs to be extracted and placed within the USHGC to ensure proper use of this term. Additionally, the term "field evaluation body (FEB)" also needs to be extracted and placed within the USHGC as the acronym FEB is used within the definition of field labeled and may not be understood by the users of this code.
Item #: 003
USHGC 2021  Section: 302.1.2

SUBMITTER:  David Mann  
Self

RECOMMENDATION:
Revise text

302.0 Standards and Alternates.
302.1 Minimum Standards.  (remaining text unchanged)

302.1.2 Standards.  Standards listed or referred to in this chapter or other chapters cover materials that will conform to the requirements of this code, where used in accordance with the limitations imposed in this or other chapters thereof and their listing. Where a standard covers materials of various grades, weights, quality, or configurations, the portion of the listed standard that is applicable shall be used. Design and materials for special conditions or materials not provided for herein shall be permitted to be used by special permission of the Authority Having Jurisdiction after the Authority Having Jurisdiction has been satisfied as to their adequacy. A list of standards that appear in specific sections of this code are referenced in Table 901.1. Standards referenced in Table 901.1 shall be applied as indicated in the applicable referenced section. A list of additional approved standards, publications, practices and guides that are not referenced in specific sections of this code appear in Table 901.2. The documents indicated in Table 901.2 shall be permitted in accordance with Section 302.2.

SUBSTANTIATION:
Section 302.1.2 is being revised to allow the end user to use an applicable approved standard in Table 901.2 without the additional step of an alternate method and material. All standards in Table 901.2 have been vetted and have a place in the code. To prevent confusion in the field and to prevent contradictions within the USHGC, Section 302.1.2 must be revised as the standards in Table 901.2 can be used, where applicable, without additional approval in accordance with Section 302.2.
Item #: 004

USHGC 2021 Section: 304.1, 304.2.2

SUBMITTER: IAPMO Staff - Update Extracts
  NFPA 54 - Extract Update

RECOMMENDATION:
Revise text

304.0 Accessibility for Service.

304.1 General. All appliances shall be located with respect to building construction and other equipment so as to permit access to the appliance. Sufficient clearance shall be maintained to permit cleaning of heating surfaces; the replacement of filters, blowers, motors, burners, controls, and vent connections; the lubrication of moving parts where necessary; the adjustment and cleaning of burners and pilots; and the proper functioning of explosion vents, if provided. For attic installation, the passageway and servicing area adjacent to the appliance shall be floored. [NFPA 54:9.2.1]

Unless otherwise specified, not less than 30 inches (762 mm) in depth, width, and height of working space shall be provided. Exception: A platform shall not be required for unit heaters or room heaters.

304.2 Access to Appliances on Roofs. (remaining text unchanged)

304.2.2 Access Type. The inside means of access shall be a permanent or foldaway inside stairway or ladder, terminating in an enclosure, scuttle, or trap door. Such scuttles or trap doors shall be at least 22 inches by 24 inches (559 mm by 610 mm) in size, shall open easily and safely under all conditions, especially snow, and shall be constructed so as to permit access from the roof side unless deliberately locked on the inside.

At least 6 feet (1829 mm) of clearance shall be available between the access opening and the edge of the roof or similar hazard, or rigidly fixed rails or guards a minimum of 42 inches (1067 mm) in height shall be provided on the exposed side. Where parapets or other building structures are utilized in lieu of guards or rails, they shall be a minimum of 42 inches (1067 mm) in height. [NFPA 54:9.4.3.3]

SUBSTANTIATION:
The above section is being revised to correlate with NFPA 54-2018 (latest version) in accordance with Section 16.0 of the IAPMO Regulations Governing Consensus Development of the Uniform Solar, Hydronics & Geothermal and Swimming Pool, Spa & Hot Tub Codes (Extract Guidelines).
Item #: 005

USHGC 2021  Section: 308.1.1

SUBMITTER: Christopher Jensen
UL LLC

RECOMMENDATION:
Revise text

308.0 Condensate Wastes and Control.
308.1 Condensate Disposal. (remaining text unchanged)
308.1.1 Condensate Pumps. Where approved by the Authority Having Jurisdiction, condensate pumps shall be installed in accordance with the manufacturer’s installation instructions. Pump discharge shall rise vertically to a point where it is possible to connect to a gravity condensate drain and discharged to an approved disposal point. Each condensing unit shall be provided with a separate sump and interlocked with the equipment to prevent the equipment from operating during a failure. Separate pumps shall be permitted to connect to a single gravity indirect waste where equipped with check valves and approved by the Authority Having Jurisdiction. Motor operated condensate pumps rated 600 volts or less shall be listed and labeled in accordance with UL 778.

Note: UL 778 meets the requirements for a mandatory reference standard in accordance with Section 15.0 of IAPMO’s Regulations Governing Consensus Development of the Uniform Solar, Hydronics & Geothermal and Swimming Pool, Spa & Hot Tub Codes.

SUBSTANTIATION:
Section 308.1.1 is being revised to include provisions for motor operated condensate pumps by requiring such pumps to be listed and labeled in accordance with UL 778.

The addition of UL 778 is necessary as it covers component specifications, electrical and fire enclosures, internal wiring, parts in contact with potable water, mechanical assemblies, protection against corrosion, supply connections, performance, ratings, and markings for motor operated condensate pumps rated 600 volts or less.

Including UL 778 within this code provides consistency and clarity for AHJ’s, manufacturers, and testing labs as to an appropriate product standard. Adding UL 778 to Section 308.1.1 is consistent with a similar reference in Section 310.1 for circulators and pumps.

Additionally, UL has 21 manufacturers that currently have condensate pumps listed to UL 778.
Item #: 006

USHGC 2021  Section: 313.2

SUBMITTER: Lance MacNevin
Plastic Pipe Institute

RECOMMENDATION:
Add new text

313.0 Heat Exchangers.

313.2 Shutoff Valves. Shutoff valves shall be installed on the supply and return side of a heat exchanger.

Exception: Where a heat exchanger is an integral part of a boiler or is a part of a manufactured boiler and heat exchanger packaged unit, and is capable of being isolated from the hydronic system by supply and return valves.

SUBSTANTIATION:
Section 313.2 is being proposed to include provisions for shutoff valves to be installed with heat exchangers. Shutoff valves installed on both the supply and return side of heat exchangers ensures safe disconnect from any piping to allow for maintenance and repair when needed.

Heat exchangers that are integral with boilers as well as boiler heat exchanger packaged units are excluded from this provision as long as they may be isolated from the hydronic system by means of the supply and return valves.

The proposed language provides clarification for the end user and further enhances the code.
Item #: 007

USHGC 2021  Section: 401.3 - 401.5

SUBMITTER: Lance MacNevin
Plastic Pipe Institute

RECOMMENDATION:
Revise text

401.0 General.

401.3 Water Hammer Protection. The flow of the hydronic piping system shall be designed to prevent water hammer.

401.4 Terminal Units. Terminal units, valves, and flow control devices shall be installed in accordance with the manufacturer’s installation instructions.

410.4 Return-Water Low-Temperature Protection. (remaining text unchanged)

(renumber remaining sections)

SUBSTANTIATION:
Section 401.3 is being revised to clarify that the piping system installed must be designed to prevent water hammer from occurring. Controlling the flow of the hydronic piping is not the only method of preventing water hammer. Adjusting the length of the piping as well as installing water hammer arrestors and check valves are piping design methods that effectively prevent such occurrences. For these reasons, the provisional language has been amended.

A terminal unit is a component of the hydronic system that receives heat and provides it to a room or space. Hydronic systems are composed of an energy source (boiler, water heater, or chiller), in combination with pumps and piping that connect the energy source to terminal heat-transfer units. There are multiple types of terminal units that can be selected from in relation to the application and budget of the installer/user. For this reason, the terminal units must be installed in compliance with the manufacturer’s installation instructions, and all connecting valves and flow control devices must be compatible with the terminal units.

Section 410.4 has been relocated to Section 401.5 as this language is better suited under “General” provisions rather than provisions for “System Controls”.

Proposals

Item #: 008
USHGC 2021 Section: 402.2, Table 901.1

SUBMITTER: Lance MacNevin
Plastic Pipe Institute

RECOMMENDATION:
Add new text

402.0 Protection of Potable Water Supply.

402.2 Chemical Injection. Where systems include an additive, chemical injection or provisions for such injection, the potable water supply shall be protected by a reduced-pressure principle backflow prevention assembly listed or labeled in accordance with ASSE 1013. Such additive or chemical shall be compatible with system components.

Note: ASSE 1013 meets the requirements for a mandatory reference standard in accordance with Section 15.0 of IAPMO's Regulations Governing Consensus Development of the Uniform Solar, Hydronics & Geothermal and Swimming Pool, Spa & Hot Tub Codes.

SUBSTANTIATION:
The addition of Section 402.2 is needed for further provisions on protecting the potable water supply from additives and chemical injections. Backflow prevention assemblies are necessary as they prevent contaminants from being drawn up into the potable water system when there is a higher pressure on the contaminant side in relation to the potable water supply side.

ASSE 1013 is provided as it lists performance requirements for reduced pressure principle backflow preventers. The standard also provides material requirements, compliance and hydrostatic backpressure testing procedures, and installation guidelines. The standard requires that such assemblies be equipped with two independent acting check valves separated by an intermediate chamber that is hydraulically operated to vent to the atmosphere. Such requirements ensure that the pressure on the contaminant side does not exceed that of the potable water side. For these reasons, the addition of standard ASSE 1013 is appropriate and aids in protecting the potable water supply.

Additionally, chemical compatibility is a necessary requirement to prevent damage to system components and piping.
Item #: 009
USHGC 2021 Section: 205.0, 403.1

SUBMITTER: Mark Eatherton
Advanced Hydronics

RECOMMENDATION:
Revise text

403.0 Capacity of Heat Source.
403.1 Heat Source. The heat source shall be sized to the design load or the connected load, whichever is more.

205.0 — C —

**Connected Load.** The total amount of heat required by all heat-consuming end-uses served by a single heat source in a system.

SUBSTANTIATION:
Section 403.1 is being modified to include considerations for any connected loads when sizing a heat source to be incorporated into a hydronic system. In addition to the design space heating load, other loads such as domestic hot water, may also be present within a system. Properly sizing the heat source ensures that the system works efficiently. An undersized heat source will constantly run and cause increased wear on the unit, and an over-sized heat source unit will cycle on and off too often.

Such language is necessary as it provides clarification for proper sizing of heat sources needed for system efficiency.

A definition for the term “connected load” has been added for further clarification on the proposed language added to Section 401.3. Such addition is necessary to ensure that the sizing requirements of Section 401.3 can be properly met.

The "connected load" in this case refers to the combined heat requirements of all heat consuming components connected to a single heat source.
Item #: 010

USHGC 2021  Section: 403.2, Table 403.2

SUBMITTER: Lance MacNevin
Plastic Pipe Institute

RECOMMENDATION:
Revise text

403.0 Capacity of Heat Source.

403.2 Dual Purpose Water Heater. Water heaters utilized for combined space-and water-heating applications shall be listed and/or labeled in accordance with the standards referenced in Table 403.2, and shall be installed in accordance with the manufacturer’s installation instructions. The total heating capacity of a dual purpose water heater shall be based on the sum of the potable hot water requirements and the space heating design requirements corrected for hot water first-hour draw recovery.

<table>
<thead>
<tr>
<th>TYPE</th>
<th>STANDARDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas-Fired, 75 000 Btu/hr or less, Storage</td>
<td>CSA Z21.10.1</td>
</tr>
<tr>
<td>Gas-Fired, above 75 000 Btu/hr, Storage, Circulating and Instantaneous</td>
<td>CSA Z21.10.3</td>
</tr>
<tr>
<td>Electric, Space Heating</td>
<td>UL 834</td>
</tr>
<tr>
<td>Solid Fuel-Fired, Hydronic</td>
<td>UL 2523</td>
</tr>
</tbody>
</table>

For SI units: 1000 British thermal units per hour = 0.293kW

SUBSTANTIATION:
Section 403.2 is being revised to show “listed or labeled” to provide clarification that water heaters do not need to be both listed and labeled. Both listing and labeling are completed by nationally recognized laboratories that make periodic inspections, determine compliance with nationally recognized standards, and test equipment for specified use. The requirement for both would be redundant and unnecessary.

Table 403.2 is also being updated to incorporate correct titles and descriptions of the types of water heaters covered by the provided correlating standards.
Item #: 011

USHGC 2021  Section: 403.3

SUBMITTER: Mark Eatherton  
Advanced Hydronics

RECOMMENDATION:  
Revise text

403.0 Capacity of Heat Source.

403.3 Tankless Water Heater. Tankless water heaters used in a space-heating applications shall be rated by the manufacturer for space-heating applications, and the output performance shall be determined by the temperature rise and flow rate of water through the unit. The ratings shall be expressed by the water temperature rise at a given flow rate. Manufacturer's flow rates shall not be exceeded.

SUBSTANTIATION:  
The proposed language adds further clarification on tankless water heaters. Tankless water heaters must only be rated by the manufacturer for space heating applications when they are used to provide space heat.
Item #: 012

USHGC 2021  Section: 403.4

SUBMITTER: Mark Eatherton
Advanced Hydronics

RECOMMENDATION:
Add new text

403.0 Capacity of Heat Source.

403.4 System Temperature. Where a hydronic distribution system is designed for use with a geothermal water-to-water heat pump or an air-to-water heat pump, the distribution system supply water temperature shall not exceed 120°F (49°C).

Exception: Hydronic distribution systems which contain components that require the hydronic system to operate at higher temperatures.

SUBSTANTIATION:
The proposed section has been added to provide a maximum supply water temperature of 120°F. This maximum temperature is within the range of what nearly all hydronic heat pumps can achieve. Lower design temperatures enhance both the heating capacity and the coefficient of performance (COP) of heat pumps. Where an existing hydronic distribution system includes heat emitters designed to operate at higher temperatures, a 120°F operating temperature may not be adequate to operate the system.
Item #: 013
USHGC 2021 Section: 405.1

SUBMITTER: Mark Eatherton
Advanced Hydronics

RECOMMENDATION:
Revise text

405.0 Installation, Testing, and Inspection.
405.1 Operating Instructions. Operating and maintenance information shall be provided to the building owner, shall be kept in the mechanical room, and shall be water-proof.

SUBSTANTIATION:
The added language clarifies that the operation and maintenance documentation should be waterproof and should be kept in the vicinity of the equipment it addresses.
Item #: 014

USHGC 2021  Section: 405.2.1

SUBMITTER:  Mark Eatherton
Advanced Hydronics

RECOMMENDATION:
Add new text

405.0 Installation, Testing, and Inspection.

405.2 Pressure Testing. (remaining text unchanged)

405.2.1 Piping Used for Combustion Venting. Where polymer-based drain, waste and vent pipe is used to vent a combustion heat source, the completed assembly shall be pressure-tested at not less than 5 psi (34 kPa).

SUBSTANTIATION:
The addition of Section 405.2.1 is to include piping utilized for combustion venting. In order to prevent leakage of exhaust gasses into occupied spaces, the polymer-based DWV exhaust piping assembly must be pressure tested. The addition of this pressure test is for safety of the end user.
Item #: 015

USHGC 2021  Section: 405.4

SUBMITTER: Mark Eatherton  
Advanced Hydronics

RECOMMENDATION:
Revise text

405.0 Installation, Testing, and Inspection.

405.4 Oxygen Diffusion Corrosion. PEX and PE-RT tubing in closed hydronic systems shall contain an oxygen barrier.  
Exception: Closed hydronic systems without ferrous components in contact with the hydronic fluid.

SUBSTANTIATION:  
Some closed hydronic systems can have ferrous components; so PEX or PE-RT in these systems must have an oxygen barrier. Therefore, the exception should be removed.
Item #: 016

USHGC 2021  Section: 406.0 - 406.2

SUBMITTER: Lance MacNevin
Plastic Pipe Institute

RECOMMENDATION:
Add new text

406.0 Pressure and Safety Devices.
406.1 General. Each closed hydronic system shall be protected against pressures exceeding design limitations with not less than one pressure relief valve. Each closed section of the system containing a heat source shall have a relief valve located so that the heat source is not capable of being isolated from a relief device. Pressure relief valves shall be installed in accordance with their listing and the manufacturer’s installation instructions.
406.2 Discharge Piping. The discharge piping serving a temperature relief valve, pressure relief valve, or combination of both shall be in accordance with Section 311.3.

(subnumber remaining sections)

SUBSTANTIATION:
Any heated closed system is capable of developing pressures that exceed its design working pressure. Closed liquid-filled systems can develop high hydrostatic pressures with even slight temperature increases. A hydronic system is more likely to be subjected to extreme temperatures and pressures that could cause associated hazards. Pressure and temperature relief valves are necessary to prevent injury that could result from the failure of pressurized vessels and piping. Typical hydronic systems involve large complex piping circuits with valve arrangements that greatly increase the likelihood of portions of the piping system being isolated from the over-pressure or over-temperature safety devices. Any portion of a system isolated from the relief valve or valves is unprotected from the danger of excessive pressures and temperatures. To ensure complete protection to all portions of a system, multiple relief valves at different locations in the system are necessary.

A safety or relief valve discharge pipe is needed to direct the discharge to a location where it cannot cause injury or property damage. The material from which the discharge pipe is constructed must be able to withstand such pressures and temperatures, as well as be able to resist the forces developed during discharge that would tend to dislocate the discharge pipe. Section 311.3 (Discharge Piping) addresses discharge piping materials as well as further provisions on discharge piping and should be referenced within Section 406.2.
Item #: 017

USHGC 2021  Section: 406.2.2

SUBMITTER: Mark Eatherton
Advanced Hydronics

RECOMMENDATION:
Revise text

406.0 Heating Appliances and Equipment.

406.2 Boilers. (remaining text unchanged)

406.2.2 Noncondensing Boilers. Where the heat exchanger and venting system are not designed to operate with condensed flue gases, the boiler shall be permitted to connect directly to the panel heating system where protected from flue gas condensation. The operating temperature of the boiler shall be more than the fluid temperature in accordance with the manufacturer’s instructions. The minimum return-water temperature to the heat source shall comply with Section 410.4.

(Section 410.4 is shown for information only)

410.4 Return-Water Low-Temperature Protection. Where a minimum return-water temperature to the heat source is specified by the manufacturer, the heating system shall be designed and installed to meet or exceed the minimum return-water temperature during the normal operation of the heat source.

SUBSTANTIATION:
A reference to Section 410.4 (Return-Water Low-Temperature Protection) has been added to ensure that the heating system is installed and designed to at least meet the minimum return water temperature specified by the manufacturer.

This is necessary to prevent condensation of moisture in the flue gases since noncondensing boilers are constructed of materials like carbon steel, cast iron or copper, and these materials are unable to withstand the corrosive condensate produced. This corrosive condensate will chemically eat away at the boiler’s heat exchanger as well as the inside of the vent connector. For these reasons, the additional proposed language is needed.
Item #: 018

USHGC 2021 Section: 406.2, 406.3

SUBMITTER: Lance MacNevin
Plastic Pipe Institute

RECOMMENDATION:
Revise text

406.0 Heating Appliances and Equipment.

406.2 Boilers. Boilers and their control systems shall comply with the mechanical code.

406.3 Dual-Purpose Water Heaters. Water heaters used for combined space- and water-heating applications shall be in accordance with the standards referenced in Table 403.2, and shall be installed in accordance with the manufacturer’s installation instructions. Water used as the heat transfer fluid in the hydronic heating system shall be isolated from the potable water supply and distribution in accordance with Section 313.0, Section 314.0, and Section 402.2.402.0.

(Section 402.0 along with pertaining subsections are shown for information only)

402.0 Protection of Potable Water Supply.
402.1 Prohibited Sources. Hydronic systems or parts thereof, shall be constructed in such a manner that polluted, contaminated water, or substances shall not enter a portion of the potable water system either during normal use or where the system is subject to pressure that exceeds the operating pressure in the potable water system. Piping, components, and devices in contact with the potable water shall be approved for such use and where an additive is used it shall not affect the performance of the system.

402.2 Protection of Potable Water. The potable water system shall be protected from backflow in accordance with the Uniform Plumbing Code.

402.3 Compatibility. Fluids used in hydronic systems shall be compatible with all components that will contact the fluid. Where a heat exchanger is installed with a dual purpose water heater, such application shall comply with the requirements for a single wall heat exchanger in Section 313.1.

SUBSTANTIATION:
Currently the mechanical code lists provisions and standards for “boilers and their control systems”. In order to correlate with such language, Section 406.2 is being revised to show “control systems” rather than “controls” as this may be confusing for the end user. Since Section 406.2 requires compliance with the mechanical code, language between the codes should be consistent to ensure that all listed provisions are clear.
Item #: 019  
USHGC 2021  Section: 406.5, Table 901.1

SUBMITTER: Lance MacNevin  
Plastic Pipe Institute

RECOMMENDATION:  
Add new text

406.0 Heating Appliances and Equipment.

406.5 Heat Pumps. Water source heat pumps shall comply with AHRI/ASHRAE/ISO 13256-1 for water-to-air heat pumps and AHRI/ASHRAE/ISO 13256-2 for water-to-water heat pumps. Air source heat pumps shall comply with ANSI/AHRI 210/240. Heat pumps shall be fitted with a means to indicate that the compressor is locked out.

### TABLE 901.1
REFERRED STANDARDS

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTIONS</th>
</tr>
</thead>
</table>

(portions of table not shown remain unchanged)

Note: AHRI/ASHRAE/ISO 13256-1, AHRI/ASHRAE/ISO 13256-2, and AHRI 210/240 meet the requirements for mandatory referenced standards in accordance with Section 15.0 of IAPMO’s Regulations Governing Consensus Development of the Uniform Solar, Hydronics & Geothermal and Swimming Pool, Spa & Hot Tub Codes.

SUBSTANTIATION:  
Section 406.5 has been added to provide standards to address both water and air source heat pumps.

Both standards provide detailed test methods, performance requirements and marking provisions for water-source heat pumps. AHRI/ASHRAE/ISO 13256-1 specifically addresses water-to-water and brine-to-water heat pumps while AHRI/ASHRAE/ISO 13256-2 addresses water-to-air and brine-to-air heat pumps. AHRI/ASHRAE/ISO 13256-1 and AHRI/ASHRAE/ISO 13256-2 have been used in the industry since 1998 and have been reaffirmed two times without substantive changes to the requirements.

AHRI 210/240 covers air source heat pumps and their classifications, markings, as well as testing and rating requirements.

The inclusion of both water and air source heat pumps is applicable to Chapter 4 (Hydronics) as these heat pumps are used in hydronic space heating applications including radiant flooring and air heating.
Item #: 020

USHGC 2021  Section: 407.4

SUBMITTER: Mark Eatherton
Advanced Hydronics

RECOMMENDATION:
Delete text without substitution

407.0 Expansion Tanks.

407.4 Open-Type Expansion Tanks. Open-type expansion tanks shall be located not less than 3 feet (914 mm) above the highest point of the system. An overflow with a diameter of not less than one-half the size of the supply or not less than 1 inch (25 mm) in diameter shall be installed at the top of the tank. The overflow shall discharge through an air gap into the drainage system.

SUBSTANTIATION:
Open type expansion tanks are no longer installed in any new or retrofit applications. These types of tanks are not capable of reaching high operating temperatures like that of closed expansion tanks. Open tanks allow for air to migrate into the system resulting in corrosion of components. Additionally, open expansion tanks must be located above the highest heating element, in general on the top of buildings, where they may be exposed to freezing conditions.

For these reasons, open type expansion tanks and their listed provisions should be removed from the code.
Item #: 021

USHGC 2021  Section: 407.5

SUBMITTER: Lance MacNevin
Plastic Pipe Institute

RECOMMENDATION:
Add new text

407.0 Expansion Tanks.

407.5 Sizing. Expansion tanks shall be sized to accept the full expansion volume of the fluid in the system. The minimum capacity of a closed-type expansion tank shall be sized in accordance with Section 605.4.

SUBSTANTIATION:
The proposed language in Section 407.5 is necessary as it addresses sizing of expansion tanks to be installed in hydronic systems. Section 407.5 also includes a reference to Section 605.4 (Minimum Capacity of Closed-Type Tank) which provides an equation for determining the minimum volume required for closed-type expansion tanks.

Sizing of expansion tanks used in hydronic systems is necessary as the tanks are utilized to accept changes in the fluid volume and density in relation to temperature gradients, maintain positive gauge pressure, and prevent cavitation at control valves.
Item #: 022
USHGC 2021 Section: Table 408.1, Table 901.1

SUBMITTER: Adam Segura
Self

RECOMMENDATION:
Revise text

TABLE 408.1
MATERIALS FOR HYDRONICS AND SOLAR THERMAL SYSTEM, PIPING, TUBING, AND FITTINGS

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARDS</th>
<th>FITTINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross-Linked Polyethylene/Aluminum/ Cross-Linked Polyethylene (PEX-AL-PEX)</td>
<td>ASTM F1281, ASTM F2262, CSA B137.10</td>
<td>ASTM F1281, ASTM F1974, ASTM F2434, CSA B137.10</td>
</tr>
</tbody>
</table>

(portions of table not shown remain unchanged)

TABLE 901.1
REFERENCED STANDARDS

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM F1961-2009</td>
<td>Metal Mechanical Cold Flare Compression Fittings with Disc Spring for Crosslinked Polyethylene (PEX) Tubing (WITHDRAWN)</td>
<td>Fittings</td>
<td>Table 408.4</td>
</tr>
<tr>
<td>ASTM F2262-2009</td>
<td>Crosslinked Polyethylene/Aluminum/Crosslinked Polyethylene Tubing OD Controlled SDR9 (WITHDRAWN)</td>
<td>Piping, Plastic</td>
<td>Table 408.4</td>
</tr>
</tbody>
</table>

(portions of table not shown remain unchanged)

SUBSTANTIATION:
The proposed modification removes reference to ASTM F1961 and ASTM F2262 as the promulgator has withdrawn the standards.
**Item #: 023**

USHGCE 2021  Section: Table 408.1, Table 901.1, Table 901.2

**SUBMITTER:** Jeff Matson  
Viega LLC

**RECOMMENDATION:**  
Revise text

**TABLE 408.1**  
MATERIALS FOR HYDRONICS AND SOLAR THERMAL  
SYSTEM, PIPING, TUBING, AND FITTINGS

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>ASTM A53, ASTM A106, ASTM A254</td>
</tr>
<tr>
<td></td>
<td>ASME B16.5, ASME B16.9, ASME B16.11, ASTM A420, ASTM F3226, IAPMO PS 117</td>
</tr>
<tr>
<td>Polyethylene (PE)</td>
<td>ASTM D1693, ASTM D2513, ASTM D2683, ASTM D2737, ASTM D3035, ASTM D3350, ASTM F714, ASTM F2165, AWWA C901, CSA B137.1, NSF 358-1</td>
</tr>
<tr>
<td></td>
<td>ASTM D2609, ASTM D2683, ASTM D3261, ASTM F1055, ASTM F2165, ASTM F2165, CSA B137.1, NSF 358-1</td>
</tr>
<tr>
<td>Cross-Linked Polyethylene (PEX)</td>
<td>ASTM F876, ASTM F2165, CSA B137.5, NSF 358-3</td>
</tr>
<tr>
<td>Polypropylene (PP)</td>
<td>ASTM F2165, ASTM F2389, NSF 358-2</td>
</tr>
<tr>
<td></td>
<td>ASTM F2165, ASTM F2389, NSF 358-2</td>
</tr>
<tr>
<td>Raised Temperature Polyethylene (PE-RT)</td>
<td>ASTM F2165, ASTM F2623, ASTM F2769, CSA B137.18</td>
</tr>
<tr>
<td></td>
<td>ASSE 1061, ASTM F1807, ASTM F2159, ASTM F2165, ASTM F2735, ASTM F2769, CSA B137.18</td>
</tr>
<tr>
<td>Cross-Linked Polyethylene/Aluminum/Cross-Linked Polyethylene (PEX-AL-PEX)</td>
<td>ASTM F1281, ASTM F2165, ASTM F2262, CSA B137.10</td>
</tr>
<tr>
<td></td>
<td>ASTM F1281, ASTM F1974, ASTM F2165, ASTM F2434, CSA B137.10</td>
</tr>
<tr>
<td>Polyethylene/Aluminum/Polyethylene (PE-AL-PE)</td>
<td>ASTM F1282, ASTM F2165, CSA B137.9</td>
</tr>
<tr>
<td></td>
<td>ASTM F1282, ASTM F1974, ASTM F2165, CSA B137.9</td>
</tr>
</tbody>
</table>

* Only Type K, L, or M shall be permitted to be installed.

(portions of table not shown remain unchanged)
### TABLE 901.1
**REFERENCED STANDARDS**

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM F2165-2019</td>
<td>Flexible Pre-Insulated Plastic Piping</td>
<td>Fittings, Piping and Tubing</td>
<td>Table 408.1</td>
</tr>
<tr>
<td>ASTM F3226/F3226M-2016</td>
<td>Metallic Press-Connect Fittings for Piping and Tubing Systems</td>
<td>Fittings</td>
<td>Table 408.1</td>
</tr>
<tr>
<td>ASTM F3347-2019</td>
<td>Metal Press Insert Fittings with Factory Assembled Stainless Steel Press Sleeve for SDR9 Cross-linked Polyethylene (PEX) Tubing</td>
<td>Fittings</td>
<td>Table 408.1</td>
</tr>
<tr>
<td>ASTM F3348-2019</td>
<td>Plastic Press Insert Fittings with Factory Assembled Stainless Steel Press Sleeve for SDR9 Cross-linked Polyethylene (PEX) Tubing</td>
<td>Fittings</td>
<td>Table 408.1</td>
</tr>
<tr>
<td>IAPMO PS 117-2018</td>
<td>Press and Nail Connections</td>
<td>Fittings</td>
<td>Table 408.1</td>
</tr>
</tbody>
</table>

(portions of table not shown remain unchanged)

### TABLE 901.2
**STANDARDS, PUBLICATIONS, PRACTICES, AND GUIDES**

<table>
<thead>
<tr>
<th>DOCUMENT NUMBER</th>
<th>DOCUMENT TITLE</th>
<th>APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>IAPMO PS-117-2016</td>
<td>Press and Nail Connections</td>
<td>Fittings</td>
</tr>
</tbody>
</table>

(portions of table not shown remain unchanged)

**Note:** ASTM F2165, ASTM F3226, ASTM F3347, ASTM F3348 and IAPMO PS 117 meet the requirements for mandatory referenced standards in accordance with Section 15.0 of IAPMO’s Regulations Governing Consensus Development of the Uniform Solar, Hydronics & Geothermal and Swimming Pool, Spa & Hot Tub Codes.

**SUBSTANTIATION:**
The proposed standards are being added to further enhance Table 408.1 by providing applicable material standards for both piping and fittings to be used in hydronics and solar thermal systems.

ASTM F2165 is being added as it covers flexible, pre-insulated plastic piping systems used to convey hot and cold fluids. This includes piping systems supplied complete with plastic carrier pipe and thermal insulation. Both bonded and non-bonded insulation types are included within this standard. Carrier pipe materials covered include PEX, PE, PP, PE-RT, PEX-AL-PEX, and PE-AL-PE. The components covered are intended for both residential and commercial applications including potable water distribution systems, radiant heating and cooling systems, and hydronic distribution systems. This standard applies to both piping/tubing and fittings and should be added to both columns for PEX, PE, PP, PE-RT, PEX-AL-PEX, and PE-AL-PE.

ASTM F3226 is added to the “Fittings” column of both steel and copper/copper-alloy as it pertains to copper/copper alloy and steel press-connect fittings for use in piping and tubing systems with a maximum allowable working pressure of 300 psi. Fittings under this standard directly attach to the pipe/tubing and create a seal and restrained joint.

ASTM F3347 is added to the “Fittings” column for PEX as it covers copper alloy press insert fittings with factory assembled stainless steel press sleeves to be used with PEX tubing. Such fittings are intended for use in 100 psi systems with a maximum operating temperature of 180°F. Requirements for materials, workmanship, dimensions, and markings are also included within this standard. The components covered are intended for use in both residential and commercial applications including potable water distribution systems and under-floor heating/cooling systems.
ASTM F3348 covers plastic press insert fittings with factory assembled stainless steel press sleeves for use with PEX tubing. Such fittings are intended for use in 100 psi cold and hot water distribution systems with a maximum operating temperature of 180°F. The standard includes requirements for material, molded part properties, performance, workmanship, dimensions, and markings.

IAPMO PS 117 is added to the “Fittings” column for steel as it covers press and nail connections made with carbon steel fittings and Schedule 10 and 40 carbon steel pipe. The standard provides specifications for materials, physical characteristics, performance and markings.
Item #: 024

USHGC 2021 Section: 408.1, Table 408.1, Table 901.1, Table 902.2

SUBMITTER: Lance MacNevin
Plastic Pipe Institute

RECOMMENDATION:
Revise text

408.0 Materials.
408.1 Pipe, Tube, Tubing, and Fittings. (remaining text unchanged)

**TABLE 408.1**
MATERIALS FOR HYDRONICS AND SOLAR THERMAL SYSTEM, PIPING, TUBING, AND FITTINGS

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARDS</th>
<th>FITTINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stainless Steel</td>
<td>ASTM A269, ASTM A312, ASTM A554, ASTM A778</td>
<td>ASTM F1476, ASTM F1548, ASTM F3226, IAPMO PS 117</td>
</tr>
<tr>
<td>Polypropylene (PP)</td>
<td>ASTM F2389, CSA B137.11, NSF 358-2</td>
<td>ASTM F2389, CSA B137.11, NSF 358-2</td>
</tr>
<tr>
<td>Raised Temperature Polyethylene (PE-RT)</td>
<td>ASTM F2623, ASTM F2769, CSA B137.18</td>
<td>ASSE 1061, ASTM F1807, ASTM F2159, ASTM F2735, ASTM F2769, ASTM D3261, ASTM F1055, CSA B137.18</td>
</tr>
</tbody>
</table>

(portions of table not shown remain unchanged)
### TABLE 901.1 REFERENCED STANDARDS

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM A554-2016</td>
<td>Welded Stainless Steel Mechanical Tubing</td>
<td>Piping</td>
<td>Table 408.1</td>
</tr>
<tr>
<td>ASTM A778/A778M-2016</td>
<td>Welded, Unannealed Austenitic Stainless Steel Tubular Products</td>
<td>Piping</td>
<td>Table 408.1</td>
</tr>
<tr>
<td>ASTM F1476-2007 (R2013)</td>
<td>Performance of Gasketed Mechanical Couplings for Use in Piping Applications</td>
<td>Fittings</td>
<td>Table 408.1</td>
</tr>
<tr>
<td>ASTM F1548-2001 (R2018)</td>
<td>Performance of Fittings for Use with Gasketed Mechanical Couplings Used in Piping Applications</td>
<td>Fittings</td>
<td>Table 408.1</td>
</tr>
<tr>
<td>ASTM F3226/F3226M-2016e1</td>
<td>Metallic Press-Connect Fittings for Piping and Tubing Systems</td>
<td>Fittings</td>
<td>Table 408.1</td>
</tr>
<tr>
<td>ASTM F3253-2018</td>
<td>Crosslinked Polyethylene (PEX) Tubing with Oxygen Barrier for Hot- and Cold-Water Hydronic Distribution Systems</td>
<td>Piping, Fittings</td>
<td>Table 408.1</td>
</tr>
<tr>
<td>IAPMO PS 117-2018</td>
<td>Press and Nail Connections</td>
<td>Fittings</td>
<td>Table 408.1</td>
</tr>
</tbody>
</table>

(portions of table not shown remain unchanged)

### TABLE 901.2 STANDARDS, PUBLICATIONS, PRACTICES, AND GUIDES

<table>
<thead>
<tr>
<th>DOCUMENT NUMBER</th>
<th>DOCUMENT TITLE</th>
<th>APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>IAPMO PS-117-2016</td>
<td>Press and Nail Connections</td>
<td>Fittings</td>
</tr>
</tbody>
</table>

(portions of table not shown remain unchanged)

**Note:** ASSE 1061, CSA B137.11, IAPMO PS 117 and the ASTM standards meet the requirements for mandatory reference standards in accordance with Section 15.0 of IAPMO’s Regulations Governing Consensus Development of the Uniform Solar, Hydronics & Geothermal and Swimming Pool, Spa & Hot Tub Codes.

**SUBSTANTIATION:**

Table 408.1 is being revised to include further material standards for copper/copper alloy, stainless steel, PEX, PP, and PE-RT.

ASSE 1061 establishes minimum performance requirements for push-fit fittings and push-fit connections intended for use in hot and cold potable water distribution and hydronic heating systems in residential and commercial applications. ASSE 1061 is applicable for fittings used with PEX, copper, CPVC, and PE-RT tubing.

Stainless steel has been added due to its corrosion resistant properties, and applicable material standards have been added for piping, tubing and fittings. The listed ASTM standards for piping and tubing address corrosion resistance, chemical composition requirements, and sizing requirements. ASTM F1476 and ASTM F3226 establish performance requirements and qualification tests required for mechanical couplings and fittings while ASTM F1548 defines classification, materials, test requirements, inspection certification, marking and packaging of fittings for use with mechanical couplings.

IAPMO PS 117 has been added to the fittings column for both copper/copper alloy and stainless steel as this standard pertains to press and nail connect fittings for both materials. This standard specifies requirements for materials, physical characteristics, performance testing, and markings.

ASTM F1055 covers electrofusion PE fittings and their requirements for materials, workmanship and testing performance. This standard is also applicable to PE electrofusion fittings to PEX pipe or tubing.

ASTM F3253 is a PEX standard for tubing with an oxygen diffusion barrier, including requirements for appropriate fittings. While ASTM F3253 is very similar to ASTM F876 for tubing (same dimensions) and ASTM F877 for fittings (same fitting connection performance), it also includes performance requirements for the oxygen diffusion resistance of integrated EVOH (ethylene vinyl alcohol) barrier layers, which is not part of ASTM F876. This is an important feature for those hydronic systems which need an oxygen barrier on the PEX tubing.

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CSA B137.11 is the approved system standard for PP pressure pipe and fittings, which is analogous to ASTM F2389, currently listed in Table 408.1 for PP pipe and fittings. It is common to list the equivalent CSA pipe and fitting system standards with the analogous ASTM and other product standards. CSA B137.11 is currently missing from Table 408.1 and this change will improve the Table.

ASTM D3261 addresses butt heat fusion PE fittings for PE piping and tubing and includes requirements for materials, workmanship, dimensions, markings as well as sustained and burst pressures.
Item #: 025

USHGC 2021  Section: 408.4

SUBMITTER: Lance MacNevin
Plastic Pipe Institute

RECOMMENDATION:
Revise text

408.0 Materials.

408.4 Oxygen Diffusion Corrosion. PEX and PE-RT tubing in closed hydronic systems shall contain an oxygen barrier with an oxygen permeation rate not to exceed 4.59 E-04 grains per square feet per day (0.32 mg/m²/day) at 104 °F (40 °C).

Exception: Closed hydronic systems without ferrous components in contact with the hydronic fluid.

SUBSTANTIATION:
PEX and PE-RT tubing used for hydronic applications requires an oxygen barrier to prevent diffusion of oxygen molecules into the water through the piping walls. An oxygen barrier also prevents corrosion of any cast iron components or parts such as circulator pumps, fill valves and boiler heating elements. The barrier allows for PEX and PE-RT use in hot water hydronic heating applications such as radiator heating, fan coils, and radiant floor heating. The revision of this section is necessary as it provides a maximum limit for oxygen permeation through the tubing.
Item #: 026
USHGC 2021 Section: 409.3

SUBMITTER: Lance MacNevin
Plastic Pipe Institute

RECOMMENDATION:
Revise text

409.0 Joints and Connections.

409.3 CPVC/AL/CPVC Plastic Pipe and Joints. Joints between chlorinated polyvinyl chloride/aluminum/ chlorinated polyvinyl chloride (CPVC/AL/CPVC) pipe and fittings shall be installed in accordance with one of the following methods: (1) Mechanical joints shall include, but not be limited to, flanged, grooved and push-fit fittings. (2) Solvent cement joints for CPVC/AL/CPVC pipe and fittings shall be clean from dirt and moisture. Solvent cements in accordance with ASTM F493, requiring the use of a primer shall be orange in color. The primer shall be colored and be in accordance with ASTM F656. Listed solvent cement in accordance with ASTM F493 that does not require the use of primers, yellow in color, shall be permitted for pipe and fittings manufactured in accordance with ASTM D2846, 1/2 inch (15 mm) through 2 inches (50 mm) in diameter, 1/2 inch (15 mm) through 3 inches (80 mm) in diameter. Apply primer where required inside the fitting and to the depth of the fitting on pipe. Apply liberal coat of cement to the outside surface of pipe to depth of fitting and inside of fitting. Place pipe inside fitting to forcefully bottom the pipe in the socket and hold together until joint is set.

SUBSTANTIATION:
Section 409.3 is being revised to clarify that joints refer to piping “and” fittings and not just one or the other. The current language is confusing and should be changed.
Item #: 027

USHGC 2021   Section: 411.4

SUBMITTER: Lee H Stevens
LH Stevens Constructors LLC

RECOMMENDATION:
Revise text

411.0 Pressure and Flow Controls.

411.4 Automatic Makeup Fluid. Where an automatic makeup fluid supply fill device is used to maintain the fluid content of the heat-source unit, or any closed loop in the system, the makeup supply shall be located at the expansion tank connection or other approved location.

Where an automatic makeup water supply fill device for a closed loop system is supplied by a potable water supply, the fill system shall automatically shut off flow when the supplied makeup water volume exceeds the greater of 5 gallons (19 L) or five percent of the total system fluid volume. A manual reset shall be required.

Where an automatic makeup fluid fill device for a closed loop system is supplied by an isolated tank, the fluid capacity of the tank shall not exceed the greater of 5 gallons (19 L) or 5 percent of the total system fluid volume.

A pressure-reducing valve shall be installed on a makeup water feed line. The pressure of the feed line shall be set in accordance with the design of the system, and connections to potable water shall be in accordance with Section 402.0 to prevent contamination due to backflow.

SUBSTANTIATION:
Homeowner insurance property losses for water damage (2011-2015) are the second most frequent loss category, and second costliest per claim. Water damage from a leaking hydronic system can include mold damage, structural damage, and may render a building temporarily uninhabitable and or subject to freezing up with additional damage.

An automatic feed valve will maintain water pressure in a hydronic system, but will also continually supply a breached system at a potentially high rate of flow. Particularly if a breach occurs while a structure is unattended, the potential exists for the consequent water damage to far exceed the actual damage to the hydronic system.

As building codes and industry practices have evolved in recent decades, largely pushed by the mandates of energy codes, hydronic systems have become more susceptible to damage and leakage.

1. Setback thermostats, along with houses being left unattended, increase the risk of freeze-thaw damage.
2. Cast iron boilers have largely been replaced by high-efficiency units with low-mass stainless steel heat exchangers, which are much more subject to corrosion damage due to water quality issues.
3. High efficiency in-floor radiant heating systems inherently have a greater vulnerability to physical damage, such as fastener penetration, than traditional baseboard systems.

A code requirement to limit water release through an automatic feed valve would be a significant step towards addressing consequential damage. This proposal also specifically addresses the trade practice of use of a system feeder, in lieu of an automatic feed valve, for the purpose of limiting water release. A release volume limit as a percentage of total system volume has the intent to address and allow for the usual losses of larger volume systems.

Furthermore, the proposed language will correlate with the actions taken by the UMC Technical Committee for the 2021 code cycle. This submittal is to further the goal of having all related codes correlate in language and intent.
Item #: 028

USHGC 2021  Section: 411.4, 411.5

SUBMITTER: Lance MacNevin
Plastic Pipe Institute

RECOMMENDATION:
Revise text

411.0 Pressure and Flow Controls.

411.4 Automatic Makeup Fluid. Where an automatic makeup fluid supply fill device is used to maintain the fluid content of the heat-source unit, or any closed loop in the system, the makeup supply shall be located at the expansion tank connection or other approved location.
A pressure-reducing valve shall be installed on a makeup water-feed line. The pressure of the feed line shall be set in accordance with the design of the system, and connections to potable water shall be in accordance with Section 402.0 to prevent contamination due to backflow.

411.5 Differential Pressure Regulation. Provisions shall be made to bypass excessive zone flows in excess of design velocity in a multi-zone hydronic system where the closing of some or all of the two-way zone valves causes excess flow through the open zones or deadheading of a fixed-speed circulator or pump.

SUBSTANTIATION:
The proposed language revisions pertaining to "Pressure and Flow Controls" are similarly found in the mechanical code.

The revision to Section 411.5 is necessary for clarification on what an excessive flow would be considered. The proposed language makes clear that "excessive" refers to zone flows that are greater than the design velocity in a multi-zone hydronic system. Other revisions to Section 411.4 and Section 411.5 have been included to reflect similar provisions in the mechanical code.
Proposals

Item #: 029

USHGC 2021  Section: 411.8

SUBMITTER: Mark Eatherton
Advanced Hydronics

RECOMMENDATION:
Revise text

411.0 Pressure and Flow Controls.

411.8 Secondary Loops. Secondary loops that are isolated from the primary heat-distribution loop by a heat exchanger are closed-loop hydronic systems and shall have a pressure relief valve in accordance with Section 311.1, an expansion tank in accordance with Section 407.0, an automatic make-up system in accordance with Section 411.4, an air-removal device in accordance with Section 411.6, and an air-separation device in accordance with Section 411.7.

(Section 311.1 and Section 411.4 are shown for information only)

311.1 General. Solar thermal system components containing pressurized fluids shall be protected against pressures exceeding the design limitations with a pressure relief valve. Hydronic or geothermal system components containing pressurized fluids shall be protected against pressures and temperatures exceeding design limitations with a pressure and temperature relief valve. Each section of the system in which excessive pressures are capable of developing shall have a relief valve located so that a section is not capable of being isolated from a relief device. Pressure and temperature relief valves shall be installed in accordance with the terms of their listing and the manufacturer’s installation instructions.

411.4 Automatic Makeup Fluid. Where an automatic makeup fluid supply fill device is used to maintain the fluid content of the heat-source unit, or any closed loop in the system, the makeup supply shall be located at the expansion tank connection or other approved location.
A pressure-reducing valve shall be installed on a makeup water feed line. The pressure of the feed line shall be set in accordance with the design of the system, and connections to potable water shall be in accordance with Section 402.0 to prevent contamination due to backflow.

SUBSTANTIATION:
The proposed revision to Section 411.8 has been made to include requirements for pressure relief valves and provisions for automatic make-up systems to be used in secondary loops of hydronics systems as these components are necessary. Provisions are already listed under the referenced sections and do not need to be repeated.
Item #: 030

USHGC 2021  Section: 414.2, 414.5, 414.7

SUBMITTER: Lance MacNevin
Plastic Pipe Institute

RECOMMENDATION:
Revise text

414.0 Radiant Heating and Cooling.

414.2 Radiant Under-Floor Heating.  (remaining text unchanged)

414.5 Poured Floor Structural Concrete Slab Systems (Thermal Mass).  (remaining text unchanged)

414.7 Wall and Ceiling Panels.  Where piping is installed in the wall stud cavity or the ceiling joist cavity, the cavity shall be insulated with material having an R-value of not less than R-12 material.  The insulation shall be installed in such a manner as to prevent heating or cooling loss from being lost from the space intended to be controlled.  An air space of not less than 1 inch (25.4 mm) and not more than 3 inches (76 mm) shall be maintained between the insulation and the interior surface of the panel unless a conductive plate is installed.

SUBSTANTIATION:
The revisions of the titles for Section 414.2 and Section 414.5 are for clarification for the end user.  Thermal mass is a material's ability to absorb, store and release heat.  Concrete in this case acts as a heat sink in warm periods and as a heat source during cooling periods.  Applying a thermal mass material such as concrete is a suitable method to minimize the energy consumption of buildings or structures.  Therefore, the revision of the title is applicable and necessary.

Section 414.7 has been revised to remove the word "material" as it seems redundant in the sentence.
Item #: 031

USHGC 2021 Section: 414.5.3

SUBMITTER: Michael Cudahy
Plastic Pipe & Fittings Association (PPFA)

RECOMMENDATION:
Revise text

414.0 Radiant Heating and Cooling.

414.5 Poured Floor Structural Concrete Slab Systems. (remaining text unchanged)

414.5.3 Types of Tube Fasteners. Tubing that is embedded within concrete shall be fastened according to manufacturer's instructions. 

(1) Ties made of wire, typically fastened to anchors such as rebar or wire mesh;
(2) Plastic tube/cable ties, typically nylon, fastened to anchors such as rebar or wire mesh;
(3) Staples made of metal or plastic or combination thereof, without sharp edges that would harm tube, fastened to insulation or subfloor;
(4) Plastic rails with integrated tube holders intended for the specific type of tube;
(5) Insulation sheets with integrated knobs for holding the specific type of tube and intended for this application;
(6) Other fasteners recommended by the manufacturer.

SUBSTANTIATION:
The phrase "unless prohibited" is improper language as it makes the manufacturer call out items they wish to prohibit instead of specifying what is acceptable. Not all manufacturers may include language of prohibited fasteners in their documents. The recommendation is to only refer to the manufacturer’s instructions, where they should call out acceptable methods.
Item #: 032
USHGC 2021 Section: 414.8

SUBMITTER: Michael Cudahy
Plastic Pipe & Fittings Association (PPFA)

RECOMMENDATION:
Revise text

414.0 Radiant Heating and Cooling.

414.8 Tubing Fasteners. Tubing that is installed within joist spaces and subfloor panel systems shall be fastened according to manufacturer's instructions. Unless prohibited by the manufacturer, tubing fasteners shall include the following:
(1) Heat transfer panel systems made of wood, aluminum or other thermally conductive materials intended for this application and the specific type of tube;
(2) Staples made of metal or plastic or combination thereof, without sharp edges that would harm tube, intended for this application and the specific type of tube fastened to subfloor; and
(3) Plastic rails with integrated tube holders intended for the specific type of tube.
(4) Other fasteners recommended by the manufacturer.

SUBSTANTIATION:
The phrase "unless prohibited" is improper language as it makes the manufacturer call out items they wish to prohibit instead of specifying what is acceptable. Not all manufacturers may include language of prohibited fasteners in their documents. The recommendation is to only refer to the manufacturer’s instructions, where they should call out acceptable methods.
Item #: 033
USHGC 2021  Section: 416.2

SUBMITTER: Michael Cudahy
Plastic Pipe & Fittings Association

RECOMMENDATION:
Revise text

416.0 Snow and Ice Melt Systems.

416.2 Types of Tube Fasteners. Tubing that is embedded within concrete shall be fastened according to manufacturer’s instructions. Unless prohibited by the manufacturer, tube fasteners include the following:

(1) Ties made of wire, typically fastened to anchors such as rebar or wire mesh;
(2) Plastic tube/cable ties, typically nylon, fastened to anchors such as rebar or wire mesh;
(3) Staples made of metal or plastic or combination thereof, without sharp edges that would harm tube, fastened to insulation or subfloor;
(4) Plastic rails with integrated tube holders intended for the specific type of tube;
(5) Insulation sheets with integrated knobs for holding the specific type of tube and intended for this application;
(6) Other fasteners recommended by the manufacturer.

SUBSTANTIATION:
The phrase "unless prohibited" is improper language as it makes the manufacturer call out items they wish to prohibit instead of specifying what is acceptable. Not all manufacturers may include language of prohibited fasteners in their documents. The recommendation is to only refer to the manufacturer’s instructions, where they should call out acceptable methods.
Item #: 034
USHGC 2021  Section: 416.1

SUBMITTER: Mark Eatherton
Advanced Hydronics

RECOMMENDATION:
Revise text

416.0 Snow and Ice Melt Systems.
416.1 Snow and Ice Melt Controls. An automatic operating control device that controls the supply hydronic fluid temperature to the snow and ice melt area shall be installed in the system. A means shall be provided to prevent low return hydronic solution temperature in accordance with Section 410.4. Snow and ice melt systems shall be protected from freezing with a mixture of propylene glycol and water, or other approved non-toxic fluid.

SUBSTANTIATION:
Section 416.1 is being revised to clarify that an approved "non-toxic" fluid may be used as a method of freeze protection for hydronic systems. This clarification is necessary as many toxic anti-freeze solutions contain silicates that tend to clog hydronic piping and disrupt pump function. Additionally, for safety reasons, only non-toxic fluids should be used in hydronics systems.
416.0 Snow and Ice Melt Systems.

416.1 Use of Chemical Additives and Corrosive Fluids. Where auxiliary systems contain chemical additives, corrosive fluids, or both not intended or designed for use in the primary system, a double wall heat exchanger shall be used in accordance with Section 313.0. The chemical additives in the auxiliary systems shall be compatible with auxiliary system components and accepted for use by the heat exchanger manufacturer.

416.2 Snow and Ice Melt Controls. An automatic operating control device that controls the supply hydronic fluid temperature to the snow and ice melt area shall be installed in the system. A means shall be provided to prevent low return hydronic solution temperature in accordance with Section 410.4. Snow and ice melt systems shall be protected from freezing with a mixture of propylene glycol or ethylene glycol, and water, or other approved fluid. Automotive antifreeze shall not be used.

416.4.4 Insulation. Where a poured concrete snow melt system is installed in contact with the soil, insulation recommended by the manufacturer for such application and with a minimum R value of 5 shall be placed between the concrete and the compacted grade and be extended as close as practicable to the outside edges of the concrete.

(renumber remaining sections)

### TABLE 416.1.1416.2.1

<table>
<thead>
<tr>
<th>NOMINAL TUBE SIZE (inches)</th>
<th>MAXIMUM ACTIVE LOOP LENGTH (feet)</th>
<th>TOTAL LOOP LENGTH (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE-RT or PEX Tubing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/2</td>
<td>115</td>
<td>140</td>
</tr>
<tr>
<td>5/8</td>
<td>225</td>
<td>250</td>
</tr>
<tr>
<td>3/4</td>
<td>300</td>
<td>325</td>
</tr>
<tr>
<td>1</td>
<td>450</td>
<td>475</td>
</tr>
<tr>
<td>Copper Tubing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/2</td>
<td>–</td>
<td>140</td>
</tr>
<tr>
<td>3/4</td>
<td>–</td>
<td>280</td>
</tr>
</tbody>
</table>

For SI units: 1 inch = 25.4 mm, 1 foot = 304.8 mm

**Notes:**

1. The total PE-RT or PEX loop lengths consist of two separate sections, the active loop, and the leader length. The active loop is installed within the heated slab. The leader length is the total distance to and from the manifold and heated slab, including vertical distances.

2. The manifolds shall be installed as close to the snow melt area as possible.

3. In concrete use not less than Type L copper water tubing. In bituminous pavement use a Type K copper water tubing.
SUBSTANTIATION:
The proposed language addresses the design, installation and operation of snow and ice melting systems. Chemical additives and corrosive fluids to be used in snow and ice melt systems need to be addressed so that primary system components are not negatively affected or contaminated by such additives and fluids. This is done by the use of double wall heat exchangers which would protect the primary system components by separating the additives and corrosive fluids from the primary system. Section 313.0 provides further clarification on double wall heat exchangers and does not need to be repeated.

Automotive antifreeze is not applicable for use in hydronics systems as it degrades rubber gaskets and seals as well as clogs systems components. Automotive antifreeze is also toxic and should not be used where it may contaminate potable water lines.
Item #: 036

USHGC 2021  Section: 417.2

SUBMITTER: Lance MacNevin
Plastic Pipe Institute

RECOMMENDATION:
Revise text

417.0 Piping Installation.

417.2 Embedded Piping Materials and Joints. Piping embedded in concrete shall be steel pipe, Type L copper tubing or plastic pipe or tubing rated at not less than 40080 psi at 180°F (689552 kPa at 82°C). Joints of pipe or tubing that are embedded in a portion of the building, such as concrete or plaster, shall be installed in accordance with Section 417.2.1 through Section 417.2.3.

SUBSTANTIATION:
The above values for pressure have been updated to reflect the most current required pressure rating for steel pipe, Type L copper tubing and plastic pipe to be embedded in concrete. Such pressure ratings are required to ensure that any piping or tubing embedded in concrete are capable of withstanding any applied stresses.
Item #: 037
USHGC 2021 Section: 417.5

SUBMITTER: Lance MacNevin
Plastic Pipe Institute

RECOMMENDATION:
Revise text

417.0 Piping Installation.

417.5 Condensate Drainage. Condensate drains from dehumidifying coils shall be constructed and sloped for condensate removal. Such drains shall be installed in accordance with Section 308.0.

(renumber remaining sections)

SUBSTANTIATION:
To facilitate system repairs and maintenance, hydronic piping systems must be sloped and arranged to allow the transfer-medium or condensate to be drained from the system. Each trapped section of the system piping must have drain cocks, unions or some other means of opening the system to drain it. Drainage discharge to the plumbing system must also be by an indirect connection. These provisions and more are provided in Section 308.0 (Condensate Wastes and Control), and referencing this section ensures that such provisions are enforced.
Item #: 038

USHGC 2021  Section: 417.6

SUBMITTER: Mark Eatherton  
Advanced Hydronics

RECOMMENDATION: 
Add new text

417.0 Piping Installation.

417.6 Hydronic Makeup Air Units. Hydronic makeup air units that can be affected by freezing shall be protected by an antifreeze-based hydronic solution.

SUBSTANTIATION: 
The proposed language is being added to address hydronic makeup air units exposed to freezing conditions. Makeup air units are important as they are needed to provide adequate airflow at the desired relative humidity for occupancy comfort. Where makeup air units may be exposed to freezing conditions, the hydronic fluid used must be antifreeze based to ensure the system is able to function. The addition of Section 417.6 is necessary and further enhances the code.
Item #: 039
USHGC 2021 Section: 501.4

SUBMITTER: Adam Chrisman
SunEarth

RECOMMENDATION:
Revise text

501.0 General.

501.4 Draining. Solar thermal system piping shall be installed to permit the draining of the system. Drainback system piping above the fluid level of the drainback reservoir shall have a slope of not less than $\frac{1}{4}$ inch per foot (20.8mm/m).

SUBSTANTIATION:
In some circumstances, drainback solar thermal systems have solar loop piping routed below the high point level of the drainback reservoir and are not in danger of freezing. Therefore, such piping does not need to be completely drained into the reservoir in order to accomplish the intended purpose of evacuation of solar collectors and piping fluid to prevent freeze damage.

For the above reasons, the addition of the proposed language is necessary and further enhances the code.
Item #: 040

USHGC 2021  Section: 501.5.4 - 501.5.4.1

SUBMITTER: Chelsea Salaiz
V&T Carbonic Inc.

RECOMMENDATION:
Revise text

501.0 General.

501.5 Materials. (remaining text unchanged)

501.5.4 Potable Water. Materials in contact with potable water shall comply with NSF 61. Piping in solar systems designed to convey potable water shall be flushed and disinfected in accordance with Section 501.5.4.1.

501.5.4.1 Disinfection of Potable Water Systems. Piping shall be disinfected prior to use where required by the Authority Having Jurisdiction. The method to be followed shall be that prescribed by the Health Authority or, in case no method is prescribed by it, the following:
(1) The pipe system shall be flushed with clean, potable water until potable water appears at the points of the outlet.
(2) The system or parts thereof shall be filled with a water-chlorine solution containing not less than 50 parts per million of chlorine, and the system or part thereof shall be valved-off and allowed to stand for 24 hours; or, the system or part thereof shall be filled with a water-chlorine solution containing not less than 200 parts per million of chlorine and allowed to stand for 3 hours.
(3) Following the allowed standing time, the system shall be flushed with clean, potable water until the chlorine residual in the water coming from the system does not exceed the chlorine residual in the flushing water.
(4) The procedure shall be repeated where it is shown by a bacteriological examination made by an approved agency that contamination persists in the system.

SUBSTANTIATION:
The additional restrictions for materials in contact with the potable water supply are proposed to address the disinfection of solar system piping and components designed to convey potable water. Disinfection is required to remove or inactivate pathogens that can cause diseases in humans and animals. Direct solar thermal water heating systems heat potable water to be utilized in a building’s potable hot water distribution system. All solar thermal system piping and components (fittings, valves, etc.) must be compatible with the potable water system and must be disinfected for safe use. The inclusion of such provisions are necessary for safety reasons.

The proposed language is in accordance with Section 609.9 (Disinfection of Potable Water Systems) of the 2018 Uniform Plumbing Code and is currently an approved method for disinfection of potable water systems.
Item #: 041

USHGC 2021  Section: 501.8

SUBMITTER: Chelsea Salaiz
V&T Carbonic Inc.

RECOMMENDATION:
Revise text

501.0 General.

501.8 Auxiliary Heating. An auxiliary heating system shall be installed in conjunction with the solar thermal system and shall be adequate to provide service in the absence of solar thermal energy input. Auxiliary heating that utilizes electricity as the energy source shall be in accordance with Section 315.0. Auxiliary heating that utilizes solid fuel or fuel gas as the energy source shall be in accordance with the mechanical code.

(renumber remaining sections)

SUBSTANTIATION:
Section 501.8 is being revised to provide further clarification on the use of auxiliary systems in conjunction with solar thermal systems. The auxiliary or back-up system installed must be readily available to meet the total design load in the event that the solar thermal system is not able to meet the demand. This may occur for a number of reasons with the most likely cause being rainy/cloudy days. For these reasons, the proposed language is necessary.
Item #: 042

USHGC 2021  Section: 501.8, Table 901.1, Table 901.2

SUBMITTER: Chelsea Salaiz  
V&T Carbonic Inc.

RECOMMENDATION:  
Add new text

501.0 General.

501.8 Water Heating Systems. Solar water heating systems shall be in accordance with IAPMO S1001.1 or ICC 900/SRCC 300. The solar collector supply and return piping shall be provided with shutoff valves for isolation of the collector loop. Where solar collectors are capable of being isolated from the remainder of the system, a suitable pressure relief valve shall be installed in the isolatable section.

(renumber remaining sections)

<table>
<thead>
<tr>
<th>TABLE 901.1 REFERENCE STANDARDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>STANDARD NUMBER</td>
</tr>
<tr>
<td>-----------------</td>
</tr>
</tbody>
</table>

(portion of table not shown remain unchanged)

Note: IAPMO S1001.1 and ICC 900/SRCC 300 meet the requirements for mandatory reference standards in accordance with Section 15.0 of IAPMO's Regulations Governing Consensus Development of the Uniform Solar, Hydronics & Geothermal and Swimming Pool, Spa & Hot Tub Codes.

<table>
<thead>
<tr>
<th>TABLE 901.2 STANDARDS, PUBLICATIONS, PRACTICES, AND GUIDES</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOCUMENT NUMBER</td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td>ICC 900/SRCC 300-2015</td>
</tr>
</tbody>
</table>

(portion of table not shown remain unchanged)

SUBSTANTIATION:
The addition of Section 501.8 is necessary as it addresses requirements for design and installation of solar water heating systems as well as includes isolation of the collector loop by means of shutoff valves.

Shutoff valves are required for manual isolation of the collector loop from the storage tank. This allows for maintenance and repair of the collector loop without disrupting the normal flow of water through the storage tank.
The standard IAPMO S1001.1 pertains to requirements for the design and installation of pre-engineered solar water heating systems intended to be installed as stand-alone systems or in conjunction with auxiliary water heaters, including component selection and sizing criteria.

The standard ICC 900/SRCC 300 pertains to the design and installation of solar thermal systems to be used in applications for heating, cooling and dehumidification.
SUBMITTER: Chelsea Salaiz  
V&T Carbonic Inc.

RECOMMENDATION:  
Revise text

502.0 Solar Collectors. 

502.5 Installation. (remaining text unchanged)

502.5.2 Above or on the Roof. New construction of Class A, B, or C type roof coverings shall be in accordance with ASTM E108 or UL 790 where collectors are installed above or on the roof. Collectors located above or on roofs, and functioning as building components, shall not reduce the required fire-resistance and fire-retardance classification of the roof covering materials.  

Exceptions:
(1) One- and two-family dwellings.  
(2) Collectors located on buildings not exceeding three stories in height, a 9000 square feet (836.13 m²) total floor area; or both providing:
(a) The collectors are noncombustible.  
(b) Collectors with plastic covers have noncombustible sides and bottoms, and the total area covered and the collector shall not exceed the following:
1. Plastic CC1 – 33 1/3 percent of the roof area.  
2. Plastic CC2 – 25 percent of the roof area.
(c) Collectors with plastic film covers having a thickness of not more than 0.010 of an inch (0.25 mm) shall have noncombustible sides and bottoms, and the total area covered by the collector shall not exceed 33 1/3 percent of the roof area.

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>UL 790-2004</td>
<td>Test Methods for Fire Tests of Roof Coverings (with revisions through October 19, 2018)</td>
<td>Safety</td>
<td>502.5.2</td>
</tr>
</tbody>
</table>

( порtions of table not shown remain unchanged)

Note: ASTM E108 and UL 790 meet the requirements for mandatory reference standards in accordance with Section 15.0 of IAPMO’s Regulations Governing Consensus Development of the Uniform Solar, Hydronics & Geothermal and Swimming Pool, Spa & Hot Tub Codes.

SUBSTANTIATION:
The proposed language is for the addition of standards ASTM E108 and UL 790. Both are fire-test-response standards used to evaluate roof coverings in both residential and commercial roofing applications. The evaluations include simulations that take into account wind conditions and fires originating outside of the building or structure. These standards also measure the surface spread of flames and the roof covering material’s ability to resist fire from reaching the underside of the roofing material. Such addition provides further restrictions on roof coverings for the safety of the end user.
Item #: 044
USHGC 2021  Section: 503.2, Table 503.3(1) - Table 503.3(4)

SUBMITTER: Chelsea Salaiz
V&T Carbonic Inc.

RECOMMENDATION:
Revise text

503.0 Insulation.

503.2 Heat Loss. Insulation shall be installed on interconnecting solar and hot water piping. The final 5 feet (1524 mm) of the cold water supply line, or the entire length where less than 5 feet (1524 mm), shall be insulated. The insulation thickness shall be in accordance with Table 503.3(1) or Table 503.3(2), or the insulation installed shall have an R-value of value not less than R-2.6 degree Fahrenheit hour square foot per British thermal unit (°F·h·ft²/Btu)(R-0.46 °K·m²/W). Piping, storage tanks, and circulating air ductwork shall be insulated. Ductwork and piping shall be permitted to not be insulated where exposed in conditioned spaces, and the heat loss from such ducts or piping does not otherwise contribute to the heating or cooling load within such space.

Exception: Low temperature, aboveground piping installed for swimming pools, spas, and hot tubs in accordance with the manufacturer’s installation instructions unless such piping is located within a building.

(delete the following table in its entirety)

TABLE 503.3(1)
MINIMUM PIPE INSULATION

(delete the following table in its entirety)

TABLE 503.3(2)
IRON PIPE AND COPPER TUBING INSULATION THICKNESS

(delete the following table in its entirety)

TABLE 503.3(3)
UNIVERSAL PIPE INSULATION THICKNESS BASED ON RADIUS AND IRON PIPE SIZE (IPS)

(delete the following table in its entirety)

TABLE 503.3(4)
DESIGN VALUES FOR THERMAL CONDUCTIVITY (k) OF INDUSTRIAL INSULATION1,3,4,5
### TABLE 503.3(1)
**PIPE INSULATION THICKNESS**

<table>
<thead>
<tr>
<th>NPS (inches)</th>
<th>PIPE O.D. (inches)</th>
<th>INSULATION I.D. (inches)</th>
<th>INSULATION O.D. (inches)</th>
<th>INSULATION NOMINAL THICKNESS (inches)*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>½</td>
</tr>
<tr>
<td>½</td>
<td>0.84</td>
<td>0.86</td>
<td></td>
<td>1.84</td>
</tr>
<tr>
<td>¾</td>
<td>1.05</td>
<td>1.07</td>
<td></td>
<td>2.06</td>
</tr>
<tr>
<td>1</td>
<td>1.315</td>
<td>1.33</td>
<td></td>
<td>2.32</td>
</tr>
<tr>
<td>1 ¼</td>
<td>1.660</td>
<td>1.68</td>
<td></td>
<td>2.66</td>
</tr>
<tr>
<td>1 ½</td>
<td>1.900</td>
<td>1.92</td>
<td></td>
<td>2.78</td>
</tr>
<tr>
<td>2 ¼</td>
<td>2.875</td>
<td>2.91</td>
<td></td>
<td>3.88</td>
</tr>
<tr>
<td>6</td>
<td>6.625</td>
<td>6.70</td>
<td></td>
<td>7.80</td>
</tr>
</tbody>
</table>

* Thickness values are applicable for calcium silicate, cellular foam plastics, cellular glass, mineral fiber, and perlite preformed insulation materials.

For SI units: 1 inch = 25 mm

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### TABLE 503.3(2)
**STANDARD TUBING INSULATION THICKNESS**

<table>
<thead>
<tr>
<th>TUBE SIZE (inches)</th>
<th>TUBE O.D. (inches)</th>
<th>INSULATION I.D. (inches)</th>
<th>INSULATION NOMINAL THICKNESS (inches)*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>3/8</td>
<td>0.500</td>
<td>0.52</td>
<td>2.38</td>
</tr>
<tr>
<td>½</td>
<td>0.625</td>
<td>0.64</td>
<td>2.88</td>
</tr>
<tr>
<td>¾</td>
<td>0.875</td>
<td>0.89</td>
<td>2.88</td>
</tr>
<tr>
<td>1</td>
<td>1.125</td>
<td>1.14</td>
<td>2.88</td>
</tr>
<tr>
<td>1 ½</td>
<td>1.625</td>
<td>1.64</td>
<td>3.50</td>
</tr>
<tr>
<td>2</td>
<td>2.125</td>
<td>2.16</td>
<td>4.00</td>
</tr>
<tr>
<td>3</td>
<td>3.125</td>
<td>3.16</td>
<td>5.00</td>
</tr>
<tr>
<td>5</td>
<td>5.125</td>
<td>5.16</td>
<td>7.62</td>
</tr>
<tr>
<td>6</td>
<td>6.125</td>
<td>6.20</td>
<td>8.62</td>
</tr>
</tbody>
</table>

* Thickness values are applicable for calcium silicate, cellular foam plastics, cellular glass, mineral fiber, and perlite preformed insulation materials.

For SI units: 1 inch = 25 mm

---

**SUBSTANTIATION:**

The proposed language is being added for additional restrictions on insulation installed with solar thermal systems and connecting piping. Proper insulation improves efficiency and prevents heat loss from the system. The minimum thermal resistance provided is a current requirement in the industry and can be found in various local codes.

Tables 503.3(1) through 503.3(4) have been deleted due to a lack of clarification on proper application. The removal was necessary as new tables have been provided that already include proper insulation thicknesses for tubing and piping. Previous tables for conductivity and resistance values are no longer needed for calculation of correct thicknesses. The new tables are applicable for calcium silicate, cellular foam plastics, cellular glass, mineral fiber, and perlite preformed insulation materials and therefore remove the need for the original Table 503.3(2).
These new tables are in accordance with industry standards such as ASHRAE. These values also do not conflict with the Uniform Plumbing Code, and they meet the minimum requirements for thicknesses based strictly on pipe diameters. Values listed in the new Table 503.3(1) correlate with the original Table 503.3(3) and cover a wider range of thickness values. The new Table 503.3(1) then provides tubing insulation thicknesses that are not only restricted to calcium silicate and fibrous glass.
Proposals
Edit Proposal
Item #: 045
USHGC 2021 Section: 209.0, 701.1, 701.1.1, 701.4 - 701.11

SUBMITTER: Cary Smith
Sound Geothermal Corporation

RECOMMENDATION:
Revise text

Part I - General.

701.0 General.
701.1 Applicability. This chapter shall apply to geothermal energy systems such as, but not limited to, building systems coupled with a ground-heat exchanger, submerged heat exchanger using water-based fluid as a heat transfer medium, or groundwater (well). The regulations of this chapter shall govern the construction, location and installation of geothermal energy systems.

Indoor piping, fittings, and accessories that are part of the groundwater system shall be in accordance with Section 703.5 and Chapter 4.

701.1.1 Prior to Construction. Documents for permits shall be submitted prior to the construction of a building system, ground heat exchanger, submerged heat exchanger, or water well. Permits shall be issued by the Authority Having Jurisdiction.

701.4 Used Materials. The installation of used pipe, fittings, valves, and other materials shall not be permitted.

701.5 Contact with Building Material. A ground source heat pump ground-loop piping system shall not be in direct contact with building materials that cause the piping or fitting material to degrade or corrode, or that interferes with the operation of the system.

701.6 Strains and Stresses. Piping shall be installed so as to prevent detrimental strains and stresses in the pipe. Provisions shall be made to protect piping from damage resulting from expansion, contraction, and structural settlement. Piping shall be installed so as to avoid structural stresses or strains within building components.

701.7 Flood Hazard. Piping located in a flood hazard area shall be capable of resisting hydrostatic and hydrodynamic loads and stresses, including the effects of buoyancy, during the occurrence of flooding to the design flood elevation.

701.8 Pipe Support. Pipe shall be supported in accordance with Section 317.1.

701.9 Velocities. Ground source heat pump ground-loop systems shall be designed so that the flow velocities do not exceed the maximum flow velocity recommended by the pipe and fittings manufacturer. Flow velocities shall be controlled to reduce the possibility of water hammer.

701.10 Chemical Compatibility. Antifreeze and other materials used in the system shall be chemically compatible with the pipe, tubing, fittings, and mechanical systems.

701.11 Transfer Fluid. The transfer fluid shall be compatible with the makeup water supplied to the system.

209.0 - G -

Geothermal Energy System. A system that uses the earth’s interior thermal energy for space heating and cooling, and water heating.

Geothermal Energy System, Closed-Loop. A continuous, sealed, underground, or submerged heat exchanger through which a heat-transfer fluid passes to and returns from a heat pump.

Geothermal Energy System, Open-Loop. A liquid-source heat pump system that uses ground water or surface water to extract or reject heat.

SUBSTANTIATION:
The proposed language and section relocations have been made to further provide clarification on the three main types of geothermal systems. Chapter 7 (Geothermal Systems) has been divided into four parts discussing general provisions, closed-loop systems, open-loop systems, and direct exchange systems.
Part I (General) pertains to all three systems discussed within Chapter 7. New proposed language addresses used materials, strains and stresses, flood hazards, pipe supports, flow velocities, and chemical compatibility. Further topics added under “General” will be addressed in following proposals.

Additionally, definitions for “Geothermal Energy System”, “Geothermal Energy System, Closed Loop” and “Geothermal Energy System, Open Loop” have been revised or added to provide clarification for terminology used within Chapter 7.
Item #: 046
USHGC 2021 Section: 703.2 - 703.4.2.1, Table 703.2, Table 703.3, Table 901.1

SUBMITTER: Cary Smith
Sound Geothermal Corporation

RECOMMENDATION:
Revise text

Part I – General.

703.2 Piping and Tubing Materials Standards. For water-based systems, ground source heat pump ground-loop pipe and tubing shall comply with the standards listed in Table 703.2. Piping and tubing used for DX systems shall be of copper in accordance with Section 715.3.

TABLE 703.2
PLASTIC GROUND SOURCE LOOP PIPING

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross-linked polyethylene (PEX)</td>
<td>ASTM F876, ASTM F3253, CSA B137.5, CSA C448, NSF 358-3</td>
</tr>
<tr>
<td>High Density Polyethylene (HDPE)</td>
<td>ASTM D2737, ASTM D3035, ASTM F714, AWWA C901, CSA B137.1, CSA 448, NSF 358-1</td>
</tr>
<tr>
<td>Polypropylene (PP)</td>
<td>ASTM F2389, CSA B137.11, NSF 358-2</td>
</tr>
<tr>
<td>Polyethylene Raised Temperature (PE-RT)</td>
<td>ASTM F2623, ASTM F2769, CSA B137.18, CSA C448, NSF 358-4</td>
</tr>
</tbody>
</table>

703.3 Fittings. For water-based systems, fittings for ground source heat pump systems shall be approved for installation with the piping materials to be installed, and shall comply with the standards listed in Table 703.3. Fittings for use in DX systems shall comply with Section 715.3.

TABLE 703.3
GROUND SOURCE LOOP PIPE FITTINGS

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Density Polyethylene (HDPE)</td>
<td>ASTM D2683, ASTM D3261, ASTM F1055, CSA B137.1, CSA C448, NSF 358-1</td>
</tr>
<tr>
<td>Polypropylene (PP)</td>
<td>ASTM F2389, CSA B137.11, NSF 358-2</td>
</tr>
</tbody>
</table>
**703.5** **Polyethylene (PEX) Pipe or Tubing.** Cross-linked polyethylene (PEX) pipe or tubing shall be manufactured to outside diameters, wall thickness, and respective tolerances in accordance with ASTM F876 or CSA B137.5. The pipe shall have a minimum wall thickness equal to SDR-11 maximum dimension ratio of 11 and shall have a minimum pressure rating of not less than 160 psi (1103 kPa) at 73°F (23°C).

Fittings shall be manufactured to dimensional specifications and requirements in accordance with ASTM D3261 for butt/sidewall fusion fittings, or ASTM F1055 for electrofusion fittings. Polyethylene pipe or tubing shall be manufactured from a PE compound that has a pipe material designation code of PE 3608, PE 3708, PE 3710, PE 4608, PE 4708, or PE 4710 as defined in the applicable standards referenced in Table 703.2, with a cell classification in accordance with ASTM D3350 appropriate for the material designation code, and a color and ultraviolet stabilizer code of C or E. Code E compounds shall be stabilized against deterioration from unprotected exposure to ultraviolet rays for not less than 3 years in accordance with the test criteria specified in ASTM D2513.

**703.5.1 Joining Methods for Polyethylene Pipe or Tubing.** Joints between **high density** polyethylene (HDPE) plastic pipe or tubing and fittings shall be installed in accordance with the manufacturer’s installation instructions, the **appropriate standards** listed in accordance with Table 703.3, and one of the following methods:

1. **Butt-fusion joints** shall be made in accordance with ASTM F2620 by heating the squared ends of two pipes, pipe and fitting, or two fittings by holding ends against a heated element. The heated element shall be removed where the proper melt is obtained, and joined ends shall be placed together with applied force.
2. **Socket-fusion joints** shall be made in accordance with ASTM F2620, by simultaneously heating the outside surface of a pipe end and the inside of a fitting socket. Where the proper melt is obtained, the pipe and fitting shall be joined by inserting one into the other with applied force. The joint shall fuse together and remain undisturbed until cool.
3. **Electrofusion joints** shall be made in accordance with ASTM F1055 by heating internally by a conductor at the interface of the joint. Align and restrain fitting to pipe to prevent movement and apply electric current to the fitting. Turn off the current when the proper time has elapsed to heat the joint. The joint shall fuse together and remain undisturbed until cool.

**TABLE 901.1 REFERENCE STANDARDS**

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</table>

(remaining sections renumbered)

(portion of table not shown remain unchanged)
SUBSTANTIATION:
New tables have been proposed under “Part I – General” to provide material standards for piping/tubing and fittings for plastic ground source looping. The standards listed in Table 703.2 and Table 703.3 are necessary to ensure the overall success of geothermal systems and help to address corrosion resistance, chemical resistance, flexibility, impact resistance, resistance to slow crack growth, long-term hydrostatic strength (pressure capability), and temperature resistance. In addition, the ground loop heat exchanger materials must provide suitable heat transfer capabilities. PE is the most common pipe material used in ground source heat exchangers. It is flexible and can be heat-fused to form joints stronger than the pipe itself. PE-RT advantages include long-term reliability, flexibility for speedy installation, freeze break resistance, noise and water hammer resistance, and resistance to corrosion, tuberculation, deposits, chlorine and chloramines.

Section 703.4.1 has been revised for clarification on maximum dimension ratios. Published text states that "Piping or tubing shall have a maximum dimension ratio of 11". This is confusing for the end user as the dimension ratio is the ratio of the average outside diameter to the minimum wall thickness, and as the value for dimension ratio (SDR) decreases, the pressure rating increases. By incorporating the minimal wall thickness to achieve a specified SDR, the language is clearer for the end user.

Additionally, standard designation codes for PE and PEX piping compositions have been included to identify the most significant engineering properties: density, resistance and hydrostatic design stress.

Section 703.4.1.1 now addresses HDPE pipe/tubing joint methods and requires that joints comply with ASTM standards. HDPE has been included as it comes in different grades and is very rigid, making it ideal for vertical well fields. HDPE has a high pressure rating and provides the same quality seal as PE pipe, as it also must be joined in a heat fusion process.
Item #: 047

USHGC 2021  Section: 703.5, 704.0 - 704.2, 715.0, 715.5

SUBMITTER: Cary Smith
Sound Geothermal Corporation

RECOMMENDATION:
Revise text

Part I – General.

703.0 Design of Systems.

703.7 Indoor Piping. Indoor piping, fittings, and accessories that are part of the groundwater system shall be in accordance with Chapter 4. Such materials shall be rated for the operating temperature and pressures of the system and shall be compatible with the type of transfer medium. For DX systems, joints shall be purged with an inert gas and brazed with a brazing alloy having 15 percent silver content in accordance with AWS A5.8.

704.0 Heat Pump and Distribution System Design.

704.1 Heat Pump Distribution System. (remaining text unchanged)

704.2 Circulating Pumps. The circulating pump shall be sized for the operating conditions and the heat transfer fluid properties.

Part IV – Direct Exchange (DX) Systems.

715.0 Direct Exchange (DX) Systems.

715.5 Indoor Piping. For DX systems, joints shall be purged with an inert gas and brazed with a brazing alloy having 15 percent silver content in accordance with AWS A5.8.

Note: AWS A5.8 meets the requirements for a mandatory reference standard in accordance with Section 15.0 of IAPMO’s Regulations Governing Consensus Development of the Uniform Solar, Hydronics & Geothermal and Swimming Pool, Spa & Hot Tub Codes.

SUBSTANTIATION:
Section relocations have been made to coincide with the four parts of Chapter 7 previously explained.

Furthermore, the section on “Indoor Piping” is being modified by striking the last sentence that is specific to DX systems. The section is being added to proposed Part IV (Direct Exchange Systems) for ease of use and will guide the end user in determining where all provisions specific to DX systems can be located.
Item #: 048
USHGC 2021 Section: 705.0 - 705.8

SUBMITTER: Cary Smith
Sound Geothermal Corporation

RECOMMENDATION:
Add new text

Part I – General.

705.0 Valves.

705.1 Where Required. Shutoff valves shall be installed in ground source-loop piping systems in the locations indicated in Section 705.2 through Section 705.8.

705.2 Heat Exchangers. Shutoff valves shall be installed on the supply and return side of a heat exchanger.

Exception: Where a heat exchanger is an integral part of a boiler or is a part of a manufactured boiler and heat exchanger packaged unit, and is capable of being isolated from the hydronic system by supply and return valves.

705.3 Central Systems. Shutoff valves shall be installed on the building supply and return of a central utility system.

705.4 Pressure Vessels. Shutoff valves shall be installed on the connection to a pressure vessel.

705.5 Pressure-Reducing Valves. Shutoff valves shall be installed on both sides of a pressure-reducing valve.

705.6 Equipment and Appliances. Shutoff valves shall be installed on connections to mechanical equipment and appliances.

705.7 Expansion Tanks. Shutoff valves shall be installed at connections to nondiaphragm-type expansion tanks.

705.8 Reduced Pressure. A pressure relief valve shall be installed on the low-pressure side of a hydronic piping system that has been reduced in pressure. The relief valve shall be set at the maximum pressure of the system design.

SUBSTANTIATION:
The use of shutoff valves in ground source loop piping systems is necessary for isolation of components for routine maintenance or repair. All proposed language is similarly found in the mechanical code, and all provisions on valves should be included under Part I (General) provisions as they are applicable to open-loop, closed-loop, and DX systems.

In particular, heat exchangers are required to have shutoff valves on the supply and return sides; however, heat exchangers that are integral with boilers as well as boiler heat exchanger packaged units are excluded from this provision as long as they may be isolated from the system.

Additionally, a pressure relief valve should be installed to divert a portion of the fluid through an auxiliary route in order to reduce the pressure within the system until it falls within the design limits.
Item #: 049

USHGC 2021  Section: 706.0 - 706.4

SUBMITTER: Cary Smith  
Sound Geothermal Corporation

RECOMMENDATION:
Revise text

Part I – General.

705.0706.0 Specific System Components Design.
705.4706.1 General. Ground coupled and water source heat pumps shall be certified in accordance with AHRI/ASHRAE/ISO 13256-1 for water-to-air heat pumps and AHRI/ASHRAE/ISO 13256-2 for water-to-water heat pumps. DX heat pumps shall be certified in accordance with ASHRAE 194. All heat pump equipment used in DX systems shall comply with AHRI 870. Heat pumps shall be fitted with a means to indicate that the compressor is locked out.
705.4706.2 Heat Exchangers. (remaining text unchanged)
705.4706.3 Heat-Transfer Medium. (remaining text unchanged)
705.4706.4 Insulation. (remaining text unchanged)

(renumber remaining sections)

SUBSTANTIATION:
The proposed change relocates sections to Part I (General) of Chapter 7. The relocation gathers sections in Chapter 7 relating to “Specific System Component Design.”
SUBMITTER: Cary Smith  
Sound Geothermal Corporation

RECOMMENDATION:  
Revise text

Part I – General.

704.0707.0 Installation Practices.
707.1 Prior to Construction. Documents for permits shall be submitted prior to the construction of a building system, or water well. Permits shall be issued by the Authority Having Jurisdiction.

707.2 Equipment, Accessories, Components, and Materials. The mechanical equipment, accessories, components, and materials used shall be of the type and rating approved for the specific use.

707.3 Construction Documents. The construction documents for the building system portion of the geothermal energy system shall be submitted to the Authority Having Jurisdiction.

707.4 Site Survey Requirements. The site survey shall identify the physical limitations of the land area, including its extent, structures, existing wells of all types, proximity of other existing ground source heat pump systems, pavements, trees, grading, ponds, waterways, easements, overhead and underground services, septic systems, any identified septic repair areas, utility of rights of way, and any other elements that could affect an open-loop configuration.

Permission shall be obtained from any adjoining property owner(s), as evidenced by the registration and approval of a formal easement that meets requirements of the authority having jurisdiction. It shall be received prior to the installation of any open-loop system that will extend into, cross, or interfere with the equipment or rights-of-way of utilities, jurisdictions, and other property owners.

The site survey shall include a subsurface investigation that meets the requirements for an open-loop heat exchanger.

707.5 Subsurface Investigation. A subsurface investigation shall be performed in accordance with Section 707.5.1 as determined by the registered design professional conducting the site survey.

707.5.1 Subsurface Conditions. The water well logs and other geological records shall be used to anticipate the subsurface conditions of the aquifer and its potential supply of fresh water, multiple aquifers, saltwater intrusions, contaminated soils and groundwater, hazardous gases, and any interference with neighboring water wells and ground source heat exchangers.

Geological issues such as permafrost conditions and building stability shall be considered when reviewing available records.

703.2707.6 Ground Heat-Exchanger Installation Practices. (remaining text unchanged)
704.4707.7 Trenching, Excavation, and Backfill. Prior to excavation, trenching, or drilling, buried utilities, drainage, water, and irrigation systems shall be located. Prior to excavation, trenching, or drilling, the contractor, and owner shall agree in writing to site restoration requirements and submit to the Authority Having Jurisdiction for approval. Prior to any excavation, trenching, or drilling, all buried utilities including drainage and irrigation systems shall be located and flagged by the appropriate utility and ground source heat pump system contractor representative.

704.2707.8 Trenches, Tunneling, and Driving. (remaining text unchanged)
704.3707.9 Excavations and Open Trenches. (remaining text unchanged)
704.4707.10 Protection of Piping, Materials, and Structures. (remaining text unchanged)
704.5707.11 Sleeves. (remaining text unchanged)
704.6707.12 Steel Nail Plates. (remaining text unchanged)

705.3707.13 On Site Storage. Exterior piping shall be fitted with end caps and protected from freezing, UV radiation, corrosion, and degradation. For DX systems, copper piping and fittings shall be stored to prevent physical damage, contamination, and each pipe or tubing shall be pressurized with an inert gas and sealed with a cap.

707.4707.14 Heat Pump and Distribution System Installation. (remaining text unchanged)
707.15 Pressurizing During Installation. Ground source heat pump ground loop piping to be embedded in concrete shall be pressure tested prior to pouring concrete. During pouring, the pipe shall be maintained at the proposed operating pressure.
Part IV – Direct Exchange (DX) Systems.

715.0 Direct Exchange (DX) Systems.

715.6 On Site Storage. For DX systems, copper piping and fittings shall be stored to prevent physical damage, contamination, and each pipe or tubing shall be pressurized with an inert gas and sealed with a cap.

SUBSTANTIATION:
The proposed language is similarly found in the mechanical code, and additional section relocations have been made to ensure that all “General” provisions are applied to all three systems.

In order to properly design an open-loop, closed-loop or DX geothermal system, it is important to know the pertinent project information identified through site survey processes and subsurface investigations. Construction documents are required to be of a quality and detail such that the Authority Having Jurisdiction can determine that the work conforms to the code and other applicable laws and regulations. All materials and equipment used must be rated and approved for such use to ensure proper functioning and safe use. Supporting documentation for installation practices have been provided.

Section 707.15 has been included to ensure that piping to be embedded in concrete will allow for proper flow once installed. Pressure testing would allow for such determination.

Additionally, Section 707.13 has been revised to exclude information explicit to DX systems, and the text has been moved to Section 715.6 (On Site Storage).
SUBMITTER: Cary Smith
Sound Geothermal Corporation

RECOMMENDATION:
Add new text

Part I – General.

704.0707.0 Installation Practices.

707.16 Horizontal Geothermal Piping - Materials and Methods. Horizontal geothermal piping shall be in accordance with Section 707.16.1 through Section 707.17.8.

707.16.1 Piping Material. Piping materials and joining methods for horizontal piping from the ground heat-exchanger shall be in accordance with Section 703.2 through Section 703.5.

707.16.2 Dissimilar Materials. Transition fittings between dissimilar materials shall be inside or accessible.

707.16.3 Protection of Piping. Pipes passing through walls shall be sleeved and sealed in accordance with Section 318.0.

707.17 Trenches, Excavation, and Backfilled. Excavation for horizontal piping shall comply with Section 707.7 through Section 707.10, Section 707.17.1 through Section 707.17.8, and in accordance with requirements of the Authority Having Jurisdiction. Prior to any excavation, trenching, or drilling, all buried utilities including drainage and irrigation systems shall be located and flagged by the appropriate utility and ground source heat pump system contractor representative.

707.17.1 Trenches. Trenches for underground piping or tubing shall be excavated in accordance with the setback requirements in Section 712.4.

707.17.2 Buried Systems. Buried open-loop system piping, shall be installed not less than 3.3 feet (1006 mm) below the finished grade.

707.17.3 Pipe Installation. Piping in horizontal trenches shall be embedded with not less than 6 inches (152 mm) of inert granular material above and below, or in accordance with the Authority Having Jurisdiction and project specifications. Horizontal piping trenching shall be backfilled with approved material and shall be compacted.

707.17.4 Separation. The horizontal piping shall be separated from fluid-based on-site service systems to prevent excessive short-circuiting heat transfer between such systems.

707.17.5 Insulation. Insulation shall be provided on the piping where there is close proximity of all site services to prevent thermal interference between fluid-based on-site service systems.

707.17.6 Pipe Bends. Sharp bending of pipe shall be prevented or approved elbow fitting shall be used with a bend-radius in accordance with the manufacturer’s installation instructions.

707.17.7 Closed Cell Insulation. Buried horizontal open-loop system pipes passing parallel within 5 feet (1524 mm) of a wall, structure, or water pipe shall be insulated with R-2 minimum closed cell insulation.

707.17.8 Tracer Markings. Means shall be provided for underground detection or utility location of the buried pipe system. This shall include, but is not limited to metallic detectable tape, with a thickness of not less than 11/64 of an inch (4.4 mm) and width of 6 inches (152 mm). This warning marking shall be permanent, conspicuous and resistant to the environmental conditions and shall be placed within 1 foot to 2 feet (305 mm to 610 mm) on top of the horizontal piping of the heat exchanger installation.

SUBSTANTIATION:
The proposed text on materials and methods for horizontal geothermal piping is similarly found in the mechanical code. The listed provisions are applicable to open-loop, closed-loop and DX systems and therefore should be added under Part I (General) provisions.
The listed provisions address piping materials and reference Section 703.2 (Piping and Tubing Material Standards) through Section 703.5 (Indoor Piping). The referenced sections provide material standards for piping/tubing and fittings, joining methods and material property designations.

Also addressed are dissimilar materials which require transition fittings to prevent leaks and allow for proper connections between varying materials.

Provisions on protection of piping have already been addressed in Section 318.0 (Protection of Piping, Materials, and Structures) and should therefore be referenced and not repeated. All sections pertaining to trenches, excavation and backfill have also be referenced.

Buried piping must be at least 3.3 feet below grade because at that depth, the earth’s temperature remains relatively constant throughout the year, and ground source heat pumps are designed to capitalize on this. Underground piping must also be separated from site services and insulated to prevent excessive short circuiting heat transfer as well as thermal interference. Additionally, sharp pipe bends should be avoided, and approved elbow fittings should be used. For easy location of underground piping for maintenance and repair, tracer markings should be installed.
Proposals

Edit Proposal

Item #: 052

USHGC 2021  Section: 708.1, 708.3 - 708.8, 715.0, 715.7, Table 901.1

SUBMITTER: Cary Smith
Sound Geothermal Corporation

RECOMMENDATION:
Revise text

Part I – General.

708.0 System Start-Up.

708.1 General. The following requirements shall be verified prior to system start-up:–

(1) Piping shall be cleaned, flushed, and purged.

(2) DX systems shall be pressurized using nitrogen for not less than 1 hour. There shall be no allowable variance to the test pressure after being corrected for ambient temperature changes during the test. The test pressure shall not exceed 150 psig (1034 kPa) when pressure testing the compressor unit and indoor system components.

(3) The ground heat exchanger and building piping shall be cleaned, flushed, and, where required, shall be filled with the heat transfer fluid medium. The ground loop system shall be tested at the design flow rate(s) and differential pressure(s) recorded. Where the actual pressure change at design flow is more than +/- 10 percent of the design flow pressure drop, the cause shall be identified and corrective action taken.

(4) A method for the removal of air and a method for adding heat transfer fluid (where necessary) shall be provided.

(5) The heat pumps shall be operational and adjustments shall be made in accordance with the manufacturer’s installation instructions.

(6) All necessary additional flow tests of the heat exchanger shall be completed prior to heat pump start-up.

(7) The system shall be labeled at the loop charging valves with a permanent-type label, indicating the type of heat transfer fluid used. Where antifreeze is used, the labels shall indicate the antifreeze type and concentration.

(8) Ground heat exchanger and building piping, valves, and operating controls, shall be set, adjusted, and operating as required.

(9) DX systems shall have permanent type labels installed and affixed on the compressor unit with the refrigerant type and quantity.

(10) Supply and return lines, as well as associated isolation valves from individual boreholes or water wells, shall be identified and tagged.

(11) For DX systems, refrigerant liquid and vapor lines from the loop system shall be identified and tagged.

(12) Supply and return lines on submerged systems shall be identified in an approved manner, at the point of entry to a surface water resource.

708.3 Labeling and Marking. Ground source heat pump ground-loop system piping shall be marked with tape, metal tags, or other methods where it enters a building. The marking shall indicate the following words: “GROUND SOURCE HEAT PUMP LOOP SYSTEM.” The marking shall indicate antifreeze used in the system by name and concentration.

708.4 Documentation. The ground source heat pump system as-built installation drawings and instructions shall be provided to the building owner or designated agent.

708.5 Maintenance. The periodic maintenance required, in accordance with the design requirements, shall be provided and be made available to the owner or designated agent.

708.6 Records. The ground source heat pump system construction documents shall be provided to the owner.

708.7 System Start-Up. System startup shall be in accordance with CSA C448.1, CSA C448.2, and Section 708.0.

708.8 Contaminants. Particulate contaminants shall be removed from the indoor piping system prior to initial start-up.
715.0 Direct Exchange (DX) Systems.

715.7 System Start-Up. DX system start-up shall be in accordance with Section 708.0 and the following:
(1) DX systems shall be pressurized using nitrogen for not less than 1 hour. There shall be no allowable variance to the test pressure after being corrected for ambient temperature changes during the test. The test pressure shall not exceed 150 psig (1034 kPa) when pressure testing the compressor unit and indoor system components.
(2) DX systems shall have permanent type labels installed and affixed on the compressor unit with the refrigerant type and quantity.
(3) For DX systems, refrigerant liquid and vapor lines from the loop system shall be identified and tagged.

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<td>CSA C448.2-2016</td>
<td>Design and Installation of Ground Source Heat Pump Systems for Residential and Other Small Buildings</td>
<td>Ground-Source Heat Pumps</td>
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Note: CSA C448.1 and CSA C448.2 meet the requirements for mandatory referenced standards in accordance with Section 15.0 of IAPMO’s Regulations Governing Consensus Development of the Uniform Solar, Hydronics & Geothermal and Swimming Pool, Spa & Hot Tub Codes.

SUBSTANTIATION:
The language pertaining to DX systems has been relocated to Part IV (Direct Exchange Systems) for clarification. Additionally, labeling and marking of ground source heat pump ground loop system piping have been addressed as well as the indication of antifreeze and its concentration for safety reasons.

Proper detailed installation drawings, records, and instructions should be provided to the owner to be used when maintenance, repair or new construction occurs. Records of periodic maintenance should also be provided to ensure all actions are accounted for.

CSA C448.1 and CSA C448.2 are applied to system start-up provisions as both of these standards provide detailed guidelines addressing heat pump performance, valves, operating controls, labeling, delivery documentation, and heat exchanger location. CSA C448.1 pertains to systems installed for commercial use, and CSA C448.2 pertains to systems installed for residential use. Both should be included within this section.

For safety reasons, contaminants must be flushed and removed from the piping system prior to start-up.
Item #: 053
USHGC 2021 Section: 709.0 - 709.1

SUBMITTER: Cary Smith
Sound Geothermal Corporation

RECOMMENDATION:
Revise text

Part I - General.

709.4-709.0 Decommissioning and Abandonment.
709.1 General. Prior to the abandonment or decommissioning of a ground heat exchanger, submerged heat exchanger or ground water (well) the owner shall obtain the necessary permits from the Authority Having Jurisdiction. Decommissioning of geothermal systems shall comply with CSA C448. Prior to the abandonment or decommissioning of geothermal systems, the owner shall obtain the necessary permits from the Authority Having Jurisdiction.

Note: CSA C448 meets the requirements for a mandatory reference standard in accordance with Section 15.0 of IAPMO’s Regulations Governing Consensus Development of the Uniform Solar, Hydronics & Geothermal and Swimming Pool, Spa & Hot Tub Codes.

SUBSTANTIATION:
Proper decommissioning or abandonment eliminates the physical hazard of the well, eliminates a pathway for migration of contamination, and prevents hydrologic changes in the aquifer system, including changes in hydraulic head and mixing of water between aquifers. The actual method will depend on both the reason for abandonment and the condition and construction details of the borehole or well. Many locations have different requirements; therefore, it is imperative to check with the local jurisdiction.

The section is being rewritten to include CSA C448 as this reference standard addresses decommissioning and abandonment of geothermal systems.
Item #: 054

USHGC 2021  Section: 710.0 - 710.6.2.4, 715.0, 715.4

SUBMITTER: Cary Smith
Sound Geothermal Corporation

RECOMMENDATION:
Revise text

Part II – Closed-Loop Systems.

710.0 General.
710.1 Applicability. Part II of this chapter shall apply to geothermal energy systems such as, but not limited to, building systems coupled with a closed-loop systems using water-based fluid as a heat transfer medium.

710.2 Piping and Tubing. Piping and tubing for closed-loop systems shall be in accordance with Section 703.2 and Table 703.2.

710.3 Borehole Piping and Tubing. Borehole piping or tubing for vertical and horizontally drilled closed-loop systems, shall have a minimum wall thickness equal to SDR-11 and shall have a minimum pressure rating of not less than 160 psi (1103 kPa) at 73°F (23°C).

710.4 Underground Fittings. Underground fittings for closed loop systems shall be in accordance with Section 703.3 and Table 703.3.

703.4.2.1 Test Pressure. The maximum test pressure shall be 1.5 times the system design pressure, as determined by Section 703.4.2.3 or Section 703.4.2.4, not to exceed 100 psi (689 kPa). Components or devices with lower pressure-ratings than the pipe shall be protected from excessive pressure during testing by removing or isolating from the test section.

Exception: Where lower pressure-rated components or devices cannot be removed or isolated from the test section, the maximum test pressure shall not exceed the pressure rating of the component or device.

703.4.2.2 Testing Procedure. (remaining text unchanged)

703.4.2.3 Calculation of Static Pressure (Water). (remaining text unchanged)

703.4.2.4 Calculation of Static Pressure (Other Fluids). (remaining text unchanged)

Part IV – Direct Exchange (DX) Systems.

715.0 Direct Exchange (DX) Systems.

706.2715.4 DX System Testing. For DX systems, each loop shall be tested with an inert gas at not less than 315 psi (2172 kPa) for not less than 15 minutes without pressure drop. The pressure reading after grouting of the boreholes shall be maintained in the ground-heat exchanger for not less than 2 hours. For direct exchange (DX) systems, each u-bend shall be tested and proved tight with an inert gas at not less than 315 psi (2172 kPa) and maintained for 15 minutes without pressure drop. The pressure reading after tremie grouting of the boreholes shall be maintained in the ground heat exchanger for not less than 2 hours, in accordance with CSA C448.
Note: CSA C448 meets the requirements for a mandatory reference standard in accordance with Section 15.0 of IAPMO's Regulations Governing Consensus Development of the Uniform Solar, Hydronics & Geothermal and Swimming Pool, Spa & Hot Tub Codes.

SUBSTANTIATION:
Section movements have been made to list all provisions explicit to closed-loop systems in a single location. The addition of Section 710.1 is necessary as it addresses the applicability of the listed provisions. Piping, tubing and fitting material standards and joining methods are already provided in Section 703.2 and Section 703.3, and therefore do not need to be repeated but only referenced.

Additionally, Section 710.3 lists an acceptable minimum wall thickness with a provided dimension ratio and pressure rating for borehole piping and tubing. The addition is necessary as applicable standards of the American Water Works Association (AWWA) require that PE piping and tubing with a minimum dimension ratio of 11 and a pressure rating of not less than a 160 psi for water at 73°F be used for such systems.

Section 710.5 has been revised to exclude information pertaining to DX systems. The removed provisions were then combined with Section 715.4 under Part IV (Direct Exchange Systems) for further clarification on DX system testing.
Item #: 055
USHGC 2021 Section: 711.0 - 711.4

SUBMITTER: Cary Smith
Sound Geothermal Corporation

RECOMMENDATION:
Revise text

**Part II – Closed-Loop Systems.**

706.0711.0 **Ground-Heat Exchanger Testing.**
706.4711.1 **Testing.** Pressure-testing of the ground-heat exchanger shall be performed in accordance with the testing method in Section 703.4710.6.

711.2 **Individual Loop Pressure Testing.** Individual loop testing shall be performed as required by the Authority Having Jurisdiction.

711.3 **Field Pressure Testing – Final.** The ground heat exchanger and building piping shall be cleaned, flushed, and, where required, shall be filled with the heat transfer fluid medium. The ground loop system shall be tested at the design flow rate(s) and differential pressure(s) recorded. Where the actual pressure change at design flow is more than +/- 10 percent of the design flow pressure drop, the cause shall be identified, and corrective action taken.

711.4 **Field Flow Testing - Final.** Final field flow testing shall be performed as required by the Authority Having Jurisdiction.

SUBSTANTIATION:
Ground heat exchanger testing is required for closed-loop systems, and therefore, listed provisions are being moved to Part II (Closed-Loop Systems). Additional provisions on individual loop pressure testing, field pressure testing, and field flow testing have been added to guarantee that such testing is completed. Field pressure testing methods are implemented to ensure that flow rates and differential pressures are within 10% of design parameters.
SUBMITTER: Cary Smith
Sound Geothermal Corporation

RECOMMENDATION:
Revise text

**Part III – Open-Loop Systems.**

**712.0 General.**

**712.1 Applicability.** Part III of this chapter shall apply to geothermal energy systems such as, but not limited to, building systems coupled with a groundwater (well) or surface water open loop using water-based fluid as a heat transfer medium. The regulations of this chapter shall govern the construction, location and installation of geothermal energy systems.

Indoor piping, fittings, and accessories that are part of the groundwater system shall be in accordance with Section 703.5 and Chapter 4.

**712.2 Test Wells.** (remaining text unchanged)

**712.3 Installation of Water Wells.** (remaining text unchanged)

**712.4 Setbacks.** Open loop ground-heat exchangers shall maintain the following minimum setbacks or at distances specified by the Authority Having Jurisdiction:
(a) Ten feet (3048 mm) horizontally from a pressure-tested sewer lateral into a building.
(b) Twenty feet (6096 mm) horizontally from a non-pressure tested sewer lateral into a building.
(c) Three feet (914 mm) horizontally from buried utilities such as electrical, gas, or water.
(d) Fifty feet (15 240 mm) from a water well.
(e) Fifty feet (15 240 mm) from a septic tank and 100 feet (30 480 mm) from a subsurface sewage leaching field.
(f) One hundred feet (30 480 mm) from a spring.

**SUBSTANTIATION:**
Part III (Open-Loop Systems) is being added to display provisions explicit to open-loop systems. Section 712.1 has also be added to clarify the scope and applicability of this part of the chapter.

Setbacks provided are intended to represent geologic averages to create effective retention times for contaminants that may be present in groundwater. Additionally, setbacks are a factor of porosity (the ratio of the void volume of a rock to the total volume of the rock, usually expressed as a percentage) and permeability (the measure of the relative ease with which a porous media can transmit a liquid under a potential gradient) of the subsurface and how groundwater will flow through a property. The proposed setbacks will help ensure safe operation.
SUBMITTER: Cary Smith  
Sound Geothermal Corporation

RECOMMENDATION:  
Add new text

Part III – Open-Loop Systems.

713.0 Open Ground Water Systems.

713.1 General. The installation and use of water wells shall be in accordance with the Authority Having Jurisdiction. The water well records shall include well logs, pumping tests, and aquifer information.

713.2 Open-Loop Water Well Drilling Logs. The water well drilling logs shall include the following:
(1) The subsurface stratigraphy.
(2) The aquifer type and conditions such as, but not limited to, confined, unconfined, flowing and depth.
(3) The drilling method used and the penetration speed.
(4) The presence of substances known to have a potential risk to health and safety shall be documented in the drill logs and the property owner shall be advised of the potential risk to health and safety.

713.3 Design Considerations. A groundwater heat pump system shall be designed by a registered design professional. Due design consideration shall be given to the following:
(1) Where multiple heat pumps or fan coils are connected to a common water loop, a diversified building design load shall be used to design a ground water heat pump.
(2) The water supply well(s) and injection wells, or water discharge system, shall be capable of being operated at sustainable pumping rates that exceed the maximum daily requirements without causing an adverse impact to existing or future offsite uses of groundwater or surface water bodies.
(3) The water temperature and the quality and chemical composition of the water resource are in accordance with the system manufacturer’s recommendations.
(4) The groundwater and surface water resources shall be protected by returning water to the source aquifer or an aquifer with the same water quality, or a surface water body.
(5) The return capacity of the injection, or surface water body discharge system, shall be suitable under winter conditions.
(6) The temperature of the return water shall have no adverse thermal impacts on offsite existing or future uses of groundwater, or on surface water bodies, in accordance with the requirements of the Authority Having Jurisdiction.
(7) Pressure gauges shall be provided to aid in start-up and monitoring of the system during operation.
(8) The ability to switch over operation of supply and return wells for 100 percent standby, redevelopment, cleaning of wells, and the thermal balancing of the ground and aquifer shall be provided.
(9) There shall be no adverse effects on the quality and quantity of offsite existing or future users of groundwater, in accordance with the requirements of the Authority Having Jurisdiction.

SUBSTANTIATION:
From a maintenance and repair perspective, documentation for project specific drilling information is critical for the reliable ongoing operation of an open-loop geothermal system. A registered design professional must determine accurate heating/cooling loads, pumping capacity requirements, source water temperature and chemical makeup as well as potential impacts resulting from re-introduction of water from the system at higher or lower temperatures than when extracted.
Item #: 058

USHGC 2021  Section: 713.0, 713.4 - 713.6

SUBMITTER: Cary Smith
Sound Geothermal Corporation

RECOMMENDATION:
Add new text

**Part III - Open Loop System.**

**713.0 Open Ground Water Systems.**

**713.4 Water Wells and Injection Wells.** Water wells and injection wells for groundwater heat pump systems shall be installed by a registered professional who is qualified to drill wells that comply with the requirements of the Authority Having Jurisdiction. Water supply wells and injection wells shall be developed in accordance with NGWA-01.

**713.5 Testing and Sampling.** Pumping tests and water sampling shall be done as required by the registered design professional.

**713.6 Disinfection.** Water wells shall be disinfected upon completion in accordance with requirements of the Authority Having Jurisdiction and NGWA-01.

Note: NGWA-01 meets the requirements for a mandatory referenced standard in accordance with Section 15.0 of IAPMO's Regulations Governing Consensus Development of the Uniform Solar, Hydronics & Geothermal and Swimming Pool, Spa & Hot Tub Codes.

SUBSTANTIATION:
Water well and injection well testing must be performed to determine both water flow and quality. In order to gain information about the producing aquifer and relating drawdowns, a multi-well test is required. In this test, the production well pumps at a controlled rate, and at least one nearby well monitors the water level. Testing periods must be 24 hours or longer. The purpose of performing water quality tests is to determine the chemical nature of the water, any impact upon system material selections, and maintenance requirements. Water quality testing is a critical part of the well testing phase as it determines whether water chemistry issues exist.
Item #: 059

USHGC 2021  Section: 714.0 - 714.7

SUBMITTER: Cary Smith
Sound Geothermal Corporation

RECOMMENDATION:
Add new text

**Part III - Open Loop System.**

714.0 Testing and Verification.  
714.1 Pumping Test. Water supply wells and injection wells shall undergo a stop and start pumping test to demonstrate the sand-free yield.  
714.2 Retesting. Where sediment is present, the problem shall be corrected, and the test shall be repeated until acceptable results are obtained.  
714.3 Variable Rate Pump Test. The operating conditions of the water supply wells and injection wells shall be evaluated and verified with variable rate pumping.  
714.4 Constant Rate Pump Test. The sustainable well yield, aquifer coefficients, and zones of influences on the groundwater flow requirements shall be confirmed with a constant rate-pumping test. The constant rate-pumping test shall be done on the water supply and injection wells at rates and durations as specified by the registered design professional.  
714.5 Water Level Monitoring. Water levels shall be monitored in the pumping well and observation wells during pumping and recovery periods. The monitoring time intervals shall be as specified by the registered design professional.  
714.6 Injection Wells. Injection testing shall be performed on water wells that are designated to be used as injection wells at rates specified by the registered design professional. The results of the drilling and pumping tests shall be provided to the owner or the owner’s representative and provided in accordance with requirements of the Authority Having Jurisdiction.  
714.7 Re-Injected Water. The water quality of re-injected water into the earth shall comply with the requirements of the Authority Having Jurisdiction.

SUBSTANTIATION:  
Section 714.0 is being added to address testing and verification of open loop systems.  

Variable and constant rate pump testing procedures are necessary to ensure that the system is free of leaks and defects as well as to verify that the water supply volume and chemical content are within specified limits.

Monitoring of nearby wells during the testing phase contributes to understanding of the aquifer characteristics, leading to reliable system design and operation. In addition, this section specifies that all water re-injection must comply with AHJ requirements.
Proposals
Edit Proposal
Item #: 060
USHGC 2021  Section: 715.0 - 715.8

SUBMITTER: Cary Smith
Sound Geothermal Corporation

RECOMMENDATION:
Revise text

Part IV – Direct Exchange (DX) Systems.

715.0 Direct Exchange (DX) Systems.
715.1 General. The installation and use of Direct Exchange (DX) wells shall be in accordance with the Authority Having Jurisdiction. The DX well records shall include well logs, pressure tests, and aquifer information.
715.2 Applicability. Part IV of this chapter shall apply to geothermal energy systems such as, but not limited to, building systems coupled with a DX closed loop using refrigerant as a heat transfer medium. The regulations of this Chapter shall govern the construction, location and installation of geothermal energy systems.

Indoor piping, fittings, and accessories that are part of the ground source system shall be in accordance with Section 703.5 and Chapter 4.

703.6 DX Systems. Copper pipe and tubing installed for DX systems shall be manufactured in accordance with ASTM B280 and copper fittings in accordance with ASME B16.22. Joints shall be purged with an inert gas and brazed with a brazing alloy having 15 percent silver content in accordance with AWS A5.8. Underground piping and tubing shall have a cathodic protection system installed.

706.2 DX System Testing. For DX systems, each loop shall be tested with an inert gas at not less than 315 psi (2172 kPa) for not less than 15 minutes without pressure drop. The pressure reading after grouting of the boreholes shall be maintained in the ground heat exchanger for not less than 2 hours. For direct exchange (DX) systems, each refrigerant u-bend shall be tested and proved tight with an inert gas at not less than 315 psi (2172 kPa) and maintained for 15 minutes without pressure drop. The pressure reading after tremie grouting of the boreholes shall be maintained in the ground heat exchanger for not less than 2 hours, in accordance with CSA C448.

715.3 Indoor Piping. For DX systems, joints shall be purged with an inert gas and brazed with a brazing alloy having 15 percent silver content in accordance with AWS A5.8.

715.4 On Site Storage. For DX systems, copper piping and fittings shall be stored to prevent physical damage, contamination, and each pipe or tubing shall be pressurized with an inert gas and sealed with a cap.

715.5 System Start-Up. DX system start-up shall be in accordance with Section 708.0 and the following:
(1) DX systems shall be pressurized using nitrogen for not less than 1 hour. There shall be no allowable variance to the test pressure after being corrected for ambient temperature changes during the test. The test pressure shall not exceed 150 psig (1034 kPa) when pressure testing the compressor unit and indoor system components.
(2) DX systems shall have permanent type labels installed and affixed on the compressor unit with the refrigerant type and quantity.
(3) For DX systems, refrigerant liquid and vapor lines from the loop system shall be identified and tagged.

715.8 DX Piping. DX Piping shall be installed in accordance with approved plans and specifications, including provisions for cathodic protection.

Note: AWS A5.8 and CSA C448 meet the requirements for mandatory reference standards in accordance with Section 15.0 of IAPMO’s Regulations Governing Consensus Development of the Uniform Solar, Hydronics & Geothermal and Swimming Pool, Spa & Hot Tub Codes.

SUBSTANTIATION:
The proposed language combines all current provisions explicit to DX systems under Part IV (Direct Exchange Systems) for clarification. All listed provisions on indoor piping, on site storage, and system start-up are not new to the code.
Additionally, Section 715.2 provides the applicability for the listed provisions as well as references Section 703.5 (Indoor Piping) and Chapter 4 (Hydronics) to address piping, fittings and accessories for indoor piping to be used in DX systems.
CHAPTER 98
SOLAR PHOTOVOLTAIC SYSTEMS

Part I - General.

901.0801.0 General.
901.1801.1 Electrical Wiring and Equipment. Electrical wiring and equipment shall comply with the requirements of NFPA 70, National Electrical Code (NEC), or local ordinances. This chapter does not provide all electrical information necessary for the installation of a photovoltaic (PV) system. Resort shall be had to the edition of NFPA 70 adopted by the Authority Having Jurisdiction.

901.2801.2 Applicability. The provisions of this chapter apply to solar PV electrical energy systems, other than those covered by Section 832.0, including the array circuit(s), inverter(s), and controller(s) for such systems [see Figure 901.2(1) and Figure 901.2(2)]. Solar-PV-The systems covered by this chapter shall be permitted to be interactive with other electrical power production sources or stand-alone or both, with or without electrical energy storage systems such as batteries. These PV systems shall be permitted to have ac or dc output for utilization. [NFPA 70:690.1]

901.3 Other Articles. Where the requirements of NFPA 70 and this chapter differ, the requirements of this chapter shall apply.

Exception: Solar PV systems, equipment, or wiring installed in a hazardous (classified) location shall also comply with the applicable portions of Article 500 through Article 516 of NFPA 70. [NFPA 70:690.3]

901.4 Output Characteristics. The output of a generator or other electric power production source operating in parallel with an electrical supply system shall be compatible with the voltage, wave shape, and frequency of the system to which it is connected. [NFPA 70:705.14]

901.5 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. [NFPA 70:705.14]
Notes:

1. These diagrams are intended to be a means of identification for photovoltaic system PV power source components, circuits, and connections that make up the PV power source.

2. Disconnecting means required by Section 909.0 are not shown.

3. System grounding and equipment grounding are not shown. See Section 911.0 of this chapter.

2. Custom PV power source designs occur, and some components are optional.

FIGURE 904.2(4) 801.2(1)
IDENTIFICATION OF SOLAR PHOTOVOLTAIC SYSTEM PV POWER SOURCE COMPONENTS
[NFPA 70: FIGURE 690.1(a)]
Notes:
1. These diagrams are intended to be a means of identification for photovoltaic PV system components, circuits, and connections.
2. The PV system disconnect in these diagrams separates the PV system from all other systems.
3. Not all disconnecting means and overcurrent protection required by Section 909.0 through Section 811.1.4 are shown.
4. System grounding and equipment grounding are not shown. See Section 816.0 through Section 822.1.
5. Custom designs occur in each configuration, and some components are optional.

FIGURE 901.2(2) 801.2(2)
IDENTIFICATION OF SOLAR PHOTOVOLTAIC PV SYSTEM COMPONENTS IN COMMON SYSTEM CONFIGURATIONS
[NFPA 70: FIGURE 690.1(b)]
901.6 Ground-Fault Protection. Where ground-fault protection is used, the output of an interactive system shall be connected to the supply side of the ground-fault protection.

Exception: Connection shall be permitted to be made to the load side of ground-fault protection, provided that there is ground-fault protection for equipment from all ground-fault current sources. [NFPA 70:705.32]

901.7 Synchronous Generators. Synchronous generators in a parallel system shall be provided with the necessary equipment to establish and maintain a synchronous condition. [NFPA 70:705.143]

902.0 General Requirements.

902.1 Photovoltaic Systems. Photovoltaic systems shall be permitted to supply a building or other structure in addition to any other electrical supply system(s). [NFPA 70:690.4(A)]

902.2 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 or field labeled for the PV application. [NFPA 70:690.4(B)]

902.3 Qualified Personnel. The installation of equipment and all associated wiring and interconnections shall be performed only by qualified persons. [NFPA 70:690.4(C)] For purposes of this chapter a qualified person is defined as “one who has skills and knowledge related to the construction and operation of the electrical equipment and installations and has received safety training to recognize and avoid the hazards involved.” [NFPA 70:100]

902.4 Multiple Inverters PV Systems. A Multiple PV systems shall be permitted to have multiple inverters be installed in or on a single building or structure. Where the inverters PV systems are remotely located from each other, a directory in accordance with Section 912.1 shall be installed provided 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. [NFPA 70:690.4(D)]

902.5 Locations Not Permitted. PV system equipment and disconnecting means shall not be installed in bathrooms. [NFPA 70:690.4(E)]

902.6 Photovoltaic Modules/Panels/Shingles. Photovoltaic modules/panels/shingles shall comply with UL 1703 and shall be installed in accordance with the manufacturer’s installation instructions and the building code.

903.0 Ground-Fault Protection.

903.1 General. Grounded dc PV arrays shall be provided with dc ground-fault protection in accordance with Section 903.2 through Section 903.4 to reduce fire hazards. Ungrounded dc PV arrays shall comply with Section 910.14.

Exception: Ground mounted or pole mounted PV arrays with not more than two paralleled source circuits and with all dc source and dc output circuits isolated from buildings shall be permitted without ground-fault protection. [NFPA 70:690.5]

903.2 Ground-Fault Detection and Interruption. The ground-fault protection device or system shall comply with the following:

(1) Be capable of detecting a ground-fault in the PV array dc current-carrying conductors and components, including any intentionally grounded conductors.

(2) Interrupt the flow of fault current.

(3) Provide an indication of the fault.

(4) Be listed for providing PV ground-fault protection.

Automatically opening the grounded conductor for measurement purposes or to interrupt the ground-fault current path shall be permitted. Where 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. [NFPA 70:690.5(A)]

903.3 Isolating Faulted Circuits. The faulted circuits shall be isolated by one of the 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 the output circuits. [NFPA 70:690.5(B)]

903.4 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
ELECTRICAL SHOCK HAZARD
IF A GROUND FAULT IS INDICATED,
NORMALLY GROUNDED CONDUCTORS
MAY BE UNGROUNDED AND ENERGIZED

Where the PV 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 Section 903.4.1. [NFPA 70:690.5(C)]
Alternating-Current (ac) Modules.

Photovoltaic Source Circuits. The requirements of this chapter pertaining to PV source circuits shall not apply to ac modules. The PV source circuit, conductors, and inverters shall be considered as internal wiring of an ac module. [NFPA 70:690.6(A)]

Inverter Output Circuit. The output of an ac module shall be considered an inverter output circuit. [NFPA 70:690.6(B)]

Disconnecting Means. A single disconnecting means, in accordance with Section 909.2 and Section 909.4 through Section 909.4.4, shall be permitted for 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. [NFPA 70:690.6(C)]

Overcurrent Protection. The output circuits of ac modules shall be permitted to have overcurrent protection and conductor sizing in accordance with the following [NFPA 70:690.6(D)]:

1. 20-ampere circuits – 18 AWG, not exceeding 50 feet (15 240 mm) of run length
2. 20-ampere circuits – 16 AWG, not exceeding 100 feet (30 480 mm) of run length
3. 20-ampere circuits – Not less than 14 AWG
4. 30-ampere circuits – Not less than 14 AWG
5. 40-ampere circuits – Not less than 12 AWG
6. 50-ampere circuits – Not less than 12 AWG [NFPA 70:240.5(B)(2)]

Part II - Circuit Requirements.

Circuit Requirements.

Maximum Voltage. The maximum voltage of PV system dc circuits shall be the highest voltage between any two circuit conductors or any conductor and ground. PV system dc circuits on or in one- and two-family dwellings shall be permitted to have a maximum voltage of 600 volts or less. PV system dc circuits on or in other types of buildings shall be permitted to have a maximum voltage of 1000 volts or less. Where not located on or in buildings, listed dc PV equipment, rated at a maximum voltage of 1500 volts or less, shall not be required to comply with Parts II and III of Article 490 of NFPA 70. [NFPA 70:690.7]

Maximum Photovoltaic System Voltage Source and Output Circuits. In a dc PV source circuit or output circuit, the maximum PV system voltage for that circuit shall be calculated as the sum of the rated open-circuit voltage of the series-connected PV modules 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 905.1. 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 -40°F (-40°C), or where other than crystalline or multicrystalline silicon PV modules are used, the system voltage adjustment shall be made in accordance with the manufacturer’s instructions. Where open-circuit voltage temperature coefficients are supplied in the instructions for listed PV modules, they shall be used to calculate the maximum PV system voltage in accordance with Section 302.1 instead of using Table 905.1. In accordance with one of the following methods:

1. Instructions in listing or labeling of the module: The sum of the PV module–rated open-circuit voltage of the series-connected modules corrected for the lowest expected ambient temperature using the open-circuit voltage temperature coefficients in accordance with the instructions included in the listing or labeling of the module.
2. Crystalline and multicrystalline modules: For crystalline and multicrystalline silicon modules, the sum of the PV module–rated open-circuit voltage of the series-connected modules corrected for the lowest expected ambient temperature using the correction factor provided in Table 804.1.1.
3. PV systems of 100 kW or larger – For PV systems with a generating capacity of 100 kW or greater, a documented and stamped PV system design, using an industry standard method and provided by a licensed professional electrical engineer, shall be permitted. The maximum voltage shall be used to determine the voltage rating of conductors, cables, disconnects, overcurrent devices, and other equipment. [NFPA 70:690.7(A)]
TABLE 905.1 804.1.1
VOLTAGE CORRECTION FACTORS FOR CRYSTALLINE
AND MULTICRYSTALLINE SILICON MODULES
[NFPA 70: TABLE 690.7(A)] 1, 2

<table>
<thead>
<tr>
<th>AMBIENT TEMPERATURE (°F)</th>
<th>FACTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>76 to 68</td>
<td>1.02</td>
</tr>
<tr>
<td>67 to 59</td>
<td>1.04</td>
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<tr>
<td>58 to 50</td>
<td>1.06</td>
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<td>49 to 41</td>
<td>1.08</td>
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<td>40 to 32</td>
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<td>1.23</td>
</tr>
<tr>
<td>-32 to -40</td>
<td>1.25</td>
</tr>
</tbody>
</table>

For SI units: °C = (°F - 32)/1.8

Notes:
1 Correction factors for ambient temperatures below 77°F (25°C).
2 Multiply the rated open circuit voltage by the appropriate correction factor shown above.

804.1.2 DC-to-DC Converter Source and Output Circuits. In a dc-to-dc converter source and output circuit, the maximum voltage shall be calculated in accordance with Section 804.1.2.1 or Section 804.1.2.2. [NFPA 70:690.7(B)]

804.1.2.1 Single DC-to-DC Converter. For circuits connected to the output of a single dc-to-dc converter, the maximum voltage shall be the maximum rated voltage output of the dc-to-dc converter. [NFPA 70:690.7(B)(1)]

804.1.2.2 Two or More Series Connected DC-to-DC Converters. For circuits connected to the output of two or more series connected dc-to-dc converters, the maximum voltage shall be determined in accordance with the instructions included in the listing or labeling of the dc-to-dc converter. If these instructions do not state the rated voltage of series-connected dc-to-dc converters, the maximum voltage shall be the sum of the maximum rated voltage output of the dc-to-dc converters in series. [NFPA 70:690.7(B)(2)]

905.5 804.2 Bipolar Source and Output Circuits. For two-wire dc circuits connected to bipolar systems PV arrays, the maximum system voltage shall be the highest voltage between the conductors of the two-wire circuit conductors where the following conditions apply: one conductor of the two-wire circuit is connected to the functional ground reference (center tap). To prevent overvoltage in the event of a ground-fault or arc-fault, the array shall be isolated from the ground reference and isolated into two two-wire circuits. [NFPA 70:690.7(C)]

(1) One conductor of each circuit of a bipolar subarray is solidly grounded.
(2) Each circuit is connected to a separate subarray.
(3) The equipment is clearly marked with a label as follows:

WARNING
BIPOLAR PHOTOVOLTAIC ARRAY.
DISCONNECTION OF NEUTRAL OR
GROUNDED CONDUCTORS MAY RESULT IN
OVERVOLTAGE ON ARRAY OR INVERTER.

The warning sign(s) or label(s) shall comply with Section 903.4.1. [NFPA 70:690.7(E)]

905.2 Direct-Current Utilization Circuits. The voltage of dc utilization circuits shall comply with Section 905.2.1 through Section 905.2.5. [NFPA 70:690.7(B)]

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905.2.1 Occupancy Limitation. In dwelling units and guest rooms or guest suites of hotels, motels, and similar occupancies, the voltage shall not exceed 120 volts, nominal, between conductors that supply the terminals of the following:

(1) Luminaires.

(2) Cord-and-plug-connected loads 1440 volt-amperes, nominal, or less than 7/4 hp (0.19 kW). [NFPA 70:210.6(A)]

905.2.2 One Hundred Twenty Volts Between Conductors. Circuits not exceeding 120 volts, nominal, between conductors shall be permitted to supply the following:

(1) The terminals of lampholders applied within their voltage ratings.

(2) Auxiliary equipment of electric-discharge lamps.

(3) Cord-and-plug-connected or permanently connected utilization equipment.

Exception: For lampholders of infrared industrial heating appliances as provided in Section 905.2.6. [NFPA 70:210.6(B)]

905.2.3 Two Hundred Seventy Seven Volts to Ground. Circuits exceeding 120 volts, nominal, between conductors and not exceeding 277 volts, nominal, to ground shall be permitted to supply the following:

(1) Listed electric discharge or listed light-emitting diodetype luminaires.

(2) Listed incandescent luminaires, where supplied at 120 volts or less from the output of a stepdown autotransformer that is an integral component of the luminaire and the outer-shell terminal is electrically connected to a grounded conductor of the branch circuit.

(3) Luminaries equipped with mogul-base screw-shell lampholders.

(4) Lampholders, other than the screw-shell type, applied within their voltage ratings.

(5) Auxiliary equipment of electric-discharge lamps.

(6) Cord-and-plug-connected or permanently connected utilization equipment.

Exception: For lampholders of infrared industrial heating appliances as provided in Section 905.2.6. [NFPA 70:210.6(C)]

905.2.4 Six Hundred Volts Between Conductors. Circuits exceeding 277 volts, nominal, to ground and not exceeding 600 volts, nominal, between conductors shall be permitted to supply the following:

(1) The auxiliary equipment of electric-discharge lamps mounted in permanently installed luminaires where the luminaires are mounted in accordance with one of the following:

(a) Not less than a height of 22 feet (6706 mm) on poles or similar structures for the illumination of outdoor areas such as highways, roads, bridges, athletic fields, or parking lots.

(b) Not less than a height of 18 feet (5486 mm) on other structures such as tunnels.

(2) Cord-and-plug-connected or permanently connected utilization equipment other than luminaires.

(3) Luminaries powered from direct current systems where the luminaire contains a listed, dc-rated ballast that provides isolation between the dc power source and the lamp circuit and protection from electric shock where changing lamps.

Exception: For lampholders of infrared industrial heating appliances as provided in Section 905.2.6. [NFPA 70:210.6(D)]

905.2.5 Over 600 Volts Between Conductors. Circuits exceeding 600 volts, nominal, between conductors shall be permitted to supply utilization equipment in installations where conditions of maintenance and supervision ensure that qualified persons service the installation. [NFPA 70:210.6(E)]

905.2.6 Infrared Lamp Industrial Heating Appliances. In industrial occupancies, infrared heating appliance lampholders shall be permitted to be operated in series on circuits exceeding 150 volts to ground, provided the voltage rating of the lampholders is not less than the circuit voltage.

Each section, panel, or strip carrying a number of infrared lampholders, (including the internal wiring of such section, panel, or strip) shall be considered an appliance. The terminal connection block of each such assembly shall be considered an individual outlet. [NFPA 70:422.14]

905.3 Photovoltaic Source and Output Circuits. In one- and two-family dwellings, PV source circuits and PV output circuits that do not include lampholders, fixtures, or receptacles shall be permitted to have a PV-system voltage not exceeding 600 volts. Other installations with a maximum PV system voltage exceeding 1000 volts shall comply with Section 915.0. [NFPA 70:690.7(C)]

905.4 Circuits Over 150 Volts to Ground. In one- and two-family dwellings, live parts in PV source circuits and PV output circuits exceeding 150 volts to ground shall not be accessible to other than qualified persons while energized. [NFPA 70:690.7(D)]

905.6 Disconnects and Overcurrent Protection. Where energy storage device output conductor length exceeds 5 feet (1524 mm), or where the circuits pass through a wall or partition, the installation shall comply with the following:

(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 shall be permitted.

(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 in Section 905.6(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. [NFPA 70:690.7(E)]

905.7 Live Parts Guarded Against Accidental Contact. Live parts of electrical equipment operating at 50 volts or more shall be guarded against accidental contact by approved enclosures or by one of the following means:
906.0 Circuit Sizing and Current.

906.1 Calculation of Maximum Circuit Current. The maximum current for the specific circuit shall be calculated as follows:

1. The sum of parallel-connected PV module-rated short-circuit currents multiplied by 125 percent. [NFPA 70:690.8(A)]
2. For PV systems with a generating capacity of 100 kW or greater, a documented and stamped PV system design, using an industry standard method and provided by a licensed professional electrical engineer, shall be permitted. The calculated maximum current value shall be based on the highest 3-hour current average resulting from the simulated local irradiance on the PV array accounting for elevation and orientation. The current value used by this method shall not be less than 70 percent of the value calculated using Section 805.1.1, [NFPA 70:690.8(A)(1)]
3. The maximum current shall be the sum of parallel source circuit maximum currents as calculated in Section 906.1. [NFPA 70:690.8(A)(2)]
4. The maximum current shall be the inverter continuous output current rating. [NFPA 70:690.8(A)(3)]
5. 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. [NFPA 70:690.8(A)(4)]
6. The maximum current shall be the dc-to-dc converter continuous output current rating. [NFPA 70:690.8(A)(5)]
7. The maximum current shall be the sum of parallel connected dc-to-dc converter output circuit currents as calculated in Section 805.1.5. [NFPA 70:690.8(A)(6)]
8. PV system currents shall be considered to be continuous. Circuit conductors shall be sized to carry not less than the larger of one of the following: Section 805.1.1 or Section 805.2.2 or where protected by a listed adjustable electronic overcurrent protective device in accordance with Section 806.2(3), not less than the current in Section 805.2.3. [NFPA 70:690.8(B)]
9. One hundred twenty-five percent of the maximum currents as calculated in Section 906.1-805.1 before the application of adjustment and correction factors. [NFPA 70:690.8(B)(1)]
10. The maximum currents calculated in accordance with Section 906.1-805.1 after the application of adjustment and correction factors. [NFPA 70:690.8(B)(2)]
11. The rating or setting of an adjustable electronic overcurrent protective device installed in accordance with Section 805.5. [NFPA 70:690.8(B)(3)]
12. 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 be not less than the sum of the ampere ratings of the overcurrent devices of the individual output circuits. [NFPA 70:690.8(C)]
13. Where a single overcurrent device is used to protect a set of parallel-connected modules. The standard ampere ratings for fuses and inverse time circuit breakers shall be considered as shown in Table 805.5.1. Additional standard ampere ratings for fuses shall be 1, 3, 6, 10, and 601. The use of fuses and inverse time circuit breakers with nonstandard ampere ratings shall be permitted. [NFPA 70:240.6(A)]
14. The rating of adjustable-trip circuit breakers having external means for adjusting the current setting (long-time pickup setting), not meeting the requirements of Section 805.5.3, shall be the maximum setting possible. [NFPA 70:240.6(B)]
15. A circuit breaker(s) that has restricted access to the adjusting means shall be permitted to have an ampere rating(s) that is equal to the adjusted current setting (long-time pickup setting),
907.0-906.0 Overcurrent Protection.  

907.1-906.1 Circuits and Equipment. PV source circuit, PV output circuit, system dc circuit and inverter output circuit, and storage battery circuit conductors and equipment shall be protected against overcurrent. Overcurrent protective devices shall not be required for circuits with sufficient ampacity for the highest available current, in accordance with the requirements of Article 240 of NFPA 70. Protection devices for PV source circuits and PV output circuits shall be in accordance with the requirements of Section 907.2 through Section 907.5. Circuits, either ac or dc, connected to current-limited supplies (e.g., PV modules, ac output of utility-interactive inverters), and connected to sources having higher current availability (e.g., parallel strings of modules, utility power), shall be protected at the source from overcurrent. Circuits connected to current limited supplies (e.g., PV modules, dc-to-dc converters, interactive inverter output circuits) and also connected to sources having higher current availability (e.g., parallel strings of modules, utility power) shall be protected at the higher current source connection.  

Exception: An overcurrent device shall not be required for PV modules or PV source circuit or dc-to-dc converters source circuit conductors sized in accordance with Section 906.2 where one of the following applies: (1) There are no external sources such as parallel-connected source circuits, batteries, or backfeed from inverters. (2) The short-circuit currents from all sources do not exceed the ampacity of the conductors and the maximum overcurrent protective device size rating specified on the PV module nameplate or dc-to-dc converter. [NFPA 70:690.9(A)]  

907.2-906.2 Overcurrent Device Ratings. Overcurrent devices used in PV system dc circuits shall be listed for use in PV systems. Overcurrent devices, where required, shall be rated in accordance with one of the following:  

1. Device ratings shall be not less than 125 percent of the maximum currents calculated in accordance with Section 906.1.  
2. 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.  
3. Adjustable electronic overcurrent protective devices rated or set in accordance with Section 805.5. [NFPA 70:690.9(B)]  

907.3 Direct-Current Rating. Overcurrent devices, either fuses or circuit breakers, used in the dc portion of a PV power system shall be listed and shall have the appropriate voltage, current, and interrupting ratings. [NFPA 70:690.9(C)]  

907.4-906.3 Photovoltaic Source and Output Circuits. Listed PV overcurrent devices. A single overcurrent protective device where required, shall be required to provide overcurrent protection in PV source and output circuits, permitted to protect the PV modules and conductors of each source circuit or the conductors of each output circuit. Where single overcurrent protection devices are used to protect PV source or output circuits, all overcurrent devices shall be placed in the same polarity for all circuits within a PV system. The overcurrent devices shall be accessible but shall not be required to be readily accessible. [NFPA 70:690.9(D)]  

907.5 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 underground PV source circuits that are in accordance with Section 910.14, an overcurrent protection device, where required, shall be installed in each undergrounded circuit conductor and shall be permitted to protect the PV modules and the interconnecting cables. [NFPA 70:690.9(E)]  

907.6-906.4 Power Transformers. Overcurrent protection for a transformer with a source(s) on each side shall be provided in accordance with Section 450.3 of NFPA 70 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. [NFPA 70:690.9(F)]  

908.0-907.0 Stand-Alone Systems.  

908.1 General 807.1 General. The premises wiring system shall be adequate to comply with the requirements of NFPA 70 for a similar installation connected to a service. The wiring on the supply side of the building or structure disconnecting means shall comply with NFPA 70, except as modified in accordance with Section 908.2 through Section 908.6. The wiring system connected to
908.2 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 not be 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. [NFPA 70:690.10(A)]

807.2 Wiring System. Premises wiring systems shall be adequate to meet the requirements of this chapter and NFPA 70 for similar installations supplied by a feeder or service. The wiring on the supply side of the building or structure disconnecting means shall comply with the requirements of this chapter and NFPA 70, except as modified by Section 807.2.1 through Section 807.2.6. [NFPA 70:710.15]

807.2.1 Supply Output. Power supply to premises wiring systems shall be permitted to have less capacity than the calculated load. The capacity of the stand-alone supply shall be equal to or greater than the load posed by the largest single utilization equipment connected to the system. Calculated general lighting loads shall not be considered as a single load. [NFPA 70:690.10(A)]

908.2.2 Sizing and Protection. The circuit conductors between the inverter output and the a stand-alone source and a building or structure disconnecting means shall be sized based on the sum of the output rating of the inverter stand-alone sources. These conductors shall be protected from overcurrents in accordance with Article 240 of NFPA 70. The overcurrent protection shall be located at the output of the inverters. [NFPA 70:690.10(B)

908.2.3 Single 120-Volt Supply. The inverter output of a stand-alone solar PV system Stand-alone systems shall be permitted to supply 120 volts to single-phase, three-wire, 120/240-volt service equipment or distribution panels where there are no 240-volt outlets and where there are no multiwire branch circuits. In all installations, the sum of the ratings of the overcurrent device connected to the output of the inverter power sources shall be less than the rating of the neutral bus in the service equipment. This equipment shall be marked with the following words or equivalent:

WARNING
SINGLE 120-VOLT SUPPLY. DO NOT CONNECT
MULTIWIRE BRANCH CIRCUITS!

The warning sign(s) or label(s) shall comply with Section 903.4.1.810.1.2.1. [NFPA 70:690.10(C)710.15(C)]

908.2.4 Energy Storage or Backup Power System Requirements. Energy storage or backup power supplies are not required. [NFPA 70:690.10(D)710.15(D)]

908.2.5 Back-Fed Circuit Breakers. Plug-in type back-fed circuit breakers connected to a stand-alone or multimode inverter output in stand-alone systems an interconnected supply shall be secured in accordance with Section 908.6.1.807.2.5.1. Circuit breakers marked “line” and “load” shall not be back-fed. [NFPA 70:690.10(E)710.15(E)]

908.2.5.1 Back-Fed Devices. Plug-in type overcurrent protection devices or plug-in type main lug assemblies that are back-fed and used to terminate field-installed ungrounded supply conductors shall be secured in place by an additional fastener that requires other than a pull to release the device from the mounting means on the panel. [NFPA 70:408.36(D)]

807.2.6 Voltage and Frequency Control. The stand-alone supply shall be controlled so that voltage and frequency remain within suitable limits for the connected loads. [NFPA 70:710.15(F)]

908.7808.0 Arc-Fault Circuit Protection (Direct Current). 908.1 Arc-Fault Circuit Protection. Photovoltaic systems with dc source circuits, dc output circuits or both, operating at a PV system maximum system voltage of not less than operating at 80 volts dc or greater between any two conductors shall be protected by a listed (de) PV arc-fault circuit interrupter, PV type, or other system components listed to provide equivalent protection. The PV arc fault protection means shall comply with the following requirements:

(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 de PV system dc 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.

Exception: For PV systems not installed on or in buildings, PV output circuits and dc-to-de converter output circuits that are direct buried, installed in metallic raceways, or installed in enclosed metallic cable trays are permitted without arc-fault circuit protection. Detached structures whose sole purpose is to house PV system equipment shall not be considered buildings according to this exception. [NFPA 70:690.11]

908.8 809.0 Rapid Shutdown of PV Systems on Buildings. 809.1 Reduce Shock Hazard. PV system circuits installed on or in buildings shall include a rapid shutdown function that controls specific conductors to reduce shock hazard for emergency responders in accordance with the following: Section 809.1.1 through Section 809.1.4.

Exception: Ground mounted PV system circuits that enter buildings, of which the sole purpose is to house PV system equipment, shall not be required to comply with Section 809.1. [NFPA 70:690.12]

(+) 809.1.1 Controlled Conductors. Requirements for controlled conductors shall apply only to PV system conductors of more than 5 feet (1524 mm) in length inside a building, or more than 10 feet (3048 mm) from a PV array; circuits supplied by the PV
The rapid shutdown initiation methods shall be labeled in accordance with Section 912.8. [NFPA 70:690.12(A)]

3. Voltage and power shall be measured between any two conductors and between any conductor and ground.

4. The rapid shutdown initiation methods shall be labeled in accordance with Section 912.8.

5. Equipment that performs the rapid shutdown shall be listed and identified. [NFPA 70:690.12(B)]

**809.1.2 Controlled Limits.** The use of the term array boundary in this section is defined as 1 foot (305 mm) from the array in all directions. Controlled conductors outside the array boundary shall comply with Section 809.1.2.1 and inside the array boundary shall comply with Section 809.1.2.2. [NFPA 70:690.12(B)]

6. **809.1.2.1 Outside the Array Boundary.** Controlled conductors located outside the boundary or more than 3 feet (914 mm) from the point of entry inside a building shall be limited to not more than 30 volts within 30 seconds of rapid shutdown initiation. Voltage shall be measured between any two conductors and between any conductor and ground. [NFPA 70:690.12(B)]

7. **809.1.2.2 Inside the Array Boundary.** The PV system shall comply with one of the following:
   (1) The PV array shall be listed or field labeled as a rapid shutdown PV array. Such a PV array shall be installed and used in accordance with the instructions included with the rapid shutdown PV array listing or field labeling.
   (2) Controlled conductors located inside the boundary or not more than 3 feet (914 mm) from the point of penetration of the surface of the building shall be limited to not more than 80 volts within 30 seconds of rapid shutdown initiation. Voltage shall be measured between any two conductors and between any conductor and ground.
   (3) PV arrays with no exposed wiring methods, no exposed conductive parts, and installed more than 8 feet (2438 mm) from exposed grounded conductive parts or ground shall not be required to comply with Section 809.1.2.2.

The requirement of Section 809.1.2.2 shall become effective January 1, 2019. [NFPA 70:690.12(B)]

8. **809.1.3 Initiation Device.** The initiation device(s) shall initiate the rapid shutdown function of the PV system. The device “off” position shall indicate that the rapid shutdown function has been initiated for all PV systems connected to that device. For one-family and two-family dwellings, an initiation device(s) shall be located at a readily accessible location outside the building. The rapid shutdown initiation device(s) shall consist of at least one of the following:
   (1) Service disconnecting means
   (2) PV system disconnecting means
   (3) Readily accessible switch that plainly indicates whether in the “off” or “on” position

Where multiple PV systems are installed with rapid shutdown functions on a single service, the initiation device(s) shall consist of not more than six switches or six sets of circuit breakers, or a combination of not more than six switches and sets of circuit breakers, mounted in a single enclosure, or in a group of separate enclosures. These initiation device(s) shall initiate the rapid shutdown of all PV systems with rapid shutdown functions on that service. Where auxiliary initiation devices are installed, these auxiliary devices shall control all PV systems with rapid shutdown functions on that service. [NFPA 70:690.12(C)]

9. **809.1.4 Equipment.** Equipment that performs the rapid shutdown functions, other than initiation devices such as listed disconnect switches, circuit breakers, or control switches, shall be listed for providing rapid shutdown protection. [NFPA 70:690.12(D)]

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**Part III - Disconnecting Means.**

**909.0-910.0 Disconnecting Means.**

**909.1-910.1 Building or Other Structure Supplied by a Photovoltaic System Disconnecting Means.** Means shall be provided to disconnect ungrounded dc conductors of a PV system from other conductors in a building or other structure all wiring systems including power systems, energy storage systems, and utilization equipment and its associated premises wiring. [NFPA 70:690.13]

**909.1.1 Location.** The PV system 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. [NFPA 70:690.13(A)]

**Exception:** Installations that comply with Section 910.6 shall be permitted to have the disconnecting means located remote from the point of entrance of the system conductors. [NFPA 70:690.13(B)]

**909.1.2 Markings.** Each PV system disconnecting means shall be permanently marked to identify it as a PV system disconnect, plainly indicate whether in the open (off) or closed (on) position and be permanently marked “PV SYSTEM DISCONNECT” or equivalent. Additional markings shall be permitted based upon the specific system configuration. For PV system disconnecting means where the line and load terminals may be energized in the open position, the device shall be marked with the following words or equivalent:

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**WARNING**

**ELECTRIC SHOCK HAZARD**

**TERMINALS ON THE LINE AND LOAD SIDES MAY BE**

**ENERGIZED IN THE OPEN POSITION**
903.4.1 810.1.2.1 Field-Applied Hazard Markings. Where caution, warning, or danger signs or labels are required by this chapter, the labels shall comply with the following requirements:

1. The marking shall adequately warn of the hazards using effective words, colors, or symbols, or any combination thereof.
2. The label shall be permanently affixed to the equipment or wiring method and shall not be hand written.

Exception: Portions of labels or markings that are variable, or that could be subject to changes, shall be permitted to be hand written and shall be legible.

3. The label shall be durable as of sufficient durability to withstand the environment involved. [NFPA 70:110.21(B)]

909.1.3 Suitable for Use. Each if the PV system is connected to the supply side of the service disconnecting means shall not be required to be suitable as permitted in Article 230.82(6) of NFPA 70, the PV system disconnecting means shall be listed as suitable for use as service equipment. [NFPA 70:690.13(C)]

909.1.4 Maximum Number of Disconnects. The Each PV system disconnecting means shall consist of not more than six switches or six sets of circuit breakers or a combination of not more than six switches and sets of circuit breakers, mounted in a single enclosure or in a group of separate enclosures. A single PV system disconnecting means shall be permitted for the combined ac output of one or more inverters or ac modules in an interactive system. [NFPA 70:690.13(D)]

909.1.5 810.1.5 Grouping Rating. The PV system disconnecting means shall be grouped with other disconnecting means for the system to be in accordance with Section 909.1.4. A PV disconnecting means shall not be required at the PV module or array location have ratings sufficient for the maximum circuit current available short-circuit current, and voltage that is available at the terminals of the PV system disconnect. [NFPA 70:690.13(E)]

810.1.6 Type of Disconnect. The type(s) of disconnect shall be in accordance with the Section 810.1.6.1 through Section 810.1.6.3.

810.1.6.1 Simultaneous Disconnection. The PV system disconnecting means shall simultaneously disconnect the PV system conductors of the circuit from all conductors of other wiring systems. The PV system disconnecting means shall be an externally operable general-use switch or circuit breaker, or other approved means. A dc PV system disconnecting means shall be marked for use in PV systems or be suitable for backfeed operation. [NFPA 70:690.13(F)(1)]

810.1.6.2 Devices Marked “Line” and “Load.” Devices marked with “line” and “load” shall not be permitted for backfeed or reverse current. [NFPA 70:690.13(F)(2)]

810.1.6.3 DC-Rated Enclosed Switches, Open-Type Switches, and Low-Voltage Power Circuit Breakers. DC-rated, enclosed switches, open-type switches, and low-voltage power circuit breakers shall be permitted for backfeed operation. [NFPA 70:690.13(F)(3)]

909.2811.0 Disconnection of Photovoltaic Equipment. 811.1 Isolating Devices. Isolating devices shall be provided to disconnect equipment, such as inverters, batteries, isolate PV modules, ac PV modules, fuses, dc-to-dc converters inverters, and charge controllers from ungrounded conductors of all sources. Where the equipment is energized from more than one source, the disconnecting means shall be grouped and identified. A single disconnecting means in accordance with Section 909.4 through Section 909.4 shall be permitted for the combined ac output of one or more inverters or ac modules in an interactive system. All conductors that are not solidly grounded. An equipment disconnecting means or a PV system disconnecting means shall be permitted in place of an isolating device. Where the maximum circuit current is greater than 30 amperes for the output circuit of a dc combiner or the input circuit of a charge controller or inverter, an equipment disconnecting means shall be provided for isolation. Where a charge controller or inverter has multiple input circuits, a single equipment disconnecting means shall be permitted to isolate the equipment from the input circuits. [NFPA 70:690.15]

811.1.1 Location. Isolating devices or equipment disconnecting means shall be installed in circuits connected to equipment at a location within the equipment, or within sight and within 10 feet (3048 mm) of the equipment. An equipment disconnecting means shall be permitted to be remote from the equipment where the equipment disconnecting means can be remotely operated from within 10 feet (3048 mm) of the equipment. [NFPA 70:690.15(A)]

811.1.2 Interrupting Rating. An equipment disconnecting means shall have an interrupting rating sufficient for the maximum short-circuit current and voltage that is available at the terminals of the equipment. An isolating device shall not be required to have an interrupting rating. [NFPA 70:690.15(B)]

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

1. A connector meeting the requirements of Section 814.1 and listed and identified for use with specific equipment
2. A finger safe fuse holder
3. An isolating switch that requires a tool to open
4. An isolating device listed for the intended application

An isolating device shall be rated to open the maximum circuit current under load or be marked “Do Not Disconnect Under Load” or “Not for Current Interrupting.” [NFPA 70:690.15(C)]

811.1.4 Equipment Disconnecting Means. An equipment disconnecting means shall simultaneously disconnect all current carrying conductors that are not solidly grounded of the circuit to which it is connected. An equipment disconnecting means shall be externally operable without exposing the operator to contact with energized parts, shall indicate whether in the open (off) or closed (on) position, and shall be lockable in accordance with Section 110.2S of NFPA 70. An equipment disconnecting means shall be one of the following devices:
A dc PV disconnecting means shall be mounted within sight of or in each inverter. A disconnecting switch shall be permitted in a grounded conductor where in accordance with the following:

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

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

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

(d) The switch is marked in accordance with the warning in Section 909.1.1.

(e) A plaque shall be installed in accordance with Section 909.4.4. Where terminals of the disconnecting means are capable of being energized in the open position, a warning sign shall be mounted on or adjacent to the disconnecting means.

(f) Non-load-break-rated disconnecting means shall be marked “Do not open under load.” [NFPA 70:690.16(B)]

(g) The switch is part of a ground-fault detection system required by Section 903.1 through Section 903.4, or that is part of an arc-fault detection or interruption system required by Section 908.7, 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.

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

(i) An ac disconnecting means shall be mounted within sight of or in each inverter.

(j) The ac output conductors from the inverter and an additional ac disconnecting means for the inverter shall comply with Section 909.1.

(k) A dc-rated switch suitable for backfeed operation.

(l) A dc-rated molded-case switch suitable for backfeed operation.

(m) A dc-rated open-type switch.

(n) A dc-rated molded-case circuit breaker.

(o) A dc-rated open-type switch.

(p) A dc-rated molded-case circuit breaker.

(q) A dc-rated open-type switch.

(r) A plaque shall be installed in accordance with Section 912.1. [NFPA 70:690.15(A)]

(q) An ac disconnecting means shall be mounted within sight of or in each inverter.

(r) The ac output conductors from the inverter and an additional ac disconnecting means for the inverter shall comply with Section 909.1.1.

(s) 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 terminals of the disconnecting means are capable of being energized in the open position, a warning sign shall be mounted on or adjacent to the disconnecting means.

(t) A dc-rated molded-case switch suitable for backfeed operation.

(u) A dc-rated open-type switch.

(v) A dc-rated molded-case circuit breaker.

(w) A dc-rated open-type switch.

(x) A plaque shall be installed in accordance with Section 912.1. [NFPA 70:690.15(A)]

(y) 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 terminals of the disconnecting means are capable of being energized in the open position, a warning sign shall be mounted on or adjacent to the disconnecting means.

(z) A dc-rated molded-case switch suitable for backfeed operation.

(aa) A dc-rated open-type switch.

(bb) A dc-rated molded-case circuit breaker.

(cc) A dc-rated open-type switch.
The warning sign(s) or label(s) shall comply with Section 903.4.1.

**Exception:** A connector shall be permitted to be used as an ac or a dc disconnecting means, provided that it is in accordance with the requirements of Section 910.12 and is listed and identified for use with specific equipment. [NFPA 70:690.17(E)]

**909.5 Installation and Service of an Array.** Open circuiting, short circuiting, or opaque covering shall be used to disable an array or portions of an array for installation and service. [NFPA 70:690.18]

### Part IV - Wiring Methods.

**940.0-812.0 Wiring Methods Permitted.**

**940.4-812.1 General Wiring Systems.** All raceway and cable wiring methods included in this chapter, 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 PV source and output circuits operating at maximum system voltages exceeding greater than 30 volts are installed in readily accessible locations, circuit conductors shall be guarded or installed in a Type MC cable or in raceway. For ambient temperatures exceeding 86°F(30°C), conductor ampacities shall be corrected in accordance with Table 812.1. [NFPA 70:690.31(A)]

#### TABLE 940-5 812.1
**CORRECTION FACTORS**

<table>
<thead>
<tr>
<th>AMBIENT TEMPERATURE (°F)</th>
<th>140°F</th>
<th>167°F</th>
<th>194°F</th>
<th>221°F</th>
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<td>86</td>
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<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>87–95</td>
<td>0.91</td>
<td>0.94</td>
<td>0.96</td>
<td>0.97</td>
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<tr>
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<td>0.88</td>
<td>0.91</td>
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<tr>
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<tr>
<td>159–176</td>
<td>—</td>
<td>—</td>
<td>0.41</td>
<td>0.58</td>
</tr>
</tbody>
</table>

For SI units: °C = (°F - 32)/1.8

**940.2-812.2 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. **The means of identification shall be permitted by separate color coding, marking tape, tagging, or other approved means.** PV system circuit conductors shall be identified and grouped as follows: required by Section 812.2.1 through Section 812.2.2. The means of identification shall be permitted by separate color coding, marking tape, tagging, or other approved means. [NFPA 70:690.31(B)]

**812.2.1 Identification.** (1) **PV source circuits** system circuit conductors shall be identified at all accessible points of termination, connection, and splices.

The means of identification shall be permitted by separate color coding, marking tape, tagging, or other approved means. **Only solidly grounded PV system circuit conductors, in accordance with Section 816.1(5), shall be marked in accordance with Section 200.6 of NFPA 70.**

(2) The conductors of PV output circuits and inverter input and output circuits shall be identified at points of termination, connection, and splices.
TABLE 812.5
MINIMUM PV WIRE STRANDS
[NFPA 70: TABLE 690.31(E)]

<table>
<thead>
<tr>
<th>PV WIRE AWG</th>
<th>MINIMUM STRANDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>17</td>
</tr>
<tr>
<td>16 – 10</td>
<td>19</td>
</tr>
<tr>
<td>8 – 4</td>
<td>49</td>
</tr>
<tr>
<td>2</td>
<td>130</td>
</tr>
<tr>
<td>1 AWG – 1000 MCM</td>
<td>259</td>
</tr>
</tbody>
</table>

910.6 812.6 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 comply with meet the ampacity requirements of Section 400.5 of NFPA 70. Section 310.15 of NFPA 70 shall be used to determine the cable ampacity adjustment and correction factors. [NFPA 70:690.31(F)]

910.7 812.7 Direct-Current Photovoltaic Source and System Direct-Current Output on or Circuits Inside On or In a Building. Where dc PV-source or dc PV-output PV system dc circuits from run inside a building-integrated systems or other PV systems are run inside a building or structure, they shall be contained in metal raceways, Type MC metal-clad cable that is in accordance with Section 250.118(10) of NFPA 70, 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 Section 909.1.2 810.1.2, Section 909.1.3 810.1.3, Section 909.2.1 811.1.1 and Section 909.2.2 811.1.2. The wiring methods shall comply with the additional installation requirements in Section 910.7.4 812.7.4 through Section 910.7.4 812.7.4. [NFPA 70:690.31(G)]

910.7.4 812.7.1 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. [NFPA 70:690.31(G)(1)]

910.7.2 812.7.2 Flexible Wiring Methods. Where flexible metal conduit (FMC) less smaller than the trade size 3/4 (21 metric designator 21) or Type MC cable less than 1 inch (25 mm) in diameter containing PV power circuit conductors is installed across ceilings or floors joists, the raceway or cable shall be protected by substantial guard strips that are not less than the height of at least...
Marking and Labeling Required. The following wiring methods and enclosures that contain PV power source system dc circuit conductors shall be marked with the wording “WARNING: Photovoltaic Power Source” by means of permanently affixed labels or other approved permanent markings:

1. Exposed raceways, cable trays, and other wiring methods.
2. Covers or enclosures of pull boxes and junction boxes.
3. Conduit bodies where in which any of the available conduit openings are unused. [NFPA 70:690.31(G)(3)]

Markings and Labeling Methods and Locations. The labels or markings shall be visible after installation. The labels shall be reflective, and all letters shall be capitalized and shall be of a minimum height of not less than 3/8 of an inch (9.5 mm) in white on a red background. PV power system dc circuit labels shall appear on every section of the wiring system that is separated by enclosures, walls, partitions, ceilings, or floors. Spacing between labels or markings, or between a label and a marking, shall not exceed more than 10 feet (3048 mm). Labels required by this section shall be suitable for the environment where they are installed. [NFPA 70:690.31(G)(4)]

Types of Equipment Grounding Conductors. The equipment grounding conductor installed with or enclosing the circuit conductors shall be one or more or a combination of the following:

1. A copper, aluminum, or copper-clad aluminum conductor. This conductor shall be solid or stranded; insulated, covered, or bare; and in the form of a wire or a busbar of any shape.
2. Rigid metal conduit.
3. Intermediate metal conduit.
4. Electrical metallic tubing.
5. Listed flexible metal conduit meeting all the following conditions:
   a. The conduit is terminated in listed fittings.
   b. The circuit conductors contained in the conduit are protected by overcurrent devices rated at 20 amperes or less.
   c. The size of the conduit does not exceed trade size 1 1/4 (35 metric designator).
   d. The combined length of flexible metal conduit and flexible metallic tubing and liquidtight flexible metal conduit in the same ground-fault current path shall not exceed 6 feet (1829 mm).
6. Listed liquidtight flexible metal conduit meeting the following conditions:
   a. The conduit is terminated in listed fittings.
   b. For trade sizes 5/8 through 1/2 (12 through 16 metric designator), the circuit conductors contained in the conduit are protected by overcurrent devices rated at 20 amperes or less.
   c. For trade sizes 3/4 through 1 1/4 (21 through 35 metric designator), the circuit conductors contained in the conduit are protected by overcurrent devices rated not more than 60 amperes and there is no flexible metal conduit, flexible metallic tubing, or liquidtight flexible metal conduit in trade sizes 5/8 through 1/2 (12 through 16 metric designator) in the ground-fault current path.
   d. The combined length of flexible metal conduit and flexible metallic tubing and liquidtight flexible metal conduit in the same ground-fault current path shall not exceed 6 feet (1829 mm).
7. Armor of Type AC cable in accordance with Section 914.3.7(1) of NFPA 70.
8. The copper sheath of mineral-insulated, metal-sheathed cable Type MI.
9. Type MC cable that provides an effective ground-fault current path in accordance with one or more of the following:
   a. It contains an insulated or uninsulated equipment grounding conductor in accordance with Section 914.3.7(1) of NFPA 70.
   b. The combined metallic sheath and uninsulated equipment grounding/bonding conductor of interlocked metal tape-type MC cable that is listed and identified as an equipment grounding conductor.
   c. The metallic sheath or the combined metallic sheath and equipment grounding conductors of the smooth or corrugated tube-type MC cable that is listed and identified as an equipment grounding conductor.
10. Cable trays in accordance with Section 392.10 of NFPA 70 and Section 392.60 of NFPA 70.
11. Cablebus framework in accordance with Section 370.60(1) of NFPA 70.
12. Other listed electrically continuous metal raceways and listed auxiliary gutters.
13. Surface metal raceways listed for grounding. [NFPA 70:250.118]
14. Flexible, fine-stranded cables shall be terminated only with terminals, lugs, devices, or connectors in accordance with Section 110.14 of NFPA 70. [NFPA 70:690.31(H)]
15. Bipolar PV 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.
unconnected 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. Solidly grounded bipolar PV systems shall be clearly marked with a permanent, legible warning notice indicating that the disconnection of the grounded conductor(s) shall be permitted to 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. [NFPA 70:690.31(I)]

**910.10 Module Connection Arrangement.** The connection to a module or panel shall be arranged so that removal of a module or panel from a PV source circuit does not interrupt a grounded conductor connection to other PV source circuits. [NFPA 70:690.31(D)]

**910.14 Ungrounded Photovoltaic Power Systems.** Photovoltaic power systems shall be permitted to operate with ungrounded PV source and output circuits where the system is in accordance with Section 910.14.1 through Section 910.14.7.

**910.14.1 Disconnects.** PV source and output circuit conductors shall have disconnects in accordance with Section 909.0. [NFPA 70:690.35(A)]

**910.14.2 Overcurrent Protection.** PV source and output circuit conductors shall have overcurrent protection in accordance with Section 907.6. [NFPA 70:690.35(B)]

**910.14.3 Ground-Fault Protection.** PV source and output circuits shall be provided with a ground-fault protection device or system that is in accordance with the following:

1. Detects ground fault(s) in the PV array dc current-carrying conductors and components.
2. Indicates that a ground fault has occurred.
3. Automatically disconnects conductors or causes the inverter or charge controller connected to the faulted circuit to automatically cease supplying power to output circuits.
4. Is listed for providing PV ground fault protection. [NFPA 70:690.35(C)]

**910.14.4 Conductors.** The PV source conductors shall consist of the following:

1. Metallic or nonmetallic jacketed multiconductor cables.
2. Conductors installed in raceways.
3. Conductors listed and identified as PV wire installed as exposed, single conductors.
4. Conductors that are direct-buried and identified for direct-burial use. [NFPA 70:690.35(D)]

**910.14.5 Battery Systems.** The PV power system direct-current circuits shall be permitted to be used with ungrounded battery systems in accordance with Section 914.7. [NFPA 70:690.35(E)]

**910.14.6 Marking.** The PV power source shall be labeled with the following warning at each junction box, combiner box,
disconnect, and device where energized, ungrounded circuits are capable of being exposed during service:

WARNING
ELECTRIC SHOCK HAZARD. THE DC CONDUCTORS OF THIS PHOTOVOLTAIC SYSTEM ARE UNGROUNDED AND MAY BE ENERGIZED.

The warning sign(s) or label(s) shall comply with Section 903.4.1. [NFPA 70:690.35(F)]

910.14.7 Equipment. The inverters or charge controllers used in systems with ungrounded PV source and output circuits shall be listed for the purpose. [NFPA 70:690.35(G)]

Part V - Grounding and Bonding.

911.0-816.0 Grounding and Bonding.
911.1-816.1 PV System Grounding Configurations. Photovoltaic systems shall comply with one of the following One or more of the following system grounding configurations shall be employed:
(1) Ungrounded systems shall comply with Section 910.14.
(2) Grounded two-wire systems shall have one conductor grounded or be impedance grounded, and the system shall comply with Section 903.0.
(3) Grounded bipolar systems shall have the reference (center tap) conductor grounded or be impedance grounded, and the system shall comply with Section 903.0.
(4) Other methods that provide equivalent system protection in accordance with Section 911.1 through Section 911.1.5 with equipment listed and identified for the use shall be permitted to be used.
(1) 2-wire PV arrays with one functional grounded conductor.
(2) Bipolar PV arrays according to Section 804.2 with a functional ground reference (center tap).
(3) PV arrays not isolated from the grounded inverter output circuit.
(4) Ungrounded PV arrays.
(5) Solidly grounded PV arrays as permitted in Section 816.2 (Exception).
(6) PV systems that use other methods that accomplish equivalent system protection in accordance with Section 816.1.1 through Section 816.1.5 with equipment listed and identified for the use. [NFPA 70:690.41(A)]

911.1.1-816.1.1 Electrical System Grounding. Electrical systems that are grounded shall be connected to earth in a manner that will limit the voltage imposed by lightning, line surges, or unintentional contact with higher-voltage lines and that will stabilize the voltage to earth during normal operation. [NFPA 70:250.4(A)(1)]

911.1.2-816.1.2 Grounding of Electrical Equipment. Normally non-current-carrying conductive materials enclosing electrical conductors or equipment, or forming part of such equipment, shall be connected to earth so as to limit the voltage to ground on these materials. [NFPA 70:250.4(A)(2)]

911.1.3-816.1.3 Bonding of Electrical Equipment. Normally non-current-carrying conductive materials enclosing electrical conductors or equipment, or forming part of such equipment, shall be connected together and to the electrical supply source in a manner that establishes an effective ground-fault current path. [NFPA 70:250.4(A)(3)]

911.1.4-816.1.4 Bonding of Electrically Conductive Materials and Other Equipment. Normally non-current-carrying electrically conductive materials that are likely to become energized shall be connected together and to the electrical supply source in a manner that establishes an effective ground-fault current path. [NFPA 70:250.4(A)(4)]

911.1.5-816.1.5 Effective Ground-Fault Current Path. Electrical equipment and wiring and other electrically conductive material that likely to become energized shall be installed in a manner that creates a low-impedance circuit facilitating the operation of the overcurrent device or ground detector for high-impedance grounded systems. It shall be capable of safely carrying the maximum ground-fault current likely to be imposed on it from any point on the wiring system where a ground fault may occur to the electrical supply source. The earth shall not be considered as an effective ground-fault current path. [NFPA 70:250.4(A)(5)]

816.2 Ground-Fault Protection. DC PV arrays shall be provided with dc ground-fault protection meeting the requirements of Section 816.3 and Section 816.4 to reduce fire hazards.
Exception: PV arrays with not more than two PV source circuits and with all PV system dc circuits not on or in buildings shall be permitted without ground-fault protection where solidly grounded. [NFPA 70:690.41(B)]

816.3 Ground-Fault Detection. The ground fault protective device or system shall detect ground fault(s) in the PV array dc current-carrying conductors and components, including any functional grounded conductors, and be listed for providing PV ground-fault protection. [NFPA 70:690.41(B)(1)]

816.4 Isolating Faulted Circuits. The faulted circuits shall be isolated by one of the following methods:
(1) The current-carrying conductors of the faulted circuit shall be automatically disconnected.
(2) The inverter or charge controller fed by the faulted circuit shall automatically cease to supply power to output circuits and isolate the PV system dc circuits from the ground reference in a functional grounded system. [NFPA 70:690.41(B)(2)]

911.2-817.0 Point of System Grounding Connection.
817.1 Grounding Connection. The dc circuit grounding connection shall be made at any single point on the PV output circuit. Exception: Systems with a ground-fault protection device in accordance with Section 903.0 shall be permitted to have the required grounded conductor to ground bond made by the ground-fault protection device. This bond, where internal to the ground-fault equipment, shall not be duplicated with an external connection. Systems with a ground-fault protection device in accordance with Section 816.2 shall have any current-carrying conductor-to-ground connection made by the ground-fault protective device. For solidly grounded PV systems, the dc circuit grounding connection shall be made at any single point on the PV output circuit. [NFPA 70:690.42]

911.3.2 Equipment Grounding Required. An equipment grounding conductor between a PV array and other equipment shall be required in accordance with Section 911.3.2.1. [NFPA 70:690.43(B)]

911.3.3.1818.1.2 Structure as Equipment Grounding Conductor Secured to Grounded Metal Supports. Devices listed, labeled and identified for bonding and grounding the metallic frames, metal parts of PV systems modules, or other equipment shall be permitted to bond the exposed metal surfaces or other equipment to mounting structures. [NFPA 70:690.43(A)]

914.3.3.1818.2 Equipment Fastened in Place or Connected by Permanent Wiring Methods (Fixed) — Grounding. Unless grounded by connection to the grounded circuit conductor as permitted by Section 250.32, Section 250.140 and Section 250.142 of NFPA 70, non-current-carrying metal parts of equipment, raceways, and other enclosures, where if grounded, shall be connected to an equipment grounding conductor by one of the following methods specified in Section 818.2.1 or Section 818.2.2. [NFPA 70:690.43(C)]

818.2.1 Equipment Grounding Conductor Types. (A) By connecting to an any of the equipment grounding conductors in accordance with Section 911.3.3.2.1. [NFPA 70:690.43(A)]

818.2.2 With Circuit Conductors. (B) By connecting to an any for circuit conductors contained within the same raceway, cable, or otherwise run with the circuit conductors.

Exceptions:
(1) As provided in Section 911.3.8.1818.3, the equipment grounding conductor shall be permitted to be run separately from the circuit conductors.
(2) For dc circuits, the equipment grounding conductor shall be permitted to be run separately from the circuit conductors. [NFPA 70:690.43(B)]

911.3.8.1818.3 Nongrounding Receptacle Replacement or Branch Circuit Extensions. The equipment grounding conductor of a grounding-type receptacle or a branch-circuit extension shall be permitted to be connected to one any of the following:
(1) An any accessible point on the grounding electrode system in accordance with Section 250.50 of NFPA 70.
(2) An any accessible point on the grounding electrode conductor.
(3) The equipment grounding terminal bar within the enclosure where the branch circuit for the receptacle or branch circuit originates.
(4) An any equipment grounding conductor that is part of another branch circuit that originates from the enclosure where the branch circuit for the receptacle or branch circuit originates.
(5) For grounded systems, the grounded service conductor within the service equipment enclosure.
(6) For ungrounded systems, the grounding terminal bar within the service equipment enclosure. [NFPA 70:250.130(C)]

911.3.4.1818.4 Equipment Considered Secured to Grounded Metal Supports. The normally non-current-carrying metal parts of the equipment shall be considered grounded where the electrical equipment is secured to and in electrical contact with a metal rack or structure provided for its support and connected to an equipment grounding conductor by one of the means indicated in Section 911.3.1.1818.2. [NFPA 70:250.130(A)]

911.3.2.1 Equipment Fastened in Place (Fixed) or Connected by Permanent Wiring Methods. Exposed, normally non-current-carrying metal parts of fixed equipment supplied by or enclosing conductors or components that are likely to become energized shall be connected to an equipment grounding conductor in accordance with one of the following conditions:
(1) Where within 8 feet (2438 mm) vertically or 5 feet (1524 mm) horizontally of ground or grounded metal objects and subject to...
contact by persons.
(2) Where located in a wet or damp location and not isolated.
(3) Where in electrical contact with metal.
(4) Where in a hazardous (classified) location.
(5) Where supplied by a wiring method that provides an equipment grounding conductor.
(6) Where equipment operates with a terminal at over 150 volts to ground.

Exceptions:
(1) Where exempted by special permission, the metal frame of electrically heated appliances that have the frame permanently and effectively insulated from ground shall not be required to be grounded.
(2) Distribution apparatus, such as transformer and capacitor cases, mounted on wooden poles at a height exceeding 8 feet (2438 mm) above ground or grade level shall not be required to be grounded.
(3) Listed equipment protected by a system of double insulation, or its equivalent, shall not be required to be connected to the equipment grounding conductor. Where such a system is employed, the equipment shall be distinctly marked. [NFPA 70:250.110]

911.3.5 Adjacent Modules. Devices identified and listed for bonding the metallic frames of PV modules shall be permitted to bond the exposed metallic frames of PV modules to the metallic frames of adjacent PV modules. [NFPA 70:690.42(E)]

941.4.819.0 Size of Equipment Grounding Conductors.
819.1 General. Equipment grounding conductors for PV source and PV output circuits shall be sized in accordance with Section 250.122 of NFPA 70. Where no overcurrent protective device is used in the circuit, an assumed overcurrent device rated at the PV maximum circuit current in accordance with Section 806.2 shall be used in accordance with when applying Table 911.4.
Increases in equipment grounding conductor size to address voltage drop considerations shall not be required. An equipment grounding conductor shall not be less than 14 AWG. [NFPA 70:690.45]

941.4.819.1 Equipment Grounding Conductor Installation. An equipment grounding conductor shall be installed in accordance with Section 941.4.819.1.2, through Section 941.4.819.1.3, and Section 819.1.4. [NFPA 70:250.120]

941.4.819.1.2 Raceway, Cable Trays, Cable Armor, Cablebus, or Cable Sheaths. Where it consists of a raceway, cable tray, cable armor, cablebus framework, or cable sheath or where it is a wire within a raceway or cable, it shall be installed in accordance with the applicable provisions of NFPA 70 using fittings for joints and terminations approved for use with the type raceway or cable used. All connections, joints, and fittings shall be made tight using suitable tools. [NFPA 70:250.120(A)]

941.4.819.1.3 Aluminum and Copper-Clad Aluminum Conductors. Equipment grounding conductors of bare or insulated aluminum or copper-clad aluminum shall be permitted. Bare conductors shall not come in direct contact with masonry or the earth or where subject to corrosive conditions. Aluminum or copper-clad aluminum conductors shall not be terminated within 18 inches (457 mm) of the earth. [NFPA 70:250.120(B)]

941.4.4 819.1.4 Equipment Grounding Conductors Less Smaller Than 6 AWG. Where not routed with circuit conductors as permitted in Section 941.3.1.1 818.3 (Exception 2) and Section 941.3.8 818.2.2 (Exception 2), equipment grounding conductors less than 6 AWG shall be protected from physical damage by an identified raceway or cable armor unless installed within hollow spaces of the framing members of buildings or structures and where not subject to physical damage. [NFPA 70:250.120(C)]

941.5820.0 Array Equipment Grounding Conductors.
820.1 PV Modules. For PV modules, equipment grounding conductors less smaller than 6 AWG shall comply with Section 941.4.4 819.1.4. Where installed in raceways, equipment grounding conductors and grounding electrode conductors not more than 6 AWG shall be permitted to be solid. [NFPA 70:690.46]
### TABLE 911.4-819.1
MINIMUM SIZE EQUIPMENT GROUNDING CONDUCTORS FOR GROUNDING RACEWAY AND EQUIPMENT
[NFPA 70: TABLE 250.122]

<table>
<thead>
<tr>
<th>RATING OR SETTING OF AUTOMATIC OVERCURRENT DEVICE IN CIRCUIT AHEAD OF EQUIPMENT, CONDUIT, ETC., NOT EXCEEDING (AMPERES)</th>
<th>COPPER</th>
<th>ALUMINUM OR COPPER CLAD ALUMINUM²</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
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</tr>
<tr>
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<td>800</td>
<td>1200</td>
</tr>
</tbody>
</table>

**Notes:**

1. Where necessary to comply with Section 911.4-816.1.5 of this chapter or 250.4(B)(4) of NFPA 70, the equipment grounding conductor shall be sized larger than given in this table.
2. See installation restrictions in Section 911.4-819.1.1.

### 941.6821.0 Grounding Electrode System.

**821.1 Electrode System.** Grounding of electrode systems shall comply with Section 941.6-821.2 through and Section 941.6-821.3.

**911.6.1 Alternating-Current Systems.** Where installing an ac system, a grounding electrode system shall be provided in accordance with Section 250.50 through Section 250.60 of NFPA 70. The grounding electrode conductor shall be installed in accordance with Section 911.6.1.1 through Section 911.6.1.4. [NFPA 70:690.47(A)].

**821.2 Buildings or Structures Supporting a PV Array.** A building or structure supporting a PV array shall have a grounding electrode system installed in accordance with Part III of Article 250 of NFPA 70.

PV array equipment grounding conductors shall be connected to the grounding electrode system of the building or structure supporting the PV array in accordance with Part VII of Article 250 of NFPA 70. This connection shall be in addition to any other equipment grounding conductor requirements in Section 818.1.3. The PV array equipment grounding conductors shall be sized in accordance with Section 819.1.

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

For solidly grounded PV systems, as permitted in Section 816.1(5), the grounded conductor shall be connected to a grounding electrode system by means of a grounding electrode conductor sized in accordance with Section 821.2.1 through Section 821.2.6. [NFPA 70:690.47(A)]

**821.2.1 Size of the Direct-Current Grounding Electrode Conductor.** The size of the grounding electrode conductor for a dc system shall be as specified in Section 821.2.2 and Section 821.2.3, except as permitted by Section 821.2.4 through Section 821.2.6. The grounding electrode conductor for a dc system shall meet the sizing requirements in this section but shall not be
Not Smaller Than the Neutral Conductor. Where the dc system consists of a three-wire balancer set or balancer winding with overcurrent protection in accordance with Section 445.12(D) of NFPA 70, the grounding electrode conductor shall be not smaller than the neutral conductor and shall be not smaller than 8 AWG copper or 6 AWG aluminum. [NFPA 70:250.166(A)]

Not Smaller Than the Largest Conductor. Where the dc system is other than as in accordance with Section 911.6.2.2, the grounding electrode conductor shall be not smaller than the largest conductor supplied by the system, and be not smaller than 8 AWG copper or 6 AWG aluminum. [NFPA 70:250.166(B)]

Connected to Rod, Pipe, or Plate Electrodes. Where connected to rod, pipe, or plate electrodes as in accordance with Section 911.6.2.3, that portion of the grounding electrode conductor that is the sole connection to the grounding electrode shall not be required to be more larger than 6 AWG copper wire or 4 AWG aluminum wire. [NFPA 70:250.166(C)]

Connected to a Concrete-Encased Electrode. Where connected to a concrete-encased electrode in accordance with Section 911.6.2.4, that portion of the grounding electrode conductor that is the sole connection to the grounding electrode shall not be required to be more larger than 6 AWG copper wire. [NFPA 70:250.166(D)]

Connection to a Ground Ring. Where connected to a ground ring as in accordance with Section 911.6.2.5, that portion of the grounding electrode conductor that is the sole connection to the grounding electrode shall not be required to be more larger than the conductor used for the ground ring. [NFPA 70:250.166(E)]

Installation of Electrodes. Grounding electrode conductor(s) and bonding jumpers interconnecting grounding electrodes shall be installed in accordance with one of the following methods. The grounding electrode conductor shall be sized for the largest grounding electrode conductor required among the electrodes connected to it.

1. The grounding electrode conductor shall be permitted to be run to a convenient grounding electrode available in the grounding electrode system where the other electrode(s), where any, is connected by bonding jumpers that are installed in accordance with Section 911.6.1.2 and Section 911.6.1.3.

2. Bonding jumpers(s) shall be permitted to be run to one or more grounding electrode(s) individually.

3. Bonding jumper(s) from grounding electrode(s) shall be permitted to be connected to an aluminum or copper busbar not less than 1/4 of an inch by 2 inches (6.4 mm by 51 mm). The busbar shall be securely fastened and shall be installed in an accessible location. Connections shall be made by a listed connector or by the exothermic welding process. The grounding electrode conductor shall be permitted to be run to the busbar. Where aluminum busbars are used, the installation shall be in accordance with Section 911.6.1.2.

Aluminum or Copper-Clad Aluminum Conductors. Bare aluminum or copper-clad aluminum grounding electrode conductors shall not be used where in direct contact with masonry, earth, or where subject to corrosive conditions. Where used outside, aluminum or copper-clad aluminum grounding electrode conductors shall not be terminated within 18 inches (457 mm) of the earth. [NFPA 70:250.64(A)]

Securing and Protection Against Physical Damage. Where exposed, a grounding electrode conductor or its enclosure shall be securely fastened to the surface on which it is carried. Grounding electrode conductors shall be permitted to be installed on or through framing members. A 4 AWG or large copper or aluminum grounding electrode conductor shall be protected where exposed to physical damage. A 6 AWG grounding electrode conductor that is free from exposure to physical damage shall be permitted to be run along the surface of the building construction without metal covering or protection where it is securely fastened to the construction; otherwise, it shall be protected in rigid metal conduit (RMC), intermediate metal conduit (IMC), rigid polyvinyl chloride conduit (PVC), reinforced thermosetting resin conduit (RTRC), electrical metallic tubing (EMT), or cable armor. Grounding electrode conductors less than 6 AWG shall be protected in RMC, IMC, PVC, RTRC, EMT, or cable armor. Grounding electrode conductors and grounding electrode bonding jumpers shall not be required to comply with Section 300.5 of NFPA 70.

Continuous. Grounding electrode conductor(s) shall be installed in one continuous length without a splice or joint. Where necessary, splices or connections shall be made in accordance with the following:

1. Splicing of the wire type grounding electrode conductor shall be permitted by irreversible compression-type connectors listed as grounding and bonding equipment or by the exothermic welding process.

2. Sections of busbars shall be permitted to be connected together to form a grounding electrode conductor.

3. Bolted, riveted, or welded connections of structural metal frames of building structures.

4. Threaded, welded, brazed, soldered, or bolted-flange connections of metal water piping. [NFPA 70:250.64(C)]

Direct-Current Systems. Where installing a dc system, a grounding electrode system shall be provided in accordance with Section 911.6.2.1 through Section 911.6.2.5 for grounded systems or Section 911.6.2.6 for ungrounded systems. The grounding electrode conductor shall be installed in accordance with Section 911.6.1.1 through Section 911.6.1.4.

A common dc grounding electrode conductor shall be permitted to serve multiple inverters. The size of the common grounding electrode and the tap conductors shall be in accordance with Section 911.6.2.1 through Section 911.6.2.5. The tap conductors shall be connected to the common grounding electrode conductor by exothermic welding or with connectors listed as grounding and bonding equipment in such a manner that the common grounding electrode conductor remains without a splice or joint.

An ac equipment grounding system shall be permitted to be used for equipment grounding of inverters and other equipment and for the ground-fault detection reference for ungrounded PV systems. [NFPA 70:690.17(B)]

Ungrounded Direct-Current Separately Derived Systems. Except as otherwise permitted in Section 250.34 of NFPA 70 for portable and vehicle-mounted generators, an ungrounded dc separately derived system supplied from a stand-alone
power source (such as an engine-generator set) shall have a grounding electrode conductor connected to an electrode that is in accordance with Article 250, Part III of NFPA 70 to provide for grounding of metal enclosures, raceways, cables, and exposed non-current-carrying metal parts of equipment. The grounding electrode conductor connection shall be to the metal enclosure at a point on the separately derived system from the source to the first system disconnecting means or overcurrent device, or it shall be made at the source of a separately derived system that has no disconnecting means or overcurrent device.

The size of the grounding electrode conductor shall be in accordance with Section 911.6.2.1 through Section 911.6.2.5. [NFPA 70:250.52(A)]

911.6.3 Systems with Alternating-Current and Direct-Current Grounding Requirements. Photovoltaic systems having dc-circuits and ac-circuits with no direct connection between the dc-grounded conductor and ac-grounded conductor shall have a dc grounding system. The dc grounding system shall be bonded to the ac grounding system by one of the methods in Section 911.6.3.1 through Section 911.6.3.3.

This section shall not apply to ac-PV modules. Where methods in Section 911.6.3.2 or Section 911.6.3.3 are used, the existing ac grounding electrode system shall be in accordance with the applicable requirements in Article 250, Part III of NFPA 70. [NFPA 70:99]

911.6.3.1 Separate Direct-Current Grounding Electrode System Bonded to the Alternating-Current Grounding Electrode System. A separate de-grounding electrode or system shall be installed, and it shall be bonded directly to the ac grounding electrode system. The size of the bonding jumper(s) between the ac and dc systems shall be based on the larger size of the existing ac grounding electrode conductor or the size of the de grounding electrode conductor in accordance with Section 911.6.2.1 through Section 911.6.2.5. The de grounding electrode system conductor(s) or the bonding jumpers to the ac grounding electrode system shall not be used as a substitute for required ac equipment grounding conductors. [NFPA 70:690.47(C)]

911.6.3.2 Common Direct-Current and Alternating-Current Grounding Electrode. A de-grounding electrode conductor of the size specified in Section 911.6.2.1 through Section 911.6.2.5 shall be run from the marked de-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 Section 911.6.1.4(1) or Section 911.6.1.4(2) or by using a connector listed for grounding and bonding. This dc grounding electrode conductor shall not be used as a substitute for required ac equipment grounding conductors. [NFPA 70:690.47(C)]

911.6.3.3 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 de-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 in Section 250.122 of NFPA 70 or Section 911.6.2.1 through Section 911.6.2.5, and shall be installed in accordance with Section 250.6(E) of NFPA 70. For underground systems, the dc conductor shall be sized in accordance with Section 250.122 of NFPA 70 and shall not be required to be larger than the largest ungrounded phase conductor. [NFPA 70:690.47(C)]

911.6.4 821.3 Additional Auxiliary Electrodes for Array Grounding. A grounding electrode shall be permitted to be installed in accordance with Section 911.6.2.3.1, Section 911.6.2.3.2, Section 911.6.2.4.1, Section 911.6.2.5.1, Section 911.6.4.1 through Section 911.6.4.5, Section 821.3.1 through Section 821.3.9; and Section 250.54 of NFPA 70 at the location of all ground- and pole-mounted PV arrays and as close as practicable to the location of-roof-mounted PV arrays. The electrodes shall be permitted to be connected directly to the array frame(s) or structure. The dc grounding electrode conductor shall be sized in accordance with Section 911.6.2.1 through Section 911.6.2.5 according to Section 250.66 of NFPA 70. Additional electrodes are permitted to be used as a substitute for equipment bonding or equipment grounding conductor requirements. The structure of a ground- or pole mounted ground-mounted PV array shall be permitted to be considered a grounding electrode where in accordance with if it meets the requirements of Section 911.6.2.3.1, Section 911.6.2.3.2, Section 911.6.2.4.1, Section 911.6.2.5.1, and Section 911.6.4.1 through Section 911.6.4.5 Section 821.3.1 through Section 821.3.9. Roof-mounted PV arrays shall be permitted to use the metal frame of a building or structure where in accordance with if the requirements of Section 911.6.4.2 821.3.2 are met.

Exceptions:
(1) An array grounding electrode(s) shall not be required where the load served by the array is integral with the array.
(2) An additional array-grounding electrode(s) shall not be required where located within 6 feet (1829 mm) of the premises wiring electrode. [NFPA 70:690.47(D)]

911.6.4.1 821.3.1 Metal Underground Water Pipe. A metal underground water pipe in direct contact with the earth for 10 feet (3048 mm) or more (including any metal well casing bonded to the pipe) and electrically continuous (or made electrically continuous by bonding around insulating joints or insulating pipe) to the points of connection of the grounding electrode conductor and the bonding conductor(s) or jumper(s), where installed. [NFPA 70:250.52(A)(1)]

911.6.4.2 Metal Frame of the Building or Structure. The metal frame of the building or structure that is connected to the earth by one or more of the following methods:
(1) At least one structural metal member that is in direct contact with the earth for 10 feet (3048 mm) or more, with or without concrete encasement.
(2) Hold down bolts securing the structural metal column that are connected to a concrete-encased electrode that are in accordance with Section 911.6.2.4.1 and is located in the support footing or foundation. The hold down bolts shall be connected to the concrete-encased electrode by welding, exothermic welding, the usual steel tie wires, or other approved means.

821.3.2 Metal In-Ground Support Structure(s). One or more metal in-ground support structure(s) in direct contact with the earth vertically for 10 feet (3048 mm) or more, with or without concrete encasement. If multiple metal in-ground support structures are present at a building or a structure, it shall be permissible to bond only one into the grounding electrode system. [NFPA 70:250.52(A)(2)]
**911.6.2.4.1 821.3.3 Concrete-Encased Electrode.** A concrete-encased electrode shall consist of not less than at least 20 feet (6096 mm) of one of the following:

1. Not less than one *One or more* bare or zinc galvanized or other electrically conductive coated steel reinforcing bars or rods of not less than 1/2 of an inch (12.7 mm) in diameter, installed in one continuous 20 feet foot (6096 mm) length, or where if in multiple pieces connected together by the usual steel tie wires, exothermic welding, welding, or other effective means to create a length of not less than 20 feet foot (6096 mm) or greater length; or.

2. Bare copper conductor not less than 4 AWG.

Metallic components shall be encased by not less than at least 2 inches (51 mm) of concrete and shall be located horizontally within that portion of a concrete foundation or footing that is in direct contact with the earth or within vertical foundations or structural components or members that are in direct contact with the earth. Where if multiple concrete-encased electrodes are present at a building or structure, it shall be permissible to bond only one into the grounding electrode system.

Concrete installed with insulation, vapor barriers, films or similar items separating the concrete from the earth shall not be considered to be in “direct contact” with the earth. [NFPA 70:250.52(A)(3)]

**911.6.2.5.1 821.1.4 Ground Ring.** A ground ring encircling the building or structure, in direct contact with the earth, consisting of not less than 20 feet (6096 mm) of bare copper conductor not less than 2 AWG. [NFPA 70:250.52(A)(4)]

**911.6.2.3.1 821.3.5 Rod and Pipe Electrodes.** Rod and pipe electrodes shall be not be less than 8 feet (2438 mm) in length and shall consist of the following materials:

1. Grounding electrodes of pipe or conduit shall be not smaller than trade size 3/4 (21 metric designator) and, where of steel, shall have the outer surface galvanized or otherwise metal-coated for corrosion protection.

2. Rod-type grounding electrodes of stainless steel and copper or zinc coated steel shall be not less than 5/8 of an inch (15.9 mm) in diameter, unless listed. [NFPA 70:250.52(A)(5)]

**911.6.4.3 821.3.6 Other Listed Electrodes.** Other listed grounding electrodes shall be permitted. [NFPA 70:250.52(A)(6)]

**911.6.2.3.2 821.3.7 Plate Electrodes.** A Each plate electrode shall expose not less than 2 square feet (0.2 m$^2$) of surface to exterior soil. Electrodes of bare or conductively coated iron or steel plates shall be not less than at least 1/4 of an inch (6.4 mm) in thickness. Solid, uncoated electrodes of nonferrous metal shall be not less than at least 0.06 of an inch (1.52 mm) in thickness. [NFPA 70:250.52(A)(7)]

**911.6.4.4 821.3.8 Other Local Metal Underground Systems or Structures.** Other local metal underground systems or structures such as piping systems, underground tanks, and underground metal well casings that are not bonded to a metal water pipe. [NFPA 70:250.52(A)(8)]

**911.6.4.5 821.3.9 Not Permitted for Use as Grounding Electrodes.** The following systems and materials shall not be used as grounding electrodes:

1. Metal underground gas piping systems.
2. Aluminum.

3. The structures and structural reinforcing steel described in Section 680.26(B)(1) of NFPA 70 and Section 680.26(B)(2) of NFPA 70. [NFPA 70:250.52(B)]

**911.7 Continuity of Equipment Grounding Systems.** Where the removal of equipment disconnects the bonding connection between the grounding electrode conductor and exposed conducting surfaces in the PV source or output circuit equipment, a bonding jumper shall be installed while the equipment is removed. [NFPA 70:690.48]

**911.8 Continuity of Photovoltaic Source and Output Circuit Grounded Conductors.** Where the removal of the utility-interactive inverter or other equipment disconnects the bonding connection between the grounding electrode conductor and the PV source, PV output circuit grounded conductor, or both, a bonding jumper shall be installed to maintain the system grounding while the inverter or other equipment is removed. [NFPA 70:690.49]

**911.822.0 Equipment Bonding Jumpers.**

**822.1 Bonding Jumpers.** Equipment bonding jumpers, where if used, shall be in accordance comply with Section 911.4.4 819.1.4. [NFPA 70:690.50]

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**Part VI - Marking.**

**912.0 823.0 Marking.**

**912.1 823.1 Directory.** A permanent plaque or directory, denoting the location of all electrical power sources source disconnecting means on or in the premises, shall be installed at each service equipment location and at location(s) of the system disconnect(s) for all electric power production sources capable of being interconnected. The marking shall comply with Section 810.1.2.1.

**Exception:** Installations with large numbers of power production sources shall be permitted to be designated by groups. [NFPA 70:705.10]

**912.2 823.2 Modules.** Modules shall be marked with identification of terminals or leads as to polarity, maximum overcurrent device rating for module protection, and with the following ratings:

1. Open-circuit voltage
2. Operating voltage
3. Maximum permissible system voltage
4. Operating current
(5) Short-circuit current
(6) Maximum power [NFPA 70:690.51]

**903.4.2823.3 Format.** The marking requirements in Section 903.4.1810.1.2.1 shall be provided in accordance with the following:

1. Red background
2. White lettering
3. Not less than \(\frac{3}{8}\) of an inch (9.5 mm) letter height
4. Capital letters
5. Made of reflective weather-resistant material

**942.3824.0 Alternating-Current Photovoltaic Modules.**

**824.1 Identification.** Alternating-current modules shall be marked with identification of terminals or leads and with identification of the following ratings:

1. Nominal operating ac voltage.
2. Nominal operating ac frequency.
3. Maximum ac power.
4. Maximum ac current.
5. Maximum overcurrent device rating for ac module protection. [NFPA 70:690.52]

**942.4825.0 Direct-Current Photovoltaic Power Source.**

**825.1 Labeling.** A permanent label for the direct-current dc PV power source indicating the information specified in Section 825.1(1) through Section 825.1(3) shall be provided by the installer at the accessible location at the PV disconnecting means as follows: dc PV system disconnecting means and at each dc equipment disconnecting means required by Section 811.1. Where a disconnecting means has more than one dc PV power source, the values in Section 825.1(1) through Section 825.1(3) shall be specified for each source.

1. Rated maximum power-point current.
2. Rated maximum power-point voltage.
3. Maximum system voltage (see Section 804.1 for voltage).
4. Maximum circuit current. Where the PV power source has multiple outputs, Section 912.4(1) and Section 912.4(4) shall be specified for each output. (see Section 805.1 for calculation of maximum circuit current)
5. Maximum rated output current of the charge controller or dc-to-dc converter (where installed). [NFPA 70:690.53]

**942.5-825.2 Interactive System Point of Interconnection.** All interactive system(s) points of interconnection with other sources shall be marked at an accessible location at the disconnecting means as a power source and with the rated ac output current and the nominal operating ac voltage. [NFPA 70:690.54]

**942.6826.0 Photovoltaic Power Systems Employing Connected to Energy Storage Systems.**

**826.1 Marking.** Photovoltaic power systems employing energy storage shall be marked with the maximum operating voltage, including any equalization voltage and the polarity of the grounded circuit conductor. The PV system output circuit conductors shall be marked to indicate the polarity where connected to energy storage systems. [NFPA 70:690.55]

**942.7827.0 Facilities with Stand-Alone Systems.**

**827.1 General.** Any structure or building with a PV power system that is not connected to a utility service source and is a stand-alone system shall have a permanent plaque or directory installed on the exterior of the building or structure at a readily visible location acceptable to the Authority Having Jurisdiction. The plaque or directory shall indicate the location of system disconnecting means and that the structure contains a stand-alone electrical power system. The marking shall be in accordance with Section 910.5. [NFPA 70:690.56(A)]

**942.8-827.2 Facilities with Utility Services and PV Photovoltaic Systems.** Buildings or structures with both utility service and a PV system shall have a permanent plaque or directory providing the location of the service disconnecting means and the PV system disconnecting means, where not located at the same location. The warning sign(s) or label(s) shall comply with Section 903.4.1. Plaques or directories shall be installed in accordance with Section 823.1. [NFPA 70:690.56(B)]

**942.9-827.3 Facilities Buildings with Rapid Shutdown.** Buildings or structures with both utility service and a PV system, in accordance with Section 908.8, shall have a permanent plaque or directory including the following wording:

**PHOTOVOLTAIC SYSTEM EQUIPPED WITH RAPID SHUTDOWN**

The plaque or directory shall be reflective, with all letters capitalized and having a minimum height of \(\frac{3}{8}\) of an inch (9.5 mm), in white on red background. Buildings with PV systems shall have permanent labels as described in Section 827.3.1 through Section 827.3.3. [NFPA 70:690.56(C)]

**827.3.1 Rapid Shutdown Type.** The type of PV system rapid shutdown shall be labeled as described in Section 827.3.1(1) or Section 827.3.1(2):
(1) For PV systems that shut down the array and conductors leaving the array:

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

The title “SOLAR PV SYSTEM IS EQUIPPED WITH RAPID SHUTDOWN” shall utilize capitalized characters with a minimum height of 3/8 of an inch (9.5 mm) in black on yellow background, and the remaining characters shall be capitalized with a minimum height of 3/16 of an inch (4.8 mm) in black on white background. [see Figure 827.3.1(1)]

FIGURE 827.3.1(1)
LABEL FOR PV SYSTEMS THAT SHUT DOWN THE ARRAY
AND THE CONDUCTORS LEAVING THE ARRAY
[NFPA 70: FIGURE 690.56(C)(1)(a)]

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

SOLAR PV SYSTEM IS EQUIPPED WITH RAPID SHUTDOWN
TURN RAPID SHUTDOWN SWITCH TO THE “OFF” POSITION
TO SHUT DOWN
CONDUCTORS OUTSIDE THE ARRAY. CONDUCTORS IN
ARRAY REMAIN
ENERGIZED IN SUNLIGHT.

The title “SOLAR PV SYSTEM IS EQUIPPED WITH RAPID SHUTDOWN” shall utilize capitalized characters with a minimum height of 3/8 of an inch (9.5 mm) in white on red background, and the remaining characters shall be capitalized with a minimum height of 3/16 of an inch (4.8 mm) in black on white background. [see Figure 827.3.1(2).]
FIGURE 827.3.1(2)
LABEL FOR PV SYSTEMS THAT SHUT DOWN THE CONDUCTORS LEAVING THE ARRAY ONLY
[NFPA 70: FIGURE 690.56(C)(1)(b)]

The labels in Section 827.3.1(1) and Section 827.3.1(2) shall include a simple diagram of a building with a roof. The diagram shall have sections in red to signify sections of the PV system that are not shut down when the rapid shutdown switch is operated.

The rapid shutdown label in Section 827.3.1 shall be located on or not more than 3 feet (914 mm) from the service disconnecting means to which the PV systems are connected and shall indicate the location of all identified rapid shutdown switches if not at the same location. [NFPA 70:690.56(C)(1)]

827.3.2 Buildings with More Than One Rapid Shutdown Type. For buildings that have PV systems with both rapid shutdown types or a PV system with a rapid shutdown type and a PV system with no rapid shutdown, a detailed plan view diagram of the roof shall be provided showing each different PV system and a dotted line around areas that remain energized after the rapid shutdown switch is operated. [NFPA 70:690.56(C)(2)]

827.3.3 Rapid Shutdown Switch. A rapid shutdown switch shall have a label located on or no more than 3 feet (914 mm) from the switch that includes the following wording:

RAPID SHUTDOWN SWITCH FOR SOLAR PV SYSTEM

The label shall be reflective, with all letters capitalized and having a minimum height of 3/8 of an inch (9.5 mm), in white on red background. [NFPA 70:690.56(C)(3)]

Part VII - Connection to Other Sources.

913.0 828.0 Connection to Other Sources.

828.1 PV Systems. PV systems connected to other sources shall be installed in accordance with Parts I and II of Article 705 of NFPA 70. [NFPA 70:690.59]

913.1 Load Disconnect. A load disconnect that has multiple sources of power shall disconnect all sources where in the off position. [NFPA 70:690.57]

913.2 Identified Interactive Equipment. Inverters and ac modules listed and identified as interactive shall be permitted in interactive systems. [NFPA 70:690.60]

913.3 Loss of Interactive System Power. An inverter or an ac module in an interactive solar PV system shall automatically de-energize its output to the connected electrical production and distribution network upon loss of voltage in that system and shall remain in that state until the electrical production and distribution network voltage has been restored. A normally interactive solar PV system shall be permitted to operate as a stand-alone system to supply loads that have been disconnected from electrical production and distribution network sources. [NFPA 70:690.61]

913.4 Unbalanced Interconnections. Single-phase inverters for hybrid systems and ac modules in interactive hybrid systems shall be connected to three-phase power systems in order to limit unbalanced voltages to not more than 3 percent. [NFPA 70:705.100(A)]

Three-phase inverters and three-phase ac modules in interactive systems shall have all phases automatically de-energized upon loss of, or unbalanced, voltage in one or more phases unless the interconnected system is designed so that significant unbalanced voltages will not result. [NFPA 70:705.100(B)]

913.5 Point of Connection. The output of an interconnected electrical power source shall be connected as specified in Section 913.5.1 through Section 913.5.4. [NFPA 70:705.12]
913.5.1 Supply Side. An electric power production source shall be permitted to be connected to the supply side of the service disconnecting means in accordance with Section 230.82(6) of NFPA 70. The sum of the ratings of all overcurrent devices connected to power production sources shall not exceed the rating of the service. [NFPA 70:705.12(A)]

913.5.2 Integrated Electrical Systems. The outputs shall be permitted to be interconnected at a point or points elsewhere on the premises where the system qualifies as an integrated electrical system and incorporates protective equipment in accordance with applicable sections of Article 685 of NFPA 70. [NFPA 70:705.12(B)]

913.5.3 Greater Than 100 kW. The outputs shall be permitted to be interconnected at a point or points elsewhere on the premises where the following conditions are met:

1. The aggregate of non-utility sources of electricity has a capacity in excess of 100 kilowatt hours (kWh) (360 MJ), or the service is more than 1000 volts.
2. The conditions of maintenance and supervision ensure that qualified persons service and operate the system.
3. Safeguards, documented procedures, and protective equipment are established and maintained. [NFPA 70:705.12(C)]

913.5.4 Utility-Interactive Inverters. The output of an utility-interactive inverter shall be permitted to be connected to the load side of the service disconnecting means of the other source(s) at any distribution equipment on the premises. Where distribution equipment, including switchgear, switchboards or panelboards, is fed simultaneously by a primary source(s) of electricity and one or more utility-interactive inverters, and where this distribution equipment is capable of supplying multiple branch circuits or feeders, or both, the interconnecting provisions for the utility-interactive inverter(s) shall be in accordance with Section 913.5.4.1 through Section 913.5.4.6. [NFPA 70:705.12(D)]

913.5.4.1 Dedicated Overcurrent and Disconnect. The source interconnection of one or more inverters installed in one system shall be made at a dedicated circuit breaker or fusible disconnecting means. [NFPA 70:705.12(D)(1)]

913.5.4.2 Bus or Conductor Ampere Rating. One hundred twenty-five percent of the inverter output circuit current shall be used in ampacity calculations for the following:

1. The feeder ampacity shall be not less than the sum of the primary source overcurrent device and 125 percent of the inverter output circuit current.
2. An overcurrent device on the load side of the inverter connection shall be rated not more than the ampacity of the feeder.
3. In Systems where inverter output connections are made at feeders, any taps shall be sized based on the sum of 125 percent of the inverter output circuit current and the rating of the overcurrent device protecting the feeder conductors as calculated in Section 240.21(B) of NFPA 70.

4. The following methods shall be used to determine the ratings of busbars in panelboard:

(a) The sum of 125 percent of the inverter output circuit current and the rating of the overcurrent device protecting the busbar shall not exceed the ampacity of the busbar.
(b) Where two sources, one a utility and the other an inverter, are located at opposite ends of a busbar that contains loads, the sum of 125 percent of the inverter output circuit current and the rating of the overcurrent device protecting the busbar shall not exceed 120 percent of the ampacity of the busbar. The busbar shall be sized for the loads connected in accordance with Article 220 of NFPA 70. A permanent warning label shall be applied to the distribution equipment adjacent to the back-fed breaker from the inverter that displays the following or equivalent wording:

WARNING:
INVERTER OUTPUT CONNECTION;
DO NOT RELOCATE THIS OVERCURRENT DEVICE.

The warning sign(s) or label(s) shall comply with Section 903.4.1.
(c) The sum of the ampere ratings of all overcurrent devices on panelboards, both load and supply devices, excluding the rating of the overcurrent device protecting the busbar, shall not exceed the ampacity of the busbar. The rating of the overcurrent device protecting the busbar shall not exceed the rating of the busbar. Permanent warning labels shall be applied to distribution equipment that displays the following or equivalent wording:

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

The warning sign(s) or label(s) shall comply with Section 903.4.1.
(d) Connections shall be permitted on multiple-ampacity busbars or center-fed panelboards where designed under engineering supervision that includes fault studies and busbar load calculations. [NFPA 70:705.12(D)(2)]

913.5.4.3 Marking. Equipment containing overcurrent devices in circuits supplying power to a busbar or conductor supplied from multiple sources shall be marked to indicate the presence of all sources. [NFPA 70:705.12(D)(3)]

913.5.4.4 Suitable for Backfeed. Circuit breakers, where back-fed, shall be suitable for such operation. [NFPA 70:705.12(D)]
913.5.4.5 Fastening. Listed plug-in-type circuit breakers backfed from utility-interactive inverters that are listed and identified as interactive shall be permitted to omit the additional fastener required in accordance with Section 908.6.1 for such application. [NFPA 70:705.12(D)(5)]

913.5.4.6 Wire Harness and Exposed Cable Arc-Fault Protection. A utility-interactive inverter(s) that has a wire harness or cable output circuit rated 240 V, 30 amperes, or less, that is not installed within an enclosed raceway, shall be provided with listed ac-AFCI protection. [NFPA 70:705.12(D)(6)]

**Part VIII - Energy Storage Systems.**

914.0 Storage Batteries Energy Storage Systems.

829.0 General. An energy storage system connected to a PV system shall be installed in accordance with Article 706 of NFPA 70. [NFPA 70:690.71]

914.1 Installation. Storage batteries in a solar photovoltaic system shall be installed in accordance with the provisions of Article 480 of NFPA 70. The interconnected battery cells shall be considered grounded where the photovoltaic power source is installed in accordance with Section 911.1. [NFPA 70:690.71(A)]

914.2 Dwellings. Storage batteries for dwellings shall have the cells connected so as to operate at a voltage of 50 volts, nominal, or less.

Exception: Where live parts are not accessible during routine battery maintenance, a battery system voltage in accordance with Section 905.0 shall be permitted. [NFPA 70:690.71(B)(1)]

Live parts of battery systems for dwellings shall be guarded to prevent accidental contact by persons or objects, regardless of voltage or battery type. [NFPA 70:690.71(B)(2)]

914.3 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 Section 909.3. [NFPA 70:690.71(C)]

914.4 Battery Nonconductive Cases and Conductive Racks. Flooded, vented, lead-acid batteries with more than 24 two-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 6 inches (152 mm) of the tops of the nonconductive cases.

This requirement shall not apply to a type of valve-regulated lead-acid (VRLA) battery or any other types of sealed batteries that require steel cases for proper operation. [NFPA 70:690.71(D)]

914.5 Disconnection of Series Battery Circuits. Battery circuits subject to field servicing, where more than 24 two-volt cells are connected in series (18 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. [NFPA 70:690.71(E)]

914.6 Battery Maintenance Disconnecting Means. Battery installations, where there are more than 24 two-volt cells connected in series (18 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. [NFPA 70:690.71(F)]

914.7 Battery Systems Exceeding 48 Volts. On photovoltaic systems where the battery system consists of more than 24 two-volt cells connected in series (exceeding 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 Section 911.1.
2. The dc and ac load circuits shall be solidly grounded.
3. Main ungrounded battery input, output, or both 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. [NFPA 70:690.71(G)]

914.8 Disconnects and Overcurrent Protection. Where energy storage device input and output terminals are more than 5 feet (1524 mm) from connected equipment, or where the circuits from these terminals pass through a wall or partition, the installation shall comply with the following:

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 shall be permitted to be used.
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 in accordance with Section 914.8(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. [NFPA 70:690.71(H)]
31.0 Self-Regulating Charge Control.

31.1 General. Equipment shall be provided to control the charging process of the battery. The PV source circuit shall be considered to comply with the requirements of 31.1.1 through 31.1.5 if:

(1) Charge control shall not be required where the design of the photovoltaic PV source circuit is matched to the voltage rating and charge current requirements of the interconnected battery cells and 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. [NFPA 70:690.72(A)] A charging controller shall comply with UL 1741.

31.1.1 Charge Control. Provisions shall be provided to control the charging process of the Energy Storage System. All adjustable means for control of the charging process shall be accessible only to qualified persons. [NFPA 70:706.23(A)]

31.1.2 Diversion Charge Controller, Sole Means of Regulating Charging. An ESS employing a diversion charge controller as the sole means of regulating charging shall be equipped with a second independent means to prevent overcharging of the storage device. [NFPA 70:706.23(B)(1)]

31.1.3 Diversion Charge Controller, Circuits with Diversion Charge Controller and Diversion Load. Circuits containing a diversion charge controller and a 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 ESS voltage. The power rating of the diversion load shall be at least 150 percent of the power rating of the charging 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. [NFPA 70:706.23(B)(2)]

31.1.4 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 Section 31.1.4(1) and Section 31.1.4(2).

(1) These systems shall not be required to comply with Section 31.1.3.

(2) These systems shall have a second independent means of controlling the ESS charging process for use when the utility is not present or when the primary charge controller fails or is disabled. [NFPA 70:706.23(B)(3)]

31.1.5 Charge Controllers and DC-to-DC Converters. Where charge controllers and other DC-to-DC power converters that increase or decrease the output current or output voltage with respect to the input current or input voltage are installed, all of the following shall apply:

(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. [NFPA 70:706.23(C)]

914.10.1 Sole Means of Regulating Charging. A photovoltaic power system employing a diversion charge controller as the sole means of regulating the charging of a battery shall be equipped with a second independent means to prevent overcharging of the battery. [NFPA 70:690.72(B)(1)]

914.10.2 Circuits with Direct-Current diversion Charge Controller and Diversion Load. Circuits containing a dc diversion charge controller and a dc diversion load shall be in accordance 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 exceed the maximum battery voltage. The power rating of the diversion load shall be not less than 150 percent of the power rating of the photovoltaic array.

(2) The conductor ampacity and the rating of the overcurrent device for this circuit shall be not less than 150 percent of the maximum current rating of the diversion charge controller. [NFPA 70:690.72(B)(2)]

914.10.3 PV Systems Using Utility-Interactive Inverters. Photovoltaic power systems using utility-interactive inverters to control battery state-of-charge by diverting excess power into the utility system shall be in accordance with the following:

(1) These systems shall not be required to be in accordance with Section 914.10.2. The charge regulation circuits used shall be in accordance with the requirements of Section 400.5 of NFPA 70.
914.10.4 Buck/Boost Direct-Current Converters. Where 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 requirements shall comply with the following:

1. An accessible mechanical or other identified means for manual tripping, independent of control power. [NFPA 70:690.72(B)(3)]

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. [NFPA 70:690.72(C)]

914.11 Battery Interconnections. Flexible cables, as identified in Article 400 of NFPA 70, in sizes not less than 2/0 AWG 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 cable shall be terminated with terminals, lugs, devices, or connectors in accordance with Section 110.14 of NFPA 70. [NFPA 70:690.74]

915.0 Systems Over 1000 Volts.

915.1 General. Solar PV systems with a system voltage exceeding 1000 volts dc shall comply with Section 915.4 through Section 915.10, Article 490 of NFPA 70, and other requirements applicable to installations with a system voltage exceeding 1000 volts. [NFPA 70:690.80]

915.2 Listing. Products listed for PV systems shall be permitted to be used and installed in accordance with their listing. PV 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 of NFPA 70. [NFPA 70:690.81]

915.3 Definitions. For the purposes of Section 914.0, the voltages used to determine cable and equipment ratings are as follows:

1. In battery circuits, the highest voltage experienced under charging or equalizing conditions.

2. In dc PV source circuits and PV output circuits, the maximum system voltage. [NFPA 70:690.85]

915.4 Guarding of High-Voltage Energized Parts Within a Compartment. Where access for other than visual inspection is required to a compartment that contains energized high-voltage parts, barriers shall be provided to prevent accidental contact by persons, tools, or other equipment with energized parts. Exposed live parts shall be permitted in compartments accessible to qualified persons. Fuses and fuseholders designed to enable future replacement without de-energizing the fuseholder shall be permitted for use by qualified persons. [NFPA 70:490.32]

915.5 High-Voltage Equipment. Doors that would provide unqualified persons access to high-voltage energized parts shall be locked. Permanent signs in accordance with Section 903.4.1 shall be installed on panels or doors that provide access to live parts over 1000 volts and shall read "DANGER — HIGH VOLTAGE — KEEP OUT". [NFPA 70:490.3(A)]

915.6 Circuit Breakers. Circuit breakers installed indoors shall be mounted either in metal-enclosed units or fire-resistant cell-mounted units, or they shall be permitted to be open-mounted in locations accessible to qualified persons. [NFPA 70:490.21(A)(1)]

915.7 Operating Characteristics. Circuit breakers shall have the following equipment or operating characteristics:

1. An accessible mechanical or other identified means for manual tripping, independent of control power.

2. Be release free (trip free).

3. Where capable of being opened or closed manually while energized, main contacts that operate independently of the speed of the manual operation.

4. A mechanical position indicator at the circuit breaker to show the open or closed position of the main contacts.

5. A means of indicating the open and closed position of the breaker at the point(s) from which they are operated. [NFPA 70:490.21(A)(2)]

915.8 Nameplate. A circuit breaker shall have a permanent and legible nameplate showing manufacturer’s name or trademark, manufacturer’s type or identification number, continuous current rating, interrupting rating in megavolt-amperes (MVA) or amperes, and maximum voltage rating. Modification of a circuit breaker affecting its rating(s) shall be accompanied by an appropriate change of nameplate information. [NFPA 70:490.21(A)(3)]

915.9 High-Voltage Fuses. Switchgear and substations that utilize high-voltage fuses shall be provided with a gang-operated disconnecting switch. Isolation of the fuses from the circuit shall be provided by either connecting a switch between the source and the fuses or providing roll-out switch and fuse-type construction. The switch shall be of the load-interrupter type, unless mechanically or electrically interlocked with a load interrupting device arranged to reduce the load to the interrupting capacity of the switch.

Exception: More than one switch shall be permitted as the disconnecting means for one set of fuses where the switches are installed to provide connection to more than a set of supply conductors. The switches shall be mechanically or electrically interlocked to permit access to the fuses where all switches are open. A conspicuous sign shall be placed at the fuses identifying the presence of more than one source. [NFPA 70:490.21(B)(7)]

915.10 Voltage Rating. The maximum voltage rating of power fuses shall not be less than the maximum circuit voltage. Fuses shall not be applied below the minimum recommended operating voltage. [NFPA 70:490.21(B)(3)]
832.1 **Scope.** Section 832.2 through Section 832.9 covers the installation of large-scale PV electric power production facilities with a generating capacity of no less than 5000 kW, and not under exclusive utility control. [NFPA 70:691.1]

832.2 **Special Requirements for Large-Scale PV Electric Supply Stations.** Large-scale PV electric supply stations shall be accessible only to authorized personnel and comply with the following:

1. Electrical circuits and equipment shall be maintained and operated only by qualified personnel.
2. Access to PV electric supply stations shall be restricted by fencing or other adequate means in accordance with Section 110.31 of NFPA 70. Field-applied hazard markings shall be applied in accordance with Section 810.1.2.1.
3. The connection between the PV electric supply station and the system operated by a utility for the transfer of electrical energy shall be through medium- or high voltage switch gear, substation, switch yard, or similar methods whose sole purpose shall be to safely and effectively interconnect the two systems.
4. The electrical loads within the PV electric supply station shall only be used to power auxiliary equipment for the generation of the PV power.
5. Large-scale PV electric supply stations shall not be installed on buildings. [NFPA 70:691.4]

832.3 **Equipment Approval.** All electrical equipment shall be approved for installation by one of the following:

1. Listing and labeling
2. Field labeling
3. Where products complying with Section 832.3(1) or Section 832.3(2) are not available, by engineering review validating that the electrical equipment is tested to relevant standards or industry practice. [NFPA 70:691.5]

832.4 **Engineered Design.** Documentation of the electrical portion of the engineered design of the electric supply station shall be stamped and provided upon request of the Authority Having Jurisdiction. Additional stamped independent engineering reports detailing compliance of the design with applicable electrical standards and industry practice shall be provided upon request of the AHJ. The independent engineer shall be a licensed professional electrical engineer retained by the system owner or installer. This documentation shall include details of conformance of the design with this chapter, and any alternative methods to this chapter, or other articles of NFPA 70. [NFPA 70:691.6]

832.5 **Conformance of Construction to Engineered Design.** Documentation that the construction of the electric supply station conforms to the electrical engineered design shall be provided upon request of the Authority Having Jurisdiction. Additional stamped independent engineering reports detailing the construction conforms with this chapter, applicable standards and industry practice shall be provided upon request of the Authority Having Jurisdiction. The independent engineer shall be a licensed professional electrical engineer retained by the system owner or installer. This documentation, where requested, shall be available prior to commercial operation of the station. [NFPA 70:691.7]

832.6 **Direct Current Operating Voltage.** For large-scale PV electric supply stations, calculations shall be included in the documentation required in Section 832.4. [NFPA 70:691.8]

832.7 **Disconnection of Photovoltaic Equipment.** Isolating devices shall be permitted to be more than 6 feet (1829 mm) from the equipment where written safety procedures and conditions of maintenance and supervision ensure that only qualified persons service the equipment.

Buildings whose sole purpose is to house and protect supply station equipment shall not be required to comply with Section 809.1. Written standard operating procedures shall be available at the site detailing necessary shutdown procedures in the event of an emergency. [NFPA 70:691.9]

832.8 **Arc-Fault Mitigation.** PV systems that do not comply with the requirements of Section 808.1 shall include details of fire mitigation plans to address dc arc-faults in the documentation required in Section 832.4. [NFPA 70:691.10]

832.9 **Fence Grounding.** Fence grounding requirements and details shall be included in the documentation required in Section 832.4. [NFPA 70:691.11]

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203.0 – A –

**Array.** A mechanically integrated assembly of module(s) or panel(s) with a support structure and foundation, tracker, and other components, as required, to form a direct-current dc or ac power-producing unit. [NFPA 70:690.2]

204.0 – B –

**Bipolar Photovoltaic Array.** A dc PV array that has two outputs each having opposite polarity to a common reference point or center tap. [NFPA 70:690.2]

**Blocking Diode.** A diode used to block reverse flow of current into a PV source circuit. [NFPA 70:690.2]

**Building Integrated Photovoltaics.** Photovoltaic cells, devices, modules, or modular materials that are integrated into the outer surface or structure of a building and serve as the outer protective surface of that building. [NFPA 70:690.2]

205.0 – C –

**Charge Controller.** Equipment that controls dc voltage or dc current, or both, and that is used to charge a battery or other energy storage device. [NFPA 70:100]

206.0 – D –
**DC-to-DC Converter.** A device installed in the PV source circuit or PV output circuit that can provide an output dc voltage and current at a higher or lower value than the input dc voltage and current. [NFPA 70:690.2]

**DC-to-DC Converter Output Circuit.** Circuit conductors between the dc-to-dc converter source circuit(s) and the inverter or dc utilization equipment. [NFPA 70:690.2]

**DC-to-DC Converter Source Circuit.** Circuits between dc-to-dc converters and from dc-to-dc converters to the common connection point(s) of the dc system. [NFPA 70:690.2]

**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. [NFPA 70:690.2]

**Electric Supply Stations.** Locations containing the generating stations and substations, including their associated generator, storage battery, transformer, and switchgear areas. [NFPA 70:691.2]

**Functional Grounded PV System.** A PV system that has an electrical reference to ground that is not solidly grounded. [NFPA 70:690.2]

**Generating Capacity.** The sum of the parallel-connected inverter rated maximum continuous output power at 104°F (40°C) in kilowatts (kW). [NFPA 70:691.2]

**Generating Station.** A plant wherein electric energy is produced by conversion from some other form of energy (e.g., chemical, nuclear, solar, wind, mechanical, or hydraulic) by means of suitable apparatus. [NFPA 70:691.2]

**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 electric power production and distribution network systems. Energy storage systems, such as batteries, flywheels, or superconducting magnetic storage equipment do not constitute a power source for the purpose of this definition. The energy regenerated by an overhauling (descending) elevator does not constitute a power source for the purpose of this definition. [NFPA 70:100]

**Interactive Inverter Output Circuit.** The conductors between the interactive inverter and the service equipment or another electrical power production and distribution network. [NFPA 70:690.2]

**Interactive System.** A solar PV 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 PV system, such as a battery, is not another electrical production source. [NFPA 70:690.2]

**Inverter Input Circuit.** Conductors between the inverter and the battery in stand-alone systems or the conductors between the inverter and the PV output circuits for electrical production and distribution network connected to the dc input of an inverter. [NFPA 70:690.2]

**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 another electric power production source, such as a utility, for electrical production and distribution network connected to the ac output of an inverter. [NFPA 70:690.2]

**Module.** A complete environmentally protected unit consisting of solar cells, optics, and other components, exclusive of tracker, designed to generate dc power when exposed to sunlight. [NFPA 70:690.2]

**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. [NFPA 70:690.2]

**Multimode Inverter.** Equipment having the capabilities of both the utility-interactive inverter and the stand-alone inverter. [NFPA 70:690.2]
Photovoltaic Panel. A collection of modules mechanically fastened together, wired, and designed to provide a field-installable unit. [NFPA 70:690.2]

Photovoltaic System DC Circuit. Any dc conductor supplied by a PV power source, including PV source circuits, PV output circuits, dc-to-dc converter source circuits, or dc-to-dc converter output circuits. [NFPA 70:690.2]

Photovoltaic System Voltage. The direct current (dc) voltage of any PV source or PV output circuit. For multiwire installations, the PV system voltage is the highest voltage between any two dc conductors. [NFPA 70:690.2]

Solar Cell. The basic PV device that generates electricity when exposed to light. [NFPA 70:690.2]

Note: NFPA 70 meets the requirements for a mandatory reference standard in accordance with Section 15.0 of IAPMO’s Regulations Governing Consensus Development of the Uniform Solar, Hydronics & Geothermal and Swimming Pool, Spa & Hot Tub Codes.

SUBSTANTIATION:
The photovoltaic definitions in Chapter 2 and the provisions in Chapter 8 are being modified to keep the language current with the source document NFPA 70-2017 (latest version) in accordance with Section 16.0 of the IAPMO Regulations Governing Consensus Development of the Uniform Solar, Hydronics & Geothermal and Swimming Pool, Spa & Hot Tub Codes (Extract Guidelines).

Section 16.3 states the following:

“16.3 Procedures for Updating Extracts. The extract procedure requires that the extracted text be kept current with that of the source document in a timely appropriate manner………If the extract is determined to be eligible for processing, the secretariat shall letter ballot the technical committee in accordance with the Regulations Governing Consensus Development on the updating of the extracted text, including any editorial revisions necessary to conform to the style of the document.”

The proposed language brings forward Item # 126.01 of the 2018 USHGC cycle for correlation with NFPA 70-2017 (latest edition).
Item #: 062
USHGC 2021 Section: 802.2.1, Table 802.2.1, Table 901.1, Table 901.2

SUBMITTER: Christopher Jensen
UL LLC

RECOMMENDATION:
Add new text

802.0 General Requirements.
802.2 Equipment. (remaining text unchanged)

**802.2.1 Listing Requirements.** Equipment used in PV power systems shall be listed or field labeled in accordance with Table 802.2.1.

### TABLE 802.2.1
STANDARDS FOR PV EQUIPMENT

<table>
<thead>
<tr>
<th>EQUIPMENT</th>
<th>STANDARDS</th>
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<tbody>
<tr>
<td>Building-integrated PV Modules and Panels</td>
<td>UL 1703 or UL 61730-1&lt;sup&gt;1&lt;/sup&gt;, UL 61730-2&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>Building-integrated PV Mounting Systems</td>
<td>UL 2703</td>
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<td>Charge controllers</td>
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<td>Combiner boxes</td>
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<td>Concentrator Photovoltaic modules</td>
<td>UL 8703</td>
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<td>DC-to-DC Converters</td>
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<td>Flat-plate Photovoltaic modules</td>
<td>UL 1703 or UL 61730-1&lt;sup&gt;1&lt;/sup&gt;, UL 61730-2&lt;sup&gt;1&lt;/sup&gt;</td>
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<tr>
<td>Inverters</td>
<td>UL 1741 or UL 62109-1</td>
</tr>
<tr>
<td>PV AC modules</td>
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</tr>
<tr>
<td>Photovoltaic Modules and Panels</td>
<td>UL 1703 or UL 61730-1&lt;sup&gt;1&lt;/sup&gt;, UL 61730-2&lt;sup&gt;1&lt;/sup&gt;</td>
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<tr>
<td>PV DC Arc Fault Circuit Interrupters</td>
<td>UL 1699B</td>
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<td>PV DC connectors</td>
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<td>PV Solar Trackers</td>
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<td>PV wire</td>
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<td>Rack mounting systems</td>
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<td>Rapid shutdown equipment and systems</td>
<td>UL 1741</td>
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</table>

**Notes:**
1<sup>1</sup> UL 61730-1 shall be used in conjunction with UL 61730-2.
2<sup>2</sup> UL 1703 shall be used in conjunction with UL 1741.
### TABLE 901.1
 REFERENCED STANDARDS

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTION</th>
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<td>UL 1699B-2018</td>
<td>Photovoltaic (PV) DC Arc-Fault Circuit Protection</td>
<td>Electrical</td>
<td>Table 802.2.1</td>
</tr>
<tr>
<td>UL 2703-2015</td>
<td>Mounting Systems, Mounting Devices, Clamping/Retention Devices, and Ground Lugs</td>
<td>Electrical</td>
<td>Table 802.2.1</td>
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<td>Solar Trackers</td>
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<td>UL 4703-2014</td>
<td>Photovoltaic Wire</td>
<td>Electrical</td>
<td>Table 802.2.1</td>
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<td>UL 6703-2014</td>
<td>Connectors for Use in Photovoltaic Systems</td>
<td>Electrical</td>
<td>Table 802.2.1</td>
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<td>(with revisions through December 22, 2017)</td>
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<tr>
<td>UL 8703-2011</td>
<td>Outline of Investigation for Concentrator Photovoltaic Modules and Assemblies</td>
<td>Electrical</td>
<td>Table 802.2.1</td>
</tr>
<tr>
<td>UL 61730-1-2017</td>
<td>Photovoltaic (PV) Module Safety Qualification - Part 1: Requirements for Construction</td>
<td>Electrical</td>
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</tr>
<tr>
<td>UL 61730-2-2017</td>
<td>Photovoltaic (PV) Module Safety Qualification - Part 2: Requirements for Testing</td>
<td>Electrical</td>
<td>Table 802.2.1</td>
</tr>
<tr>
<td>UL 62109-1-2014</td>
<td>Safety of Power Converters for Use in Photovoltaic Power Systems - Part 1: General Requirements</td>
<td>Electrical</td>
<td>Table 802.2.1</td>
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</tbody>
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(portions of table not shown remain unchanged)

**Note:** UL 1699B, UL 1703, UL 1741, UL 2703, UL 3703, UL 4703, UL 6703, UL 61730-1, UL 61730-2 and UL 62109-1 meet the requirements for mandatory referenced standards in accordance with Section 15.0 of IAPMO's Regulations Governing Consensus Development of the Uniform Solar, Hydronics & Geothermal and Swimming Pool, Spa & Hot Tub Codes.

**Note:** UL 8703 does not meet the requirements for a consensus referenced standard in accordance with Section 15.2 of IAPMO's Regulations Governing Consensus Development of the Uniform Solar, Hydronics & Geothermal and Swimming Pool, Spa & Hot Tub Codes.

### TABLE 901.2
 STANDARDS, PUBLICATIONS, PRACTICES, AND GUIDES

<table>
<thead>
<tr>
<th>DOCUMENT NUMBER</th>
<th>DOCUMENT TITLE</th>
<th>APPLICATION</th>
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</thead>
<tbody>
<tr>
<td>UL 4703-2014</td>
<td>Photovoltaic Wire</td>
<td>Electrical</td>
</tr>
<tr>
<td>UL 6703-2014</td>
<td>Connectors for Use in Photovoltaic Systems</td>
<td>Electrical</td>
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<tr>
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<td>(with revisions through March 2, 2017)</td>
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<tr>
<td>UL 8703-2011</td>
<td>Outline of Investigation for Concentrator Photovoltaic Modules and Assemblies</td>
<td>Electrical</td>
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</table>

(portions of table not shown remain unchanged)

**SUBSTANTIATION:**
The USHGC requires that all equipment associated with a PV system must be listed or field labeled; however, the USHGC falls short on identifying the applicable safety standards. The 2017 National Electrical Code (NEC) includes Annex A (Product Safety Standards) which provides product safety standards used for product listing where that listing is required by the NEC. Since the majority of Chapter 8 (Solar Photovoltaic Systems) is extracted material without the extraction of Annex A, the information that is necessary for the AHJ to determine approval of the product is not available within this code.
Item #: 063
USHGC 2021  Section: Table 901.1, Table 901.2

SUBMITTER: Connor Barbaree
ASHRAE

RECOMMENDATION:
Revise text

TABLE 901.1
REFERENCED STANDARDS

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTIONS</th>
</tr>
</thead>
</table>

(portions of table not shown remain unchanged)

Note: ASHRAE 194 meets the requirements for a mandatory reference standard in accordance with Section 15.0 of IAPMO's Regulations Governing Consensus Development of the Uniform Solar, Hydronics & Geothermal and Swimming Pool, Spa & Hot Tub Codes.

TABLE 901.2
STANDARDS, PUBLICATIONS, PRACTICES, AND GUIDES

<table>
<thead>
<tr>
<th>DOCUMENT NUMBER</th>
<th>DOCUMENT TITLE</th>
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(portions of table not shown remain unchanged)

SUBSTANTIATION:
The above revisions reflect the latest updates to the ASHRAE standards that are referenced in Table 901.1 and Table 901.2.
Item #: 064

USHGC 2021  Section: Table 901.1, Table 901.2

SUBMITTER: Carlton Ramcharran/Angel Guzman

ASME

RECOMMENDATION:
Revise text

### TABLE 901.1
REFERENCED STANDARDS

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<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTIONS</th>
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<tbody>
<tr>
<td>ASME B16.5-20142017</td>
<td>Pipe Flanges and Flanged Fittings: NPS ½ Through NPS 24 Metric/Inch</td>
<td>Fittings</td>
<td>Table 408.1</td>
</tr>
<tr>
<td>ASME B16.9-20122018</td>
<td>Factory-Made Wrought Buttwelding Fittings</td>
<td>Fittings</td>
<td>Table 408.1</td>
</tr>
<tr>
<td>ASME B16.15-20132018</td>
<td>Cast Copper Alloy Threaded Fittings: Classes 125 and 250</td>
<td>Fittings</td>
<td>Table 408.1</td>
</tr>
<tr>
<td>ASME B16.18-20122018</td>
<td>Cast Copper Alloy Solder Joint Pressure Fittings</td>
<td>Fittings</td>
<td>Table 408.1</td>
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<tr>
<td>ASME B16.22-20132018</td>
<td>Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings</td>
<td>Fittings</td>
<td>703.6, Table 408.1</td>
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<tr>
<td>ASME B16.26-20132018</td>
<td>Cast Copper Alloy Fittings for Flared Copper Tubes</td>
<td>Fittings</td>
<td>Table 408.1</td>
</tr>
<tr>
<td>ASME B16.29-20122017</td>
<td>Wrought Copper and Wrought Copper Alloy Solder-Joint Drainage Fittings – DWV</td>
<td>Fittings</td>
<td>Table 408.1</td>
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<tr>
<td>ASME B16.51-20132018</td>
<td>Copper and Copper Alloy Press-Connect Pressure Fittings</td>
<td>Fittings</td>
<td>Table 408.1</td>
</tr>
<tr>
<td>ASME BPVC Section VIII 1-20152017</td>
<td>Rules for Construction of Pressure Vessels Division 1</td>
<td>Miscellaneous</td>
<td>407.3, 601.2.1, 603.6, 605.3</td>
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<tr>
<td>ASME BPVC Section X-20152017</td>
<td>Fiber-Reinforced Plastic Pressure Vessels</td>
<td>Pressure Vessel Construction, Pressure Vessels</td>
<td>603.6</td>
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**Note:** The ASME standards meet the requirements for mandatory reference standards in accordance with Section 15.0 of IAPMO's Regulations Governing Consensus Development of the Uniform Solar, Hydronics & Geothermal and Swimming Pool, Spa & Hot Tub Codes.
### TABLE 901.2
STANDARDS, PUBLICATIONS, PRACTICES, AND GUIDES

<table>
<thead>
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<th>APPLICATION</th>
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<td>ASME B16.34-2013 2017</td>
<td>Valves – Flanged, Threaded, and Welding End</td>
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<tr>
<td>ASME B16.47-2011 2017</td>
<td>Large Diameter Steel Flanges: NPS 26 Through NPS 60 Metric/Inch</td>
<td>Fittings</td>
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<tr>
<td>ASME BPVC Section IV-2015 2017</td>
<td>Rules for Construction of Heating Boilers</td>
<td>Miscellaneous</td>
</tr>
<tr>
<td>ASME BPVC Section IX-2015 2017</td>
<td>Welding, Brazing, and Fusing Qualifications</td>
<td>Certification</td>
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(portions of table not shown remain unchanged)

**SUBSTANTIATION:**
The above revisions reflect the latest updates to the ASME standards that are referenced in Table 901.1 and Table 901.2.
**Item #: 065**
USHGC 2021  Section: Table 901.1, Table 901.2

**SUBMITTER:** Steve Mawn  
ASTM

**RECOMMENDATION:**  
Revise text

### TABLE 901.1  
REFERENCED STANDARDS

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
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<tr>
<td>ASTM A53/A53M-2012-2018</td>
<td>Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless</td>
<td>Piping</td>
<td>Table 408.1</td>
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<tr>
<td>ASTM A106/A106M-2015-2018</td>
<td>Seamless Carbon Steel Pipe for High-Temperature Service</td>
<td>Piping</td>
<td>Table 408.1</td>
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<tr>
<td>ASTM A312/A312M-2017-2018</td>
<td>Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes</td>
<td>Piping</td>
<td>Table 408.1</td>
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<td>ASTM B135/B135M-2010-2017</td>
<td>Seamless Brass Tube</td>
<td>Piping</td>
<td>Table 408.1</td>
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<tr>
<td>ASTM B251/B251M-2014-2017</td>
<td>General Requirements for Wrought Seamless Copper and Copper-Alloy Tube</td>
<td>Piping</td>
<td>Table 408.1</td>
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<tr>
<td>ASTM B280-2016</td>
<td>Seamless Copper Tube for Air Conditioning and Refrigeration Field Service</td>
<td>Piping</td>
<td>703.6</td>
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<td>ASTM B302-2014-2017</td>
<td>Threadless Copper Pipe, Standard Sizes</td>
<td>Piping</td>
<td>Table 408.1</td>
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<tr>
<td>ASTM B813-2014-2016</td>
<td>Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube</td>
<td>Joints</td>
<td>409.4(6)</td>
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<tr>
<td>ASTM C411-2014-2019</td>
<td>Hot-Surface Performance of High-Temperature Thermal Insulation</td>
<td>Duct Coverings and Linings</td>
<td>502.4.1</td>
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<td>ASTM D1785-2015</td>
<td>Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120</td>
<td>Piping</td>
<td>Table 408.1</td>
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<tr>
<td>ASTM D2466-2014-2017</td>
<td>Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40</td>
<td>Fittings</td>
<td>Table 408.1</td>
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<td>ASTM D2513-2016-2018</td>
<td>Polyethylene (PE) Gas Pressure Pipe, Tubing, and Fittings</td>
<td>Piping</td>
<td>Table 408.1</td>
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<tr>
<td>ASTM D2564-2012</td>
<td>Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems</td>
<td>Joints</td>
<td>409.11(2)</td>
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<tr>
<td>ASTM D2846/D2846M-2014-2019</td>
<td>Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Hot- and Cold-Water Distribution Systems</td>
<td>Piping</td>
<td>409.2(2), 409.3(2), Table 408.1</td>
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<td>ASTM F438-2014-2017</td>
<td>Socket-Type Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40</td>
<td>Fittings</td>
<td>Table 408.1</td>
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<td>ASTM F876-2015a2017</td>
<td>Crosslinked Polyethylene (PEX) Tubing</td>
<td>Piping</td>
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<td>ASTM F877-2014a2018a</td>
<td>Crosslinked Polyethylene (PEX) Hot- and Cold-Water Distribution Systems</td>
<td>Piping</td>
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<td>ASTM F1281-20142017</td>
<td>Crosslinked Polyethylene-Aluminum/Crosslinked Polyethylene (PEX-AL-PEX) Pressure Pipe</td>
<td>Piping</td>
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<td>ASTM F1807-20122019</td>
<td>Metal Insert Fittings Utilizing a Copper Crimp Ring, or Alternate Stainless Steel Clamps, for SDR9 Crosslinked Polyethylene (PEX) Tubing and SDR9 Polyethylene of Raised Temperature (PE-RT) Tubing</td>
<td>Fittings</td>
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<td>ASTM F1960-20152018a</td>
<td>Cold Expansion Fittings with PEX Reinforcing Rings for Use with Cross-linked Polyethylene (PEX) and Polyethylene of Raised Temperature (PE-RT) Tubing</td>
<td>Fittings</td>
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<tr>
<td>ASTM F1961-2009</td>
<td>Metal-Mechanical Cold Flare Compression Fittings with Disc Spring for Crosslinked Polyethylene (PEX) Tubing (WITHDRAWN)</td>
<td>Fittings</td>
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<td>ASTM F2080-20162018</td>
<td>Cold-Expansion Fittings with Metal Compression-Sleeves for Cross-linked Polyethylene (PEX) Pipe and SDR9 Polyethylene of Raised Temperature (PE-RT) Pipe</td>
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<td>ASTM F2098-20142018</td>
<td>Stainless Steel Clamps for Securing SDR9 Crosslinked Polyethylene (PEX) Tubing and SDR9 Polyethylene of Raised Temperature (PE-RT) Tubing to Metal Insert and Plastic Insert Fittings</td>
<td>Fittings</td>
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<td>ASTM F2159-20142019</td>
<td>Plastic Insert Fittings Utilizing a Copper Crimp Ring, or Alternate Stainless Steel Clamps for SDR9 Crosslinked Polyethylene (PEX) Tubing and SDR9 Polyethylene of Raised Temperature (PE-RT) Tubing</td>
<td>Fittings</td>
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<tr>
<td>ASTM F2262-2009</td>
<td>Crosslinked Polyethylene-Aluminum-Crosslinked Polyethylene Tubing OD Controlled SDR9 (WITHDRAWN)</td>
<td>Piping, Plastic</td>
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<tr>
<td>ASTM F2434-20142018</td>
<td>Metal Insert Fittings Utilizing a Copper Crimp Ring for SDR9 Cross-linked Polyethylene (PEX) Tubing and SDR9 Cross-linked Polyethylene/Aluminum/Cross-linked Polyethylene (PEX-AL-PEX) Tubing</td>
<td>Pipe, Fittings</td>
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</tr>
<tr>
<td>ASTM F2735-2009(R2016)-2018</td>
<td>Plastic Insert Fittings for SDR9 Cross-linked Polyethylene (PEX) and Polyethylene of Raised Temperature (PE-RT) Tubing</td>
<td>Fittings</td>
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<tr>
<td>ASTM F2769-20162018</td>
<td>Polyethylene of Raised Temperature (PE-RT) Plastic Hot and Cold-Water Tubing and Distribution Systems</td>
<td>Piping, Fitting</td>
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(portions of table not shown remain unchanged)

Note: The ASTM standards meet the requirements for mandatory reference standards in accordance with Section 15.0 of IAPMO’s Regulations Governing Consensus Development of the Uniform Solar, Hydronics & Geothermal and Swimming Pool, Spa & Hot Tub Codes.

### TABLE 901.2

<table>
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<tr>
<th>DOCUMENT NUMBER</th>
<th>DOCUMENT TITLE</th>
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<tbody>
<tr>
<td>ASTM D93-20142018</td>
<td>Flash Point by Pensky-Martens Closed Cup Tester</td>
<td>Testing</td>
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<tr>
<td>ASTM D635-20142018</td>
<td>Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position</td>
<td>Testing</td>
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**SUBSTANTIATION:**
The above revisions reflect the latest updates to the ASTM standards that are referenced in Table 901.1 and Table 901.2.
**TABLE 901.1**

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<th>REFERENCED SECTIONS</th>
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<tr>
<td>AWS A5.8M/A5.8-2011-AMD 1</td>
<td>Filler Metals for Brazing and Braze Welding</td>
<td>Joints</td>
<td>409.4(1), 703.6, 703.7</td>
</tr>
</tbody>
</table>

(portions of table not shown remain unchanged)

**Note:** AWS meets the requirements for a mandatory reference standard in accordance with Section 15.0 of IAPMO’s Regulations Governing Consensus Development of the Uniform Solar, Hydronics & Geothermal and Swimming Pool, Spa & Hot Tub Codes.

**Substantiation:**
The above revision reflects the latest update to the AWS standard that is referenced in Table 901.1.
Item #: 067

USHGC 2021  Section: Table 901.2

SUBMITTER: Paul Olson  
American Water Works Association (AWWA)

RECOMMENDATION:  
Revise text

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<th>DOCUMENT TITLE</th>
<th>APPLICATION</th>
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<tr>
<td>AWWA C507-2015-2018</td>
<td>Ball Valves, 6 in. through 60 in. (150 mm through 1,500 mm)</td>
<td>Valves</td>
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</table>

(portions of table not shown remain unchanged)

SUBSTANTIATION:  
The above revisions reflect the latest updates to the AWWA standards that are referenced in Table 901.2.
Item #: 068
USHGC 2021  Section: Table 901.2

SUBMITTER: Ed Tsang
BSI

RECOMMENDATION:
Revise text

### TABLE 901.2
STANDARDS, PUBLICATIONS, PRACTICES, AND GUIDES

<table>
<thead>
<tr>
<th>DOCUMENT NUMBER</th>
<th>DOCUMENT TITLE</th>
<th>APPLICATION</th>
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(portions of table not shown remain unchanged)

**SUBSTANTIATION:**
The above revision reflects the latest update to the BSI standard that is referenced in Table 901.2.
Item #: 069
USHGC 2021 Section: Table 901.1

SUBMITTER: Nikki Kidd
Canadian Standards Association (CSA)

RECOMMENDATION:
Revise text

### TABLE 901.1
**REFERENCED STANDARDS**

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<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTIONS</th>
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<tbody>
<tr>
<td>CSA/IGSHPA C448-2016</td>
<td>Design and Installation of Ground Source Heat Pump Systems for Commercial and Residential Buildings</td>
<td>Miscellaneous</td>
<td>703.3, 703.4, 703.4.2</td>
</tr>
<tr>
<td>CSA Z21.10.1-2014</td>
<td>Gas Water Heaters, Volume I, Storage Water Heaters with Input Ratings of 75,000 Btu Per Hour or Less (same as CSA 4.1)</td>
<td>Fuel Gas, Appliances</td>
<td>Table 403.2</td>
</tr>
<tr>
<td>CSA Z21.10.3-2015</td>
<td>Gas-Fired Water Heaters, Volume III, Storage Water Heaters with Input Ratings Above 75,000 Btu Per Hour, Circulating and Instantaneous (same as CSA 4.3)</td>
<td>Fuel Gas, Appliances</td>
<td>Table 403.2</td>
</tr>
</tbody>
</table>

(portions of table not shown remain unchanged)

**Note:** CSA C448, CSA Z21.10.1 and CSA Z21.10.3 meet the requirements for mandatory reference standards in accordance with Section 15.0 of IAPMO’s Regulations Governing Consensus Development of the Uniform Solar, Hydronics & Geothermal and Swimming Pool, Spa & Hot Tub Codes.

**SUBSTANTIATION:**
The above revisions reflect the latest updates to the CSA standards that are referenced in Table 901.1.
**Item #:** 070

USHGC 2021  Section: Table 901.2

**SUBMITTER:** Kyle Thompson  
IAPMO

**RECOMMENDATION:** 
Revise text

### TABLE 901.2

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<tbody>
<tr>
<td>IAPMO PS-117-20162018</td>
<td>Press and Nail Connections</td>
<td>Fittings</td>
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(portions of table not shown remain unchanged)

**SUBSTANTIATION:** 
The above revision reflects the latest update to the IAPMO standard that is referenced in Table 901.2.
Item #: 071

USHGC 2021  Section: Table 901.2

SUBMITTER: Anasthasie Sainvilus
IEEE

RECOMMENDATION:
Revise text

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<th>DOCUMENT NUMBER</th>
<th>DOCUMENT TITLE</th>
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<tr>
<td>IEEE 1547-2003-2018</td>
<td>Interconnection and Interoperability of Interconnecting Distributed Energy Resources with Associated Electric Power Systems Interfaces</td>
<td>Connections, Photovoltaic</td>
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</table>

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SUBSTANTIATION:
The above revision reflects the latest update to the IEEE standard that is referenced in Table 901.2.
Item #: 072

USHGC 2021  Section: Table 901.2

SUBMITTER: David Thompson
Manufacturers Standardization Society (MSS)

RECOMMENDATION:
Revise text

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SUBSTANTIATION:
The above revision reflects the latest update to the MSS standard that is referenced in Table 901.2.
Item #: 073
USHGC 2021 Section: Table 901.1, Table 901.2

SUBMITTER: Heath Dehn
National Fire Protection Association (NFPA)

RECOMMENDATION:
Revise text

**TABLE 901.1**
REFERRED TO STANDARDS

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<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTIONS</th>
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<tr>
<td>NFPA 70-20142017</td>
<td>National Electrical Code</td>
<td>Miscellaneous</td>
<td>315.1, 801.1, 804.1, 806.4, 807.2, 810.1.3, 811.1.4, 812.1, 812.2.1, 812.3, 812.5, 812.6, 812.7.5(8), 812.7.5(11), 812.7.5(12), 812.8, 818.2, 818.3(1), 819.1, 819.1.2, 821.2, 821.2.2, 821.3, 821.3.9(3), 828.1, 829.1, 832.2, 832.4, B 104.1, C 101.9(7)</td>
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(portions of table not shown remain unchanged)

**Note:** NFPA 70 meets the requirements for a mandatory reference standard in accordance with Section 15.0 of IAPMO’s Regulations Governing Consensus Development of the Uniform Solar, Hydronics & Geothermal and Swimming Pool, Spa & Hot Tub Codes.

**TABLE 901.2**
STANDARDS, PUBLICATIONS, PRACTICES, AND GUIDES

<table>
<thead>
<tr>
<th>DOCUMENT NUMBER</th>
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<tr>
<td>NFPA 54/Z223.1-20142018</td>
<td>National Fuel Gas Code</td>
<td>Fuel Gas</td>
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<tr>
<td>NFPA 274-20132018</td>
<td>Test Method to Evaluate Fire Performance Characteristics of Pipe Insulation</td>
<td>Pipe Insulation</td>
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(portions of table not shown remain unchanged)

**SUBSTANTIATION:**
The above revisions reflect the latest updates to the NFPA standards that are referenced in Table 901.1 and Table 901.2.
Item #: 074

USHGC 2021 Section: Table 901.1, Table 901.2

SUBMITTER: Jeremy Brown
NSF International (NSF)

RECOMMENDATION:
Revise text

TABLE 901.1
REFERENCED STANDARDS

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<tr>
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<th>REFERENCED SECTIONS</th>
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<tbody>
<tr>
<td>NSF 60-20162017</td>
<td>Drinking Water Treatment Chemicals - Health Effects</td>
<td>Backfill</td>
<td>703.4.1</td>
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<tr>
<td>NSF 61-20162018</td>
<td>Drinking Water System Components - Health Effects</td>
<td>Miscellaneous</td>
<td>501.5.4</td>
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<tr>
<td>NSF 358-2-20122017</td>
<td>Polypropylene Pipe and Fittings for Water-Based Ground-</td>
<td>Piping, Fittings</td>
<td>Table 408.1</td>
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<td>Source “Geothermal” Heat Pump Systems</td>
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Note: NSF 60, NSF 61 and NSF 358-2 meet the requirements for mandatory reference standards in accordance with Section 15.0 of IAPMO’s Regulations Governing Consensus Development of the Uniform Solar, Hydronics & Geothermal and Swimming Pool, Spa & Hot Tub Codes.

TABLE 901.2
STANDARDS, PUBLICATIONS, PRACTICES, AND GUIDES

<table>
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<tbody>
<tr>
<td>NSF 14-2016a2018</td>
<td>Plastic Piping System Components and Related Materials</td>
<td>Piping, Plastic</td>
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SUBSTANTIATION:
The above revision reflects the latest update to the NSF standard that is referenced in Table 901.1 and Table 901.2.
Item #: 075

USHGC 2021  Section: Table 901.1, Table 901.2

SUBMITTER: Christopher Jensen  
UL LLC

RECOMMENDATION: 
Revise text

TABLE 901.1
REFERENCED STANDARDS

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<tr>
<th>DOCUMENT NUMBER</th>
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<td>UL 723-2008</td>
<td>Test for Surface Burning Characteristics of Building Materials (with revisions through August 12, 2013)</td>
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<td>401.2, 502.4, 503.1, 606.5</td>
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<td>UL 778-2016</td>
<td>Motor-Operated Water Pumps (with revisions through February 22, 2017 January 17, 2019)</td>
<td>Pumps</td>
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<td>UL 834-2004</td>
<td>Heating, Water Supply, and Power Boilers - Electric (with revisions through December 9, 2013 September 24, 2018)</td>
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<td>UL 1703-2002</td>
<td>Flat-Plate Photovoltaic Modules and Panels (with revisions through March 10, 2017 September 26, 2018)</td>
<td>Electrical</td>
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<td>UL 1741-2010</td>
<td>Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources (with revisions through September 7, 2016 February 15, 2018)</td>
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<td>UL 2523-2009</td>
<td>Solid Fuel-Fired Hydronic Heating Appliances, Water Heaters, and Boilers (with revisions through February 8, 2013 March 16, 2018)</td>
<td>Fuel Gas, Appliances</td>
<td>Table 403.2</td>
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</tbody>
</table>

(portions of table not shown remain unchanged)

Note: The UL standards meet the requirements for mandatory reference standards in accordance with Section 15.0 of IAPMO’s Regulations Governing Consensus Development of the Uniform Solar, Hydronics & Geothermal and Swimming Pool, Spa & Hot Tub Codes.

TABLE 901.2
STANDARDS, PUBLICATIONS, PRACTICES, AND GUIDES

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<td>UL 1453-2016</td>
<td>Electric Booster and Commercial Storage Tank Water Heaters (with revisions through March 9, 2017 May 18, 2018)</td>
<td>Appliances</td>
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</table>

(portions of table not shown remain unchanged)
SUBSTANTIATION:
The above revisions reflect the latest updates to the Underwriters Laboratories, Inc. (UL) standards that are referenced in Table 901.1 and Table 901.2.